



# ECCA 2017

Glasgow, June 5-9

“Our Climate Ready Future”

## Full Programme



# Contents

<b>Plenary Sessions .....</b>	<b>5</b>
<b>Business Day Programme .....</b>	<b>6</b>
<b>Innovation Day .....</b>	<b>8</b>
<b>Social Programme.....</b>	<b>9</b>
<b>How the sessions are classified into themes and topics .....</b>	<b>11</b>
<b>Session overview: colours indicate main topic .....</b>	<b>14</b>
<b>List of Sessions by Theme .....</b>	<b>17</b>
<b>Sessions by Topic.....</b>	<b>23</b>
<b>Tuesday 6 June AM (11:00-12:45) .....</b>	<b>32</b>
1.7 Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change .....	32
12.1 Ecosystem service provision, biodiversity and ecosystem function under a changing climate .....	38
13.1 Progress on adaptation in national health systems .....	43
2.3 Making decisions with multiple stakeholders for long-term resilience .....	48
10.1 Projections of climate change vulnerability in the agriculture and forestry sectors - decision support to guide adaptation strategies.....	52
11.2 Tools for understanding the economic impacts of floods and droughts .....	56
4.1 A better understanding of adaptation governance.....	60
5.9 US NOAA Sea Grant Program Facilitates Coastal Adaptation Planning Efforts .....	64
4.4 Making change happen: Learning from practical climate projects working across communities, governance, and policy.....	68
2.5 Foresight in Climate Change Adaptation and Disaster Risk Reduction .....	72
<b>Tuesday 6 June 2017 PM1 (13:45-15:30) .....</b>	<b>75</b>
1.2 Compiling adaptation-relevant data for climate services .....	75
4.8 Local adaptation pathway design in practice. Gaining flexibility and managing uncertainty in the long-term climate resilience planning .....	79
6.12 Objectives and guidelines in urban design to adapt to the risks of urban heat.....	84
2.4 Community-based adaptation planning .....	88
Business Day 1: Business solutions for climate readiness – Infrastructure and Water.....	92
Business Day 2: Business solutions for climate readiness – Bio-economy.....	92
Business Day 3: Business solutions for climate readiness – Health .....	92
Business Day 4: Business solutions for climate readiness – Risk management and consulting.....	92
11.3 Strategies for managing flood risk and water quality .....	93
6.9 Fostering dialogue and learning on monitoring and evaluation of climate change adaptation and disaster risk reduction policies.....	98
4.10 Living with coastal change: risk, resilience, adaptation and working with nature.....	102
4.5 Social justice in urban adaptation and transformation under climate change: what does this look like in practice? .....	107
1.3 The challenge of communicating high-end climate change .....	111
<b>Tuesday 6 June 2017 PM2 (16:00-17:45) .....</b>	<b>113</b>
1.1 New knowledge and its communication .....	113
5.7 Constituting Local Knowledge of Natural Disasters in Climate Adaptation .....	117

13.2 Implications for policy and planning of the impacts of climate change on health and wellbeing .....	120
4.6 Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges .....	124
10.2 Understanding adaptation practices in agriculture and fisheries .....	129
5.2 Novel methodologies & tools for knowledge co-production .....	133
6.13 Monitoring and evaluating adaptation in practice: learning from (sub) national examples from Europe and beyond .....	137
2.1 Adaptation options for coastal areas .....	141
4.11 Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities .....	145
5.4 Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU .....	149
Business Day 5: Opportunities for climate readiness: market demand & finance.....	153
<b>Wednesday 7 June 2017 AM (11:00-12:45).....</b>	<b>154</b>
6.5 How climate services can enable successful urban adaptation .....	154
8.1 Adaptation, Mitigation and Transformation: The high-end context, synergies and trade-offs.....	159
3.1 The economics of climate change .....	163
5.1 Co-production as a means of climate change governance.....	166
2.7 Food security and supply chain resilience under a changing climate .....	170
6.7 Adaptation cultures: knowledge, values and practices .....	173
6.8 Adaptation in action: case studies from the water and sewerage sectors .....	176
11.1 Adapting to floods in coastal areas .....	181
2.6 Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty .....	185
6.14 Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland .....	188
7.3 Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development.....	193
<b>Wednesday 7 June 2017 PM1 (13:45-15:30) .....</b>	<b>197</b>
2.2 Data and information tools for adaptation planning .....	197
2.9 Pathways to climate-ready infrastructure: progress and challenges.....	201
3.2 Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector.....	206
4.2 Emerging priorities and sensitive topics in adaptation .....	208
5.3 Learning from co-production of adaptation practice and climate services .....	212
6.6 Inclusive and local adaptation studies.....	216
8.2 Dealing with the complexity of multiple sectors, scales, stakeholders, risks and benefits.....	220
12.2 Adaptation in Coastal and Marine Ecosystems .....	224
6.15 Tackling the challenge of adaptation, lessons learned in the Netherlands.....	228
1.9 Learning from failures in communication: Sharing lessons from research and practice .....	231
<b>Wednesday 7 June 2017 PM2 (16:00-17:45) .....</b>	<b>235</b>
2.8 Increasing Resilience: Integrating climate change adaptation and disaster risk reduction in planning. European and national level policy approaches and practices .....	235
5.5 Participatory modelling in climate change adaptation – methods and experiences .....	239
4.7 Institutional economics of climate change adaptation .....	244
6.11 Evaluating participatory social change processes for adaptation .....	248
10.3 Climate change adaptation in agriculture, agroforestry, and fisheries – from knowledge to policy instruments and concrete solutions.....	252

11.6 Managing rainfall to control flooding and improve water quality .....	256
8.3 Cross-boundary implementation of climate adaptation plans in Central Denmark Region .....	259
5.11 Exploring urban adaptation practice: a focus on co-production and multi-level governance.....	264
12.5 Using nature-based solutions to manage flood risk – challenges, tools and experience .....	268
1.5 Providing a fit-for-purpose climate service for Europe: users’ and purveyors’ perspectives .....	272
6.10 Horses for courses: adaptation pathways for different contexts.....	275
<b>Thursday 8 June 2017 AM1 (09:00-10:45).....</b>	<b>279</b>
1.4 Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment .....	279
12.4 Adapting nature conservation strategies to climate change: how can science inform this process? .....	283
1.8 Understanding, Analysing and Adapting to Climate Change Impacts on the Historic Environment .....	287
7.1 Climate adaptation and sustainability. Part I: Approaches to integrate the SDGs into climate adaptation ..	291
10.4 Adaptation of crop and livestock production to climate change and mitigation policies in a +1.5 K world	296
5.6 Integrated research methods for co-creating adaptation solutions .....	300
4.3 Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban.....	304
6.4 Adaptation in practice: Case studies of flooding.....	309
9.1 Urban development toward sustainability and resilience: from mega-city to dwelling .....	313
5.8 Adapting to droughts and water scarcity: Supporting decision making, identifying solutions and delivering evidence to inform adaptation and mitigation .....	318
<b>Thursday 8 June 2017 AM2 (11:15-13:00).....</b>	<b>321</b>
1.6 Information needs for planning adaptation at national and local level .....	321
2.10 Guidance for EU and national bodies in identifying options for innovative solutions to increase resilience .....	324
6.1 Tools for economic analysis of adaptation options.....	328
7.2 Climate adaptation and sustainability. Part II: Knowledge management and learning examples from around the world .....	332
10.5 Adapting Scotland’s natural capital: appraisal methods, research and policy priorities .....	336
6.2 Tools for inclusive and local adaptation options .....	340
6.3 A tour of local adaptation in Europe .....	344
4.9 Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments .....	348
11.5 Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance .....	353
12.3 The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas.	357
9.2 Energy and Transport Infrastructure under Climate Change: Adaptation, Mitigation and Resilience .....	361
<b>Theme Convenors.....</b>	<b>366</b>

# Plenary Sessions

## Opening plenary: Setting the challenge (Tuesday 6 June, 9.00-10.30am)

- Andrea Tilche, Head of Unit, Climate Action and Earth Observations, Directorate-General for Research and Innovation, European Commission
- Roseanna Cunningham, MSP Cabinet Secretary for Environment, Climate Change and Land Reform, Scottish Government
- Hans-Otto Pörtner, Co-Chair IPCC WGII, Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research
- Stephanie Lyons, Global Policy Team, WaterAid
- Jack Dudgeon, Scottish Youth Parliament

Moderated by Martin Watson and Marc Gramberger (Prospex)

## Day 2 Plenary: Adaptation in practice (Wednesday 7 June, 9.00-10.30am)

- The Baroness Brown of Cambridge DBE FREng, Chair of the Adaptation Sub-Committee of the UK Committee on Climate Change
- Claus Kondrup, Acting Head of Unit, European & International Carbon Markets, Directorate-General for Climate Action, European Commission
- Duarte d'Araújo Mata, Green Structure and Energy Deputy Mayor's Office, Lisbon
- Lolita Jackson, Special Advisor, Climate Policy & Programs, New York City Office of the Mayor
- Alasdair Adey, Vice Chair of the Scottish Young Planners Network – Royal Town Planning Institute

Moderated by Marc Gramberger and Stefan Haenen (Prospex)

## Closing Plenary: Going forwards (Thursday 8 June, 1.45-3.15pm)

- Diogo de Gusmão-Sørensen, Head of Climate Services, Climate Action and Earth Observations, Directorate-General for Research and Innovation, European Commission
- Paul McAleavey, Head of the Air and Climate Change Programme, European Environment Agency
- John Firth, CEO, Acclimatise
- Jill Jäger, Senior Researcher
- Elizabeth Dirth, Former Chair, 2050 Climate Group, (Engaging, educating and empowering Scotland's future leaders on climate change)

Moderated by Marc Gramberger and Stefan Haenen (Prospex)

Hand-over to ECCA 2019 (Lisbon)

# Business Day Programme

**Tuesday 6th June 2017**

## **11.00: Business Day Opening Plenary: The business case for climate readiness**

This session will explore and discuss the need and added value for businesses becoming climate-ready with participation from the audience. Speakers in this session include:

- Lady Susan Rice CBE, Chair of Scottish Water, Chair of Scotland's 2020 Climate Group
- Baroness Brown of Cambridge DBE FREng, Chair UK Adaptation Sub-Committee
- Miroslav Petkov, Head of Financial Services Environmental and Climate Risk Research, Standard & Poor's
- Craig Davies, Head, Climate Resilience Investments, Energy Efficiency & Climate Change Team, European Bank for Reconstruction and Development
- Diogo de Gusmão-Sørensen, Head of Climate Services, Climate Action and Earth Observations, Directorate-General for Research and Innovation, European Commission

## **13.45: Business solutions for climate readiness**

In a series of parallel sessions, the business day focusses on four different sectors highly affected by upcoming climate change, identifying possible business solutions. Interactive, parallel, and professionally facilitated sessions will include presentations, contributions and discussions among others by the following confirmed speakers:

### **Infrastructure and water**

- Paris Sansoglou, Secretary-General, European Dredging Association
- Pieter de Boer, representative of the Central Dredging Association, CEDA, Ministry of Infrastructure & Environment, the Netherlands
- Alan Hendry, Jacobs, Director of Sustainability
- Dr Mark Williams, Head of Environmental Science and Regulation, Scottish Water
- Peter Murphy, Operations Director, UK Water and Scottish Hydro Nation Water Innovation Service

### **Bio-economy**

- Andy Griffiths, Sustainability Manager, Nestlé
- Liz Bowles, Head of Farming, Soil Association
- Dr. Marta Modelewska, Principal, Climate Resilience Investments, Energy Efficiency and Climate Change team, European Bank for Reconstruction and Development
- Ms. Morag Garden, Head of Sustainability and Innovation, Scotch Whisky Association

### **Health**

- Roxane Feller, Secretary-General, International Federation for Animal Health Europe
- Vladimir Kendrovski, Technical Officer, World Health Organisation
- Diane Duncan, Head of Low Carbon, Highlands and Islands Enterprise
- Dr. Sari Kovats, Associate Professor, London School of Hygiene & Tropical Medicine

### **Risk management and consulting**

- Miroslav Petkov, Head of Financial Services Environmental and Climate Risk Research, Standard & Poor's
- John Firth, CEO and co-founder, Acclimatise

- Dr. David Viner, Global Practice Leader – Climate Resilience, Mott MacDonald
- Dickie Whitaker, Chief Executive, Oasis Loss Modelling Framework

## **16.00: Opportunities for climate readiness: market demand & finance**

What opportunities are there for businesses to prepare for a world facing climate change? In this interactive session, we will explore market demand and financing for demand and supply. Speakers:

- Kirsten Dunlop, CEO, Climate-KIC
- Wolfgang Teubner, Regional Director Europe, ICLEI – Local Governments for Sustainability
- Mr Claus Kondrup, Acting Head of Adaptation Unit, DG CLIMA, European Commission
- Craig Davies, Head, Climate Resilience Investments, Energy Efficiency & Climate Change Team, European Bank for Reconstruction and Development

### **Enabling market development for climate readiness**

Market development for products and services in climate readiness will be key for successful business solutions. This session explores different top-level showcases on how to develop concerted cross-society support as a basis for market uptake.

- Developing shared regional adaptation plans across society
- Preparing society for high-end climate change

## **Evening: Business reception, networking and introducing the ECCA Innovation Day**

At the end of the programme, Dr. Marc Gramberger, Managing Director of Prospex, will wrap up the ECCA Business Day, and hand over to Tom Mitchell, Director at Climate-KIC UK & Ireland, to introduce the ECCA Innovation Day on Wednesday 7 June. Participants will be invited to join the ECCA 2017 evening reception, providing ample opportunities for networking.

# Innovation Day

Glasgow City Council is seeking innovative ways of tackling two of Glasgow's climate resilience challenges:

- **Challenge 1: Innovative solutions to help Glasgow reduce its flood risk that can be retrofitted to commercial or residential properties**
- **Challenge 2: Innovative ways to engage stakeholders and communities to act to address Glasgow's climate resilience and environmental challenges**

The Glasgow Resilience Innovation Challenge is open to start-up businesses, SMEs, innovation arms of larger businesses, researchers, individual entrepreneurs, students and community groups.

## **10.30am – 12pm Launch – Glasgow Resilience Innovation Challenge (Innovation Stage, Exhibition Hall)**

- Introduction to the Challenges and the Selection Panel
- Welcome to the Challenge finalists
- Guide to the Day – Resources Available – Pitching Schedule for Finalists

***After 12pm The Glasgow Resilience Innovation Challenges continues in the Networking Area of the Exhibition Hall***

## **12pm – 12.45pm Resilience Innovation Exchange 1**

***Innovative data tools and services to support climate resilience decision-making***

Start-ups, SMEs and research teams pitch their ideas through 5 minute presentations, followed by 3 minutes of questions and answers.

## **1pm – 2pm Supporting Innovation for Climate Resilience**

***Hear from Innovate UK, Climate-KIC, NERC and others about:***

- What they are doing to support innovation in adapting to climate change
- Opportunities to receive support and funding to nurture innovative ideas for tackling climate resilience challenges.

## **2pm – 3pm Resilience Innovation Exchange 2**

***Technologies and services for climate-resilient infrastructure***

Start-ups, SMEs and research teams pitch their ideas through 5 minute presentations, followed by 3 minutes of questions and answers.

## **3pm – 4pm Resilience Innovation Exchange 3**

***Innovations for climate resilience in the context of sustainable land use***

Start-ups, SMEs and research teams pitch their ideas through 5 minute presentations, followed by 3 minutes of questions and answers.

## **4.00pm – 5.30pm Final – Glasgow Resilience Innovation Challenge**

- Introduction to the Short-listed Pitches and Judging Panel
- Pitches – 5 minutes, plus 3 minutes of questions
- Judges retire to deliberate the decisions
- Keynote presentation
- Announcement of Challenge Winners.

## **5.45pm – 7.00pm Innovation Day Reception, Hosted by Climate-KIC and Innovate UK**

Opportunities for matchmaking for collaboration and networking



# Social Programme

## Monday 5th June

### Civic Reception

**Location:** City Chambers Glasgow

**Time:** 7:00pm to 8:00pm

The Civic Reception will take place on Monday 5th June 2017 at the City Chambers located in George Square in the heart of the city. This is an informal drinks reception open to all delegates at no extra cost.



## Tuesday 6th June

### Poster Drinks Reception

**Location:** Exhibition Hall, Scottish Event Campus

**Time:** 6:00pm to 8:00pm

The Poster Drinks reception will be an opportunity to visit the extensive display of conference posters as well as to meet other delegates, including those from the ECCA Business Day. This is open to all delegates at no extra cost.

Posters are grouped according to the topics listed on Page 11. There will be guided poster tours to visit groups of posters arranged by topic. These will start at 6.30pm and 7.15pm and each tour will last about 30 minutes. Look out for the tour guides who will pass through the hall carrying signs labelled with the topic, and just join the group that interests you the most. During the tours, poster presenters will each give a two minute summary of their poster, and there will be an opportunity for questions and discussion. The poster tours will operate at the following times:

#### 6.30 pm – 7.00 pm tours

1. CCRA: UK Climate Change Risk Assessment (posters 1-6)
2. Climate Services tour 1 (posters 13-21)
3. Monitoring, evaluation and governance (posters 22-28)
4. Participation and co-production tour 1 (posters 37-43)
5. Pathways and transformation (posters 61-65)
6. Health (posters 79-89)
7. Agriculture, forestry and fisheries tour 1 (posters 101-106)
8. Drought and flooding tour 1 (posters 117-124)
9. Coastal adaptation plus urban water issues (posters 132-137)
10. Urban, energy and infrastructure tour 1 (energy focus) (posters 138-148)

#### 7.15 pm – 7.45 pm tours

1. Climate Services tour 2 (posters 7-12)
2. Governance (posters 29-36)
3. Participation and co-production tour 2 (posters 44-51)
4. Communication, art and culture (posters 53-60)
5. Disaster risk reduction and climate justice (posters 66-72)
6. Biodiversity, ecosystem services and nature-based solutions (posters 90-100)
7. Agriculture, forestry and fisheries tour 2 (posters 107-116)
8. Flooding tour 2 (posters 125-131)
9. Urban, energy and infrastructure tour 2 (transport, planning and business) (posters 149-166)

## Wednesday 7th June

### Conference Dinner and Ceilidh

**Location:** Kelvingrove Art Gallery and Museum

**Time:** 7:00pm to 11:00pm

Join us for a traditional Scottish Ceilidh in the stunning setting of Kelvingrove Art Gallery. Enjoy fine Scottish cuisine in an informal party setting in this unique and history-rich building. After food and drinks, have a go at traditional Scottish dancing – no experience necessary!



## Thursday 8th June

**Film evening in partnership with the Glasgow Science Festival**

**Location:** Kelvin Hall Lecture Theatre, near Glasgow University

**Time:** 6pm to 9:30pm

**Book free tickets on the Glasgow Science Festival website (separate tickets for Part 1 and Part 2).**

### **Part 1: 6:00pm – 7:30pm**

#### **Le Jardin d'Ewald**

This 60 minute film follows Senegalese people in rural areas as they try to outwit the threat of drought due to climate change. It has been shown at film festivals worldwide (Winner Best Documentary Los Angeles Urban Film Festival, Nomination Water for Life Award CMS Vatavaran in New Delhi, Official Selection Mumbai International Film Festival, Official Selection Ekotopfilm Prague). We are very lucky to secure this film as the one originally scheduled for this slot was, ironically, damaged in the Brisbane floods a few weeks ago.

### **Part 2: 8:00pm – 9:30pm Climate Change Shorts (three short films)**

- **Small Island States** (James Butler, CSIRO), 5 and 7 minutes.
- **Listening for the Rain**, Indigenous Perspectives on Climate Change (Renee McPherson, USA), 23 minutes.
- **Aghbalou, the source of water** (Anna and Remi Sowa, Chouette Films), 29 minutes. An internationally acclaimed film exploring traditional irrigation practices and 'science wars', set in a small river oasis in the High Atlas Mountains of Morocco. See the blog on the News page.

**Panel discussion 9:00pm – 9:30pm.**

## How the sessions are classified into themes and topics

Each session has a main theme, indicated by the first part of the session number (e.g. session 1.2 is part of Theme 1, Evidence for action). There are eight cross-cutting themes (numbered 1 to 8) and five sectoral themes (numbered 9 to 13).

We have also identified a range of topics indicated by coloured tags, which can help you to track specific topics of interest to you that may range across the numbered themes.

### Topics (indicated by coloured blocks)

Climate services
Communication, art and culture
Monitoring and evaluation
Economics and business
Climate justice
Governance
Participation and co-production
DRR (disaster risk reduction)
Pathways and transformation
Urban, energy & infrastructure
Agriculture & forestry
Drought
Coastal
Flooding
Biodiversity, ecosystem services and nature-based solutions (NBS)
Health

### Cross-cutting themes (indicated by first part of session number 1-8)

**1. Evidence for action: data, climate services & communication.**

This theme focuses on gathering and using evidence on the impacts and risks of climate change and the need for adaptation. It covers compilation of data on climate impacts and vulnerability; modelling and monitoring of impacts such as sea-level rise and extreme weather (droughts, storms, floods and heatwaves); assessing climate risks to society; and exploring the best way to use this knowledge to protect the public and inform policymakers, including addressing the needs of specific sectors and stakeholders, such as the private sector.

**2. Planning ahead: delivering resilience in the face of climate uncertainty.**

This covers the way in which we can address the risks and uncertainties of climate change by building societies, ecosystems and infrastructure that are resilient to environmental and socio-economic change. It includes risk and uncertainty assessment, scenario development and planning, participatory modelling, and developing transformative adaptation pathways that can cope with a wide range of future conditions. Specific options for improving resilience, such as nature-based solutions or urban planning, are also covered within the sectoral themes.

3. **Business and finance: mobilising investment in climate change adaptation and building low carbon, climate resilient economies.**

This year, for the first time, ECCA 2017 features a separate tailor-made business and innovation programme, to be run in parallel with the first two days of the main conference. This reflects the increasing importance of the business sector in developing and delivering climate ready solutions, as well as the urgency of adapting businesses to be climate ready. It also reinforces the need for business, research, education and public bodies to learn and innovate together about what it takes to create scalable adaptation measures. It will include interactive sessions on risks, opportunities, financing and business solutions in different sectors, as well as an open Innovation event where creative solutions can be presented via a Pitching Stage. We also include a number of business and finance-themed sessions within the main conference.

4. **Making it happen: organisations, policy, governance, justice & ethics.**

This is a broad theme covering a wide range of issues around climate change adaptation policy and action aimed at enhancing progress in the pre-2020 period as well as facilitating the implementation of the Paris Agreement requirements. This includes the major themes of governance, climate justice and ethics.

5. **Working together: co-production of knowledge between science, business, policy, practice and local communities.**

This theme aims to encourage interactions between the policy, practice and research communities, including local authorities, government departments, businesses and community groups as well as researchers and consultants. It showcases projects that demonstrate how these groups can work together to co-produce knowledge around climate change adaptation, and it hosts interactive events, debates and workshops designed to encourage this interaction and knowledge exchange at the conference.

6. **Adaptation in practice: case studies, monitoring, support tools and guidance.**

This is where we explore how adaptation can be put into practice. This theme presents tools and guidance for planning, monitoring and assessing adaptation options, including accounting for co-benefits, as well as case studies and evaluations of real-life adaptation projects.

7. **Global challenges: climate adaptation and the UN Sustainable Development Goals.**

Climate change adaptation and mitigation are addressed directly in the 2030 Agenda for Sustainable Development under SDG 13 (Climate Action) but also have strong links to the other SDGs: poverty, hunger, health, education, gender, water, energy, economy, infrastructure, inequality, cities, consumption, ecosystems, peace, justice and partnerships. This theme will focus on climate change adaptation in the global context, including major issues such as forced migration, disaster risk reduction and health impacts of climate change.

8. **Whole system sustainable solutions: acting across multiple sectors and scales.**

Action that focuses on a single sector such as food, energy, transport, water or biodiversity may have unintended adverse impacts in other areas. Climate action therefore needs to take a holistic view across all sectors, and at multiple scales from the local to the global. This theme covers research, policy and practice that attempts to take this wide view across multiple sectors or scales. It covers action and research aimed at increasing sustainability, which has multiple benefits across a range of sectors. It also covers synergies and trade-offs between adaptation and mitigation.

## **Sectoral themes (indicated by first part of session number 9-13)**

### **9. Urban, energy & infrastructure**

This theme covers urban planning, transport, energy supply, energy demand management, coastal protection and the built environment. It covers the design, implementation and assessment of options to increase resilience to climate change impacts such as sea-level rise, increased temperatures and extreme weather events, as well as planning for disaster risk reduction in these sectors.

### **10. Agriculture & forestry**

Climate impacts on agriculture and forestry, including impacts on food security and livelihoods, are addressed under this theme, with a focus on practical methods and policy guidelines for making agriculture and forestry more sustainable and more resilient to climate change.

### **11. Water security & flooding**

Water security, like energy and food security, covers the physical amount of water available for use, as well as accessibility, affordability and continuity of supply. It is thus related not just to climate but also to socio-economic factors including governance, pricing and the use of water by different sectors of society. The water sector could be heavily affected by climate change, which can result in either too much water (floods) or too little water (droughts), at different times and in different places. This theme looks at how adaptation to flooding and water shortages can be delivered by working through land management (e.g. catchment management or re-aligning the land-water border), behavioural change (demand management) and technological solutions (e.g. improved water treatment).

### **12. Biodiversity, ecosystem services & nature-based solutions**

Ecosystems play a vital role in offering cost-effective adaptation solutions with multiple benefits for biodiversity, health and wellbeing, and possible mitigation co-benefits. Well-managed and healthy ecosystems can provide flood and erosion protection, urban cooling and clean air and water, as well as storing carbon and thus helping to reduce climate change impacts. Ecosystems also provide cultural services including aesthetic value and places for recreation. This theme addresses these options, covering the topics of green infrastructure, ecosystem services and nature-based solutions, including mechanisms to encourage them such as payment for ecosystem services or result-based payments.

### **13. Health & wellbeing**

Effective climate change adaptation is vital for long term health and wellbeing, through providing food, energy and water security, as well as ensuring labour productivity. This theme provides a venue for work that focusses on the way in which adaptation can address climate impacts on human health and wellbeing, with a view to increasing resilience to disasters, and advancing our understanding of temperature-related death and illness, air quality impacts, impacts of extreme events on human (and animal) health, vector-borne diseases, water-related illnesses, nutrition, mental health and populations of concern.

## Session overview: colours indicate main topic

Climate services	Communication, art and culture	Coastal	Flooding	Participation and co-production	DRR	Drought	Economics / business	Monitoring and evaluation	Urban	Climate justice	Agriculture & forestry	Ecosystem services	Health	Pathways and transformation	Governance
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Room	Tue AM	Tue PM 1	Tue PM 2
<b>Carron 1</b>	1.7 Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change. Chair: Michalis Vousdoukas and Piero Lionello	1.2 Compiling adaptation-relevant data for climate services. Chair: Svetlana Jevrejeva	1.1 New knowledge and its communication. Chair: Timothy Carter
<b>Carron 2</b>	12.1 Ecosystem service provision, biodiversity and ecosystem function under a changing climate. Chair: John Haslett	4.8 Local adaptation pathway design in practice. Gaining flexibility and managing uncertainty in the long-term climate resilience planning. Chair: Maddalen Mendizabal, Efren Feliu and Kristen Guida	5.7 Constituting Local Knowledge of Natural Disasters in Climate Adaptation. Chair: Lisa Van Well
<b>Leven</b>	13.1 Progress on adaptation in national health systems. Chair: Vladimir Kendrovski	6.12 Objectives and guidelines in urban design to adapt to the risks of urban heat. Chair: Mendel Giezen and Lisette Klok	13.2 Implications for policy and planning of the impacts of climate change on health and wellbeing. Chair: Sari Kovats
<b>Morar + Ness</b>	2.3 Making decisions with multiple stakeholders for long-term resilience. Chair: Calum Brown	2.4 Community-based adaptation planning. Chair: Robert Dunford	4.6 Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges. Chair: Sebastian Seebauer and Thomas Thaler
<b>Dochart 1</b>	10.1 Projections of climate change vulnerability in the agriculture and forestry sectors - decision support to guide adaptation strategies. Chair: Marcus Lindner	Business Day Parallel Session: Business solutions for climate readiness: Infrastructure & Water	10.2 Understanding adaptation practices in agriculture and fisheries. Chair: Stefan Fronzek
<b>Dochart 2</b>	11.2 Tools for understanding the economic impacts of floods and droughts. Chair: Florian Gallo	11.3 Strategies for managing flood risk and water quality. Chair: Tom Spencer	5.2 Novel methodologies & tools for knowledge co-production. Chair: Kirsty Lewis
<b>Boisdale 1</b>	4.1 A better understanding of adaptation governance. Chair: Robbert Biesbroek	6.9 Fostering dialogue and learning on monitoring and evaluation of climate change adaptation & disaster risk reduction policies. Chair: Eleni Karali & Patrick Pringle	6.13 Monitoring and evaluating adaptation in practice: learning from (sub) national examples from Europe and beyond. Chair: Timo Leiter and Mike Harley
<b>Boisdale 2</b>	5.9 US NOAA Sea Grant Program Facilitates Coastal Adaptation Planning Efforts. Chair: Libby Carnahan	4.10 Living with coastal change: risk, resilience, adaptation and working with nature. Chair: Larissa Naylor and Jim Densham	2.1 Adaptation options for coastal areas. Chair: Mário Pulquério
<b>Alsh 1</b>	4.4 Making change happen: Learning from practical climate projects working across communities, governance, and policy. Chair: Katharine Knox and Ioan Fazey	4.5 Social justice in urban adaptation and transformation under climate change: what does this look like in practice? Chair: Eric Chu and Thomas Thaler	4.11 Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities. Chair: Kit England and Sophie Turner
<b>Alsh 2</b>	2.5 Foresight in Climate Change Adaptation and Disaster Risk Reduction. Chair: Rob Swart and Markus Leitner	1.3 The challenge of communicating high-end climate change. Chair: Tim Rayner	5.4 Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU. Chair: André Jol and Kati Mattern
<b>Forth/Gala</b>	Business Day Plenary	Business Day: Bioeconomy, Health, Risk management	Business Day: Market demand and finance



Room	Wed AM	Wed PM 1	Wed PM 2
<b>Carron 1</b>	6.5 How climate services can enable successful urban adaptation. Chair: Kit England	2.2 Data and information tools for adaptation planning. Chair: Christopher Reyer	2.8 Increasing Resilience: Integrating climate change adaptation and disaster risk reduction in planning. European and national level policy approaches and practices. Chair: Sergio Castellari and Markus Leitner
<b>Carron 2</b>	8.1 Adaptation, Mitigation and Transformation: The high-end context, synergies and trade-offs. Chair: Diogo de Gusmão-Sørensen	2.9 Pathways to climate-ready infrastructure: progress and challenges. Chair: Erika Palin and Mike Keil	5.5 Participatory modelling in climate change adaptation – methods and experiences. Chair: Sadie McEvoy
<b>Leven</b>	3.1 The economics of climate change. Chair: Andrea Roventini and Shouro Dasgupta	3.2 Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector. Chair: Karianne De Bruin and Cosima Stahr	4.7 Institutional economics of climate change adaptation. Chair: Alexander Bisaro
<b>Morar + Ness</b>	5.1 Co-production as a means of climate change governance. Chair: Tim Rayner	4.2 Emerging priorities and sensitive topics in adaptation. Chair: Marco Grasso	6.11 Evaluating participatory social change processes for adaptation. Chair: James Butler
<b>Dochart 1</b>	2.7 Food security and supply chain resilience under a changing climate. Chair: Katy Richardson	5.3 Learning from co-production of adaptation practice and climate services. Chair: Saskia Werners	10.3 Climate change adaptation in agriculture, agroforestry, and fisheries – from knowledge to policy instruments and concrete solutions. Chair: Ana Iglesias
<b>Dochart 2</b>	6.7 Adaptation cultures: knowledge, values and practices. Chair: Melanie Boeckmann and Thorsten Heimann	6.6 Inclusive and local adaptation studies. Chair: Simona Pedde	11.6 Managing rainfall to control flooding and improve water quality. Chair: James Murray
<b>Boisdale 1</b>	6.8 Adaptation in action: case studies from the water and sewerage sectors. Chair: Mike Keil	8.2 Dealing with the complexity of multiple sectors, scales, stakeholders, risks and benefits. Chair: Henrik Carlsen	8.3 Cross boundary implementation of climate adaptation plans in Central Denmark Region. Chair: Rolf Johnsen
<b>Boisdale 2</b>	11.1 Adapting to floods in coastal areas. Chair: Agustin Sanchez-Arcilla	12.2 Adaptation in Coastal and Marine Ecosystems. Chair: Paolo Scussolini	5.11 Exploring urban adaptation practice: a focus on co-production and multi-level governance. Chair: Jeremy Carter and Filip Lefebvre
<b>Alsh 1</b>	2.6 Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty. Chair: Karianne De Bruin and Thordis Thorarinsdottir	6.15 Tackling the challenge of adaptation, lessons learned in the Netherlands. Chair: Stéphanie Ijff and Erin Hoogenboom	12.5 Using nature-based solutions to manage flood risk – challenges, tools and experience. Chair: Stéphanie Ijff
<b>Alsh 2</b>	6.14 Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland. Chair: Barry O'Dwyer	1.9 Learning from failures in communication: Sharing lessons from research and practice. Chair: Tanya Wilkins and Celeste Young	1.5 Providing a fit-for-purpose climate service for Europe: users' and purveyors' perspectives. Chair: Maria Noguer and Francesca Larosa
<b>Lomond</b>	7.3 Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development. Chair: Manuela Di Mauro	6.10 Horses for courses: adaptation pathways for different contexts. Chair: James Butler	

Room	Thur AM 1	Thur AM 2
<b>Carron 1</b>	1.4 Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment. Chair: Paul Buckley and Phil Williamson	1.6 Information needs for planning adaptation at national and local level. Chair: Roger Street
<b>Carron 2</b>	12.4 Adapting nature conservation strategies to climate change: how can science inform this process?. Chair: Jeff Price	2.10 Guidance for EU and national bodies in identifying options for innovative solutions to increase resilience. Chair: Mário Pulquério
<b>Leven</b>	1.8 Understanding, Analysing and Adapting to Climate Change Impacts on the Historic Environment. Chair: Mairi Davies, Ewan Hislop and Carsten Hermann	6.1 Tools for economic analysis of adaptation options. Chair: Marjolijn Haasnoot
<b>Morar + Ness</b>	7.1 Climate adaptation and sustainability. Part I: Approaches to integrate the SDGs into climate adaptation. Chair: Laszlo Pinter	7.2 Climate adaptation and sustainability. Part II: Knowledge management and learning examples from around the world. Chair: J. David Tàbara
<b>Dochart 1</b>	10.4 Adaptation of crop and livestock production to climate change and mitigation policies in a +1.5 K world. Chair: Martin Köchy	10.5 Adapting Scotland's natural capital: appraisal methods, research and policy priorities. Chair: Ragne Low
<b>Dochart 2</b>	5.6 Integrated research methods for co-creating adaptation solutions. Chair: Katharina Hölscher and Simona Pedde	6.2 Tools for inclusive and local adaptation options. Chair: Rob Swart
<b>Boisdale 1</b>	4.3 Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban. Chair: Robbert Biesbroek and Marta Olazabal and Elisa Sainz de Murieta	6.3 A tour of local adaptation in Europe. Chair: Ad Jeuken
<b>Boisdale 2</b>	6.4 Adaptation in practice: Case studies of flooding. Chair: Sally Brown	4.9 Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments. Chair: Marco Pütz
<b>Alsh 1</b>	9.1 Urban development toward sustainability and resilience: from mega-city to dwelling. Chair: Jill Jaeger	11.5 Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance. Chair: Peter Driessen and Dries Hegger
<b>Alsh 2</b>	5.8 Adapting to droughts and water scarcity: Supporting decision making, identifying solutions and delivering evidence to inform adaptation and mitigation. Chair: Len Shaffrey	12.3 The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas. Chair: Pam Berry and Nicolas Faivre
<b>Lomond</b>		9.2 Energy and Transport Infrastructure under Climate Change: Adaptation, Mitigation and Resilience. Chair: Olivier Dessens



## List of Sessions by Theme

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
<b>THEME 1. Evidence for Action: data, climate services &amp; communication</b>						
1.1	New knowledge and its communication	Timothy Carter	Tue PM2	Carron 1	Climate services	Communication, art and culture
1.2	Compiling adaptation-relevant data for climate services	Svetlana Jevrejeva	Tue PM1	Carron 1	Climate services	
1.3	The challenge of communicating high-end climate change	Tim Rayner	Tue PM1	Alsh 2	Communication, art and culture	
1.4	Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment	Paul Buckley & Phil Williamson	Thur AM1	Carron 1	Climate services	Coastal
1.5	Providing a fit-for-purpose climate service for Europe: users' and purveyors' perspectives	Maria Noguer & Francesca Larosa	Wed PM2	Alsh 2	Climate services	
1.6	Information needs for planning adaptation at national and local level	Roger Street	Thur AM2	Carron 1	Climate services	
1.7	Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change	Michalis Vousdoukas & Piero Lionello	Tue AM	Carron 1	Climate services	Coastal
1.8	Understanding, Analysing and Adapting to Climate Change Impacts on the Historic Environment	Mairi Davies, Ewan Hislop & Carsten Hermann	Thur AM1	Leven	Climate services	
1.9	Learning from failures in communication: Sharing lessons from research and practice	Tanya Wilkins & Celeste Young	Wed PM1	Alsh 2	Communication, art and culture	
<b>THEME 2. Planning Ahead: delivering resilience in the face of climate uncertainty</b>						
2.1	Adaptation options for coastal areas	Mário Pulquério	Tue PM2	Boisdale 2	Coastal	
2.2	Data and information tools for adaptation planning	Christopher Reyer	Wed PM1	Carron 1	Climate services	
2.3	Making decisions with multiple stakeholders for long-term resilience	Calum Brown	Tue AM	Morar + Ness	Participation and co-production	
2.4	Community-based adaptation planning	Robert Dunford	Tue PM1	Morar + Ness	Participation and co-production	
2.5	Foresight in Climate Change Adaptation and Disaster Risk Reduction	Rob Swart & Markus Leitner	Tue AM	Alsh 2	DRR	
2.6	Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty	Karianne De Bruin & Martin Drews	Wed AM	Alsh 1	Participation and co-production	Communication, art and culture
2.7	Food security and supply chain resilience under a changing climate	Katy Richardson	Wed AM	Dochart 1	Agriculture & forestry	Economics and business

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
2.8	Increasing Resilience: Integrating climate change adaptation and disaster risk reduction in planning. European and national level policy approaches and practices	Sergio Castellari & Markus Leitner	Wed PM2	Carron 1	DRR	
2.9	Pathways to climate-ready infrastructure: progress and challenges	Erika Palin & Mike Keil	Wed PM1	Carron 2	Urban, energy & infrastructure	Pathways and transformation
2.10	Guidance for EU and national bodies in identifying options for innovative solutions to increase resilience	Mário Pulquério	Thur AM2	Carron 2	DRR	
<b>THEME 3. Business and Finance: mobilising investment in climate change adaptation and building low carbon, climate resilient economies</b>						
3.1	The economics of climate change	Andrea Roventini & Shouro Dasgupta	Wed AM	Leven	Economics and business	
3.2	Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector	Karianne De Bruin & Cosima Stahr	Wed PM1	Leven	Economics and business	Climate services
<b>Business Day Sessions: organised by Prospex</b>						
Plenary	The business case for climate readiness	Marc Gramberger	Tue AM	Forth	Economics and business	
Parallel sessions:	Business solutions for climate readiness:	Marc Gramberger			Economics and business	
1	1. Infrastructure and water		Tue PM1	Dochart 1	Economics and business	Urban, energy & infrastructure
2	2. Bio-economy		Tue PM1	Forth	Economics and business	Agriculture & forestry
3	3. Health		Tue PM1	Gala 1	Economics and business	Health
4	4. Risk management and consulting		Tue PM1	Gala 2	Economics and business	Climate services
Plenary	Opportunities for climate readiness: market demand & finance	Marc Gramberger	Tue PM2	Forth	Economics and business	
<b>Innovation Day: organised by Climate-KIC and Innovate UK</b>						
Innovation	The Glasgow Resilience Innovation Challenge	Tom Mitchell	Wed 10.30-12.00am	Exhibition Hall	Economics and business	
	Resilience Innovation Exchange 1: Innovative data tools and services to support climate resilience decision-making	Tom Mitchell	Wed 12-12.45pm	Exhibition Hall	Economics and business	
	Supporting Innovation for Climate Resilience	Tom Mitchell	Wed 1.00-2.00pm	Exhibition Hall	Economics and business	
	Resilience Innovation Exchange 2: Technologies and services for climate-resilient infrastructure	Tom Mitchell	Wed 2.00-3.00pm	Exhibition Hall	Economics and business	
	Resilience Innovation Exchange 3: Innovations for climate resilience in the context of sustainable land use	Tom Mitchell	Wed 3.00-4.00pm	Exhibition Hall	Economics and business	

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
	Final – Glasgow Resilience Innovation Challenge	Tom Mitchell	Wed 4.00-5.30pm	Exhibition Hall	Economics and business	
	Innovation Day Reception, Hosted by Climate-KIC and Innovate UK	Tom Mitchell	Wed 5.45-7.00pm	Exhibition Hall	Economics and business	
<b>THEME 4. Making it Happen: organisations, policy, governance, justice &amp; ethics</b>						
4.1	A better understanding of adaptation governance	Robbert Biesbroek	Tue AM	Boisdale 1	Governance	
4.2	Emerging priorities and sensitive topics in adaptation	Marco Grasso	Wed PM1	Morar + Ness	Climate justice	
4.3	Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban	Robbert Biesbroek, Marta Olazabal and Elisa Sainz de Murieta	Thur AM1	Boisdale 1	Monitoring and evaluation	Governance
4.4	Making change happen: Learning from practical climate projects working across communities, governance, and policy	Katherine Knox & Ioan Fazey	Tue AM	Alsh 1	Climate justice	Governance
4.5	Social justice in urban adaptation and transformation under climate change: what does this look like in practice?	Eric Chu & Thomas Thaler	Tue PM1	Alsh 1	Climate justice	
4.6	Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges	Sebastian Seebauer & Thomas Thaler	Tue PM2	Morar + Ness	Climate justice	Flooding
4.7	Institutional economics of climate change adaptation	Alexander Bisaro	Wed PM2	Leven	Economics and business	Governance
4.8	Local adaptation pathway design in practice. Gaining flexibility and managing uncertainty in the long-term climate resilience planning	Maddalen Mendizabal, Efren Feliu & Kristen Guida	Tue PM1	Carron 2	Pathways and transformation	
4.9	Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments	Marco Pütz	Thur AM2	Boisdale 2	Governance	Monitoring and evaluation
4.10	Living with coastal change: risk, resilience, adaptation and working with nature	Larissa Naylor & Jim Densham	Tue PM1	Boisdale 2	Coastal	Ecosystem services and NBS
4.11	Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities	Kit England & Sophie Turner	Tue PM2	Alsh 1	Participation and co-production	Urban, energy & infrastructure
<b>THEME 5: Working Together: co-production of knowledge between science, business, policy, practice and local communities</b>						
5.1	Co-production as a means of climate change governance	Tim Rayner	Wed AM	Morar + Ness	Participation and co-production	Governance
5.2	Novel methodologies & tools for knowledge co-production	Kirsty Lewis	Tue PM2	Dochart 2	Communication, art and culture	Participation and co-production
5.3	Learning from co-production of adaptation practice and climate services	Saskia Werners	Wed PM1	Dochart 1	Participation and co-production	Climate services
5.4	Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU	André Jol & Kati Mattern	Tue PM2	Alsh 2	Participation and co-production	Climate services

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
5.5	Participatory modelling in climate change adaptation – methods and experiences	Sadie McEvoy	Wed PM2	Carron 2	Participation and co-production	
5.6	Integrated research methods for co-creating adaptation solutions	Katharina Hölscher & Simona Pedde	Thur AM1	Dochart 2	Participation and co-production	
5.7	Constituting Local Knowledge of Natural Disasters in Climate Adaptation	Lisa Van Well	Tue PM2	Carron 2	DRR	Participation and co-production
5.8	Adapting to droughts and water scarcity: Supporting decision making, identifying solutions and delivering evidence to inform adaptation and mitigation	Len Shaffrey	Thur AM1	Alsh 2	Drought	
5.9	US NOAA Sea Grant Program Facilitates Coastal Adaptation Planning Efforts	Libby Carnahan	Tue AM	Boisdale 2	Coastal	
5.11	Exploring urban adaptation practice: a focus on co-production and multi-level governance	Jeremy Carter & Filip Lefebvre	Wed PM2	Boisdale 2	Participation and co-production	Governance
<b>THEME 6. Adaptation in Practice: case studies, monitoring, support tools and guidance</b>						
6.1	Tools for economic analysis of adaptation options	Marjolijn Haasnoot	Thur AM2	Leven	Economics and business	
6.2	Tools for inclusive and local adaptation options	Rob Swart	Thur AM2	Dochart 2	Participation and co-production	
6.3	A tour of local adaptation in Europe	Ad Jeuken	Thur AM2	Boisdale 1	Monitoring and evaluation	Flooding
6.4	Adaptation in practice: Case studies of flooding	Sally Brown	Thur AM1	Boisdale 2	Flooding	
6.5	How climate services can enable successful urban adaptation	Kit England	Wed AM	Carron 1	Climate services	Urban, energy & infrastructure
6.6	Inclusive and local adaptation studies	Simona Pedde	Wed PM1	Dochart 2	Participation and co-production	
6.7	Adaptation cultures: knowledge, values and practices	Melanie Boeckmann and Thorsten Heimann	Wed AM	Dochart 2	Communication, art and culture	
6.8	Adaptation in action: case studies from the water and sewerage sectors	Mike Keil	Wed AM	Boisdale 1	Flooding	Ecosystem services and NBS
6.9	Fostering dialogue and learning on monitoring and evaluation of climate change adaptation and disaster risk reduction policies	Eleni Karali	Tue PM1	Boisdale 1	Monitoring and evaluation	DRR
6.10	Horses for courses: adaptation pathways for different contexts	James Butler	Wed PM1	Lomond	Pathways and transformation	
6.11	Evaluating participatory social change processes for adaptation	James Butler	Wed PM2	Morar + Ness	Participation and co-production	
6.12	Objectives and guidelines in urban design to adapt to the risks of urban heat	Mendel Giezen & Lisette Klok	Tue PM1	Leven	Urban, energy & infrastructure	Health
6.13	Monitoring and evaluating adaptation in practice: learning from (sub) national examples from Europe and beyond	Timo Leiter & Mike Harley	Tue PM2	Boisdale 1	Monitoring and evaluation	

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
6.14	Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland	Barry O'Dwyer	Wed AM	Alsh 2	Participation and co-production	Governance
6.15	Tackling the challenge of adaptation, lessons learned in the Netherlands	Stéphanie Ijff & Erin Hoogenboom	Wed PM1	Alsh 1	Ecosystem services and NBS	Flooding
<b>THEME 7: Global Challenges: climate adaptation and the UN Sustainable Development Goals</b>						
7.1	Climate adaptation and sustainability. Part I: Approaches to integrate the SDGs into climate adaptation	Laszlo Pinter	Thur AM1	Morar + Ness	Climate justice	
7.2	Climate adaptation and sustainability. Part II: Knowledge management and learning examples from around the world	J. David Tàbara	Thur AM2	Morar + Ness	Climate justice	
7.3	Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development	Manuela Di Mauro	Wed AM	Lomond	Governance	Climate justice
<b>THEME 8. Whole System Sustainable Solutions: acting across multiple sectors and scales</b>						
8.1	Adaptation, Mitigation and Transformation: The high-end context, synergies and trade-offs	Diogo de Gusmão-Sørensen	Wed AM	Carron 2	Pathways and transformation	
8.2	Dealing with the complexity of multiple sectors, scales, stakeholders, risks and benefits	Henrik Carlsen	Wed PM1	Boisdale 1	Governance	
8.3	Cross-boundary implementation of climate adaptation plans in Central Denmark Region	Rolf Johnsen	Wed PM2	Boisdale 1	Governance	
<b>THEME 9. Urban, Energy &amp; Infrastructure</b>						
9.1	Urban development toward sustainability and resilience: from mega-city to dwelling	Jill Jaeger	Thur AM1	Alsh 1	Urban, energy & infrastructure	
9.2	Energy and Transport Infrastructure under Climate Change: Adaptation, Mitigation and Resilience	Olivier Dessens	Thur AM2	Lomond	Urban, energy & infrastructure	
<b>THEME 10. Agriculture, Fisheries &amp; Forestry</b>						
10.1	Projections of climate change vulnerability in the agriculture and forestry sectors - decision support to guide adaptation strategies	Marcus Lindner	Tue AM	Dochart 1	Agriculture & forestry	
10.2	Understanding adaptation practices in agriculture and fisheries	Stefan Fronzek	Tue PM2	Dochart 1	Agriculture & forestry	
10.3	Climate change adaptation in agriculture, agroforestry, and fisheries – from knowledge to policy instruments and concrete solutions	Ana Iglesias	Wed PM2	Dochart 1	Agriculture & forestry	
10.4	Adaptation of crop and livestock production to climate change and mitigation policies in a +1.5 K world	Martin Köchy	Thur AM1	Dochart 1	Agriculture & forestry	
10.5	Adapting Scotland's natural capital: appraisal methods, research and policy priorities	Ragne Low	Thur AM2	Dochart 1	Agriculture & forestry	

Number	Session name	Chair	Time	Room	Topic 1	Topic 2
<b>THEME 11. Flooding &amp; Water Scarcity</b>						
11.1	Adapting to floods in coastal areas	Agustin Sanchez-Arcilla	Wed AM	Boisdale 2	Coastal	Urban, energy & infrastructure
11.2	Tools for understanding the economic impacts of floods and droughts	Florian Gallo	Tue AM	Dochart 2	Flooding	Drought
11.3	Strategies for managing flood risk and water quality	Tom Spencer	Tue PM1	Dochart 2	Flooding	
11.5	Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance	Peter Driessen & Dries Hegger	Thur AM2	Alsh 1	Flooding	Governance
11.6	Managing rainfall to control flooding and improve water quality	James Murray	Wed PM2	Dochart 2	Flooding	Urban, energy & infrastructure
<b>THEME 12. Biodiversity, Ecosystem Services &amp; Nature-based Solutions</b>						
12.1	Ecosystem service provision, biodiversity and ecosystem function under a changing climate	John Haslett	Tue AM	Carron 2	Ecosystem services and NBS	
12.2	Adaptation in Coastal and Marine Ecosystems	Paulo Scussolini	Wed PM1	Boisdale 2	Coastal	Ecosystem services and NBS
12.3	The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas	Pam Berry and Nicolas Faivre	Thur AM2	Alsh 2	Ecosystem services and NBS	Urban, energy & infrastructure
12.4	Adapting nature conservation strategies to climate change: how can science inform this process?	Jeff Price	Thur AM1	Carron 2	Ecosystem services and NBS	
12.5	Using nature-based solutions to manage flood risk – challenges, tools and experience	Stéphanie IJff	Wed PM2	Alsh 1	Ecosystem services and NBS	Flooding
<b>THEME 15. Health &amp; Wellbeing</b>						
13.1	Progress on adaptation in national health systems	Vladimir Kendrovski	Tue AM	Leven	Health	
13.2	Implications for policy and planning of the impacts of climate change on health and wellbeing	Sari Kovats	Tue PM2	Leven	Health	

## Sessions by Topic

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
<b>Agriculture &amp; forestry</b>						
Agriculture & forestry		10.1	Projections of climate change vulnerability in the agriculture and forestry sectors - decision support to guide adaptation strategies	Marcus Lindner	Tue AM	Dochart 1
Agriculture & forestry		10.2	Understanding adaptation practices in agriculture and fisheries	Stefan Fronzek	Tue PM2	Dochart 1
Agriculture & forestry	Economics and business	2.7	Food security and supply chain resilience under a changing climate	Katy Richardson	Wed AM	Dochart 1
Agriculture & forestry		10.3	Climate change adaptation in agriculture, agroforestry, and fisheries – from knowledge to policy instruments and concrete solutions	Ana Iglesias	Wed PM2	Dochart 1
Agriculture & forestry		10.4	Adaptation of crop and livestock production to climate change and mitigation policies in a +1.5 K world	Martin Köchy	Thur AM1	Dochart 1
Agriculture & forestry		10.5	Adapting Scotland's natural capital: appraisal methods, research and policy priorities	Ragne Low	Thur AM2	Dochart 1
Economics and business	Agriculture & forestry	<b>Business Day</b>	Business solutions for climate readiness: Bio-economy	Marc Gramberger	Tue PM1	Forth
<b>Climate services</b>						
Climate services	Coastal	1.7	Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change	Michalis Vousdoukas & Piero Lionello	Tue AM	Carron 1
Climate services		1.2	Compiling adaptation-relevant data for climate services	Svetlana Jevrejeva	Tue PM1	Carron 1
Climate services	Communication, art and culture	1.1	New knowledge and its communication	Timothy Carter	Tue PM2	Carron 1
Climate services	Urban, energy & infrastructure	6.5	How climate services can enable successful urban adaptation	Kit England	Wed AM	Carron 1
Climate services		2.2	Data and information tools for adaptation planning	Christopher Reyer	Wed PM1	Carron 1
Climate services		1.5	Providing a fit-for-purpose climate service for Europe: users' and purveyors' perspectives	Maria Noguer & Francesca Larosa	Wed PM2	Alsh 2
Climate services		1.8	Understanding, Analysing and Adapting to Climate Change Impacts on the Historic Environment	Mairi Davies, Ewan Hislop & Carsten Hermann	Thur AM1	Leven
Climate services	Coastal	1.4	Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment	Paul Buckley & Phil Williamson	Thur AM1	Carron 1

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Climate services		1.6	Information needs for planning adaptation at national and local level	Roger Street	Thur AM2	Carron 1
Economics and business	Climate services	3.2	Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector	Karianne De Bruin & Cosima Stahr	Wed PM1	Leven
Economics and business	Climate services	Business Day	Business solutions for climate readiness: Risk management and consulting	Marc Gramberger	Tue PM2	Forth
Participation and co-production	Climate services	5.4	Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU	André Jol & Kati Mattern	Tue PM2	Alsh 2
Participation and co-production	Climate services	5.3	Learning from co-production of adaptation practice and climate services	Saskia Werners	Wed PM1	Dochart 1
<b>Communication, art and culture</b>						
Communication, art and culture		1.3	The challenge of communicating high-end climate change	Tim Rayner	Tue PM1	Alsh 2
Communication, art and culture	Participation and co-production	5.2	Novel methodologies & tools for knowledge co-production	Kirsty Lewis	Tue PM2	Dochart 2
Communication, art and culture		6.7	Adaptation cultures: knowledge, values and practices	Melanie Boeckmann and Thorsten Heimann	Wed AM	Dochart 2
Communication, art and culture		1.9	Learning from failures in communication: Sharing lessons from research and practice	Tanya Wilkins & Celeste Young	Wed PM1	Alsh 2
Climate services	Communication, art and culture	1.1	New knowledge and its communication	Timothy Carter	Tue PM2	Carron 1
Participation and co-production	Communication, art and culture	2.6	Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty	Karianne De Bruin & Martin Drews	Wed AM	Alsh 1
<b>Climate justice</b>						
Climate justice	Governance	4.4	Making change happen: Learning from practical climate projects working across communities, governance, and policy	Katharine Knox & Ioan Fazey	Tue AM	Alsh 1
Climate justice		4.5	Social justice in urban adaptation and transformation under climate change: what does this look like in practice?	Eric Chu & Thomas Thaler	Tue PM1	Alsh 1
Climate justice	Flooding	4.6	Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges	Sebastian Seebauer & Thomas Thaler	Tue PM2	Morar + Ness



Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Climate justice		4.2	Emerging priorities and sensitive topics in adaptation	Marco Grasso	Wed PM1	Morar + Ness
Climate justice		7.1	Climate adaptation and sustainability. Part I: Approaches to integrate the SDGs into climate adaptation	Laszlo Pinter	Thur AM1	Morar + Ness
Climate justice		7.2	Climate adaptation and sustainability. Part II: Knowledge management and learning examples from around the world	J. David Tàbara	Thur AM2	Morar + Ness
Governance	Climate justice	7.3	Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development	Manuela Di Mauro	Wed AM	Lomond
<b>Coastal</b>						
Coastal		5.9	US NOAA Sea Grant Program Facilitates Coastal Adaptation Planning Efforts	Libby Carnahan	Tue AM	Boisdale 2
Coastal	Ecosystem services and NBS	4.10	Living with coastal change: risk, resilience, adaptation and working with nature	Larissa Naylor & Jim Densham	Tue PM1	Boisdale 2
Coastal		2.1	Adaptation options for coastal areas	Mário Pulquério	Tue PM2	Boisdale 2
Coastal	Flooding	11.1	Adapting to floods in coastal areas	Agustin Sanchez-Arcilla	Wed AM	Boisdale 2
Coastal	Ecosystem services and NBS	12.2	Adaptation in Coastal and Marine Ecosystems	Paulo Scussolini	Wed PM1	Boisdale 2
Climate services	Coastal	1.7	Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change	Michalis Vousdoukas & Piero Lionello	Tue AM	Carron 1
Climate services	Coastal	1.4	Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment	Paul Buckley & Phil Williamson	Thur AM1	Carron 1
<b>Drought and water scarcity</b>						
Drought		5.8	Adapting to droughts and water scarcity: Supporting decision making, identifying solutions and delivering evidence to inform adaptation and mitigation	Len Shaffrey	Thur AM1	Alsh 2
Flooding	Drought	11.2	Tools for understanding the economic impacts of floods and droughts	Florian Gallo	Tue AM	Dochart 2
<b>Disaster Risk Reduction (DRR)</b>						
DRR		2.5	Foresight in Climate Change Adaptation and Disaster Risk Reduction	Rob Swart & Markus Leitner	Tue AM	Alsh 2
DRR	Participation and co-production	5.7	Constituting Local Knowledge of Natural Disasters in Climate Adaptation	Lisa Van Well	Tue PM2	Carron 2

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
DRR		2.8	Increasing Resilience: Integrating climate change adaptation and disaster risk reduction in planning. European and national level policy approaches and practices	Sergio Castellari & Markus Leitner	Wed PM2	Carron 1
DRR		2.10	Guidance for EU and national bodies in identifying options for innovative solutions to increase resilience	Mário Pulquério	Thur AM2	Carron 2
Monitoring and evaluation	DRR	6.9	Fostering dialogue and learning on monitoring and evaluation of climate change adaptation and disaster risk reduction policies	Eleni Karali and Patrick Pringle	Tue PM1	Boisdale 1
<b>Economics and business</b>						
Economics and business		3.1	The economics of climate change	Andrea Roventini & Shouro Dasgupta	Wed AM	Leven
Economics and business	Climate services	3.2	Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector	Karianne De Bruin & Cosima Stahr	Wed PM1	Leven
Economics and business	Governance	4.7	Institutional economics of climate change adaptation	Alexander Bisaro	Wed PM2	Leven
Economics and business		6.1	Tools for economic analysis of adaptation options	Marjolijn Haasnoot	Thur AM2	Leven
Agriculture & forestry	Economics and business	2.7	Food security and supply chain resilience under a changing climate	Katy Richardson	Wed AM	Dochart 1
Economics and business		<b>Business Day</b>	Plenary: The Business Case for Climate Readiness	Marc Gramberger	Tue AM	Forth
Economics and business	Urban, energy & infrastructure	<b>Business Day</b>	Business solutions for climate readiness: Infrastructure and water	Marc Gramberger	Tue PM1	Dochart 1
Economics and business	Agriculture & forestry	<b>Business Day</b>	Business solutions for climate readiness: Bio-economy	Marc Gramberger	Tue PM1	Forth
Economics and business	Health	<b>Business Day</b>	Business solutions for climate readiness: Health	Marc Gramberger	Tue PM1	Forth
Economics and business	Climate services	<b>Business Day</b>	Business solutions for climate readiness: Risk management and consulting	Marc Gramberger	Tue PM1	Forth
Economics and business		<b>Business Day</b>	Opportunities for climate readiness: market demand & finance	Marc Gramberger	Tue PM2	Forth
Economics and business		<b>Innovation Day</b>	The Glasgow Innovation Resilience Challenge: from 10.30 to 5.30 in the Exhibition Hall	Tom Mitchell	Wed AM-PM2	Exhibition Hall

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
<b>Ecosystem services and NBS</b>						
Ecosystem services and NBS		<b>12.1</b>	Ecosystem service provision, biodiversity and ecosystem function under a changing climate	John Haslett	Tue AM	Carron 2
Ecosystem services and NBS	<b>Flooding</b>	<b>6.15</b>	Tackling the challenge of adaptation, lessons learned in the Netherlands	Stéphanie Ijff & Erin Hoogenboom	Wed PM1	Alsh 1
Ecosystem services and NBS	<b>Flooding</b>	<b>12.5</b>	Using nature-based solutions to manage flood risk – challenges, tools and experience	Stéphanie Ijff	Wed PM2	Alsh 1
Ecosystem services and NBS		<b>12.4</b>	Adapting nature conservation strategies to climate change: how can science inform this process?	Jeff Price	Thur AM1	Carron 2
Ecosystem services and NBS	<b>Urban, energy &amp; infrastructure</b>	<b>12.3</b>	The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas	Pam Berry and Nicolas Faivre	Thur AM2	Alsh 2
<b>Coastal</b>	Ecosystem services and NBS	<b>4.10</b>	Living with coastal change: risk, resilience, adaptation and working with nature	Larissa Naylor & Jim Densham	Tue PM1	Boisdale 2
<b>Flooding</b>	Ecosystem services and NBS	<b>6.8</b>	Adaptation in action: case studies from the water and sewerage sectors	Mike Keil	Wed AM	Boisdale 1
<b>Coastal</b>	Ecosystem services and NBS	<b>12.2</b>	Adaptation in Coastal and Marine Ecosystems	Paulo Scussolini	Wed PM1	Boisdale 2
<b>Flooding</b>						
<b>Flooding</b>	<b>Drought</b>	<b>11.2</b>	Tools for understanding the economic impacts of floods and droughts	Florian Gallo	Tue AM	Dochart 2
<b>Flooding</b>		<b>11.3</b>	Strategies for managing flood risk and water quality	Tom Spencer	Tue PM1	Dochart 2
<b>Flooding</b>	Ecosystem services and NBS	<b>6.8</b>	Adaptation in action: case studies from the water and sewerage sectors	Mike Keil	Wed AM	Boisdale 1
<b>Flooding</b>		<b>6.4</b>	Adaptation in practice: Case studies of flooding	Sally Brown	Wed PM2	Lomond
<b>Flooding</b>	<b>Urban, energy &amp; infrastructure</b>	<b>11.6</b>	Managing rainfall to control flooding and improve water quality	James Murray	Wed PM2	Dochart 2
<b>Flooding</b>	<b>Governance</b>	<b>11.5</b>	Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance	Peter Driessen & Dries Hegger	Thur AM2	Alsh 1
<b>Coastal</b>	<b>Flooding</b>	<b>11.1</b>	Adapting to floods in coastal areas	Agustin Sanchez-Arcilla	Wed AM	Boisdale 2

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Climate justice	Flooding	4.6	Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges	Sebastian Seebauer & Thomas Thaler	Tue PM2	Morar + Ness
Ecosystem services and NBS	Flooding	6.15	Tackling the challenge of adaptation, lessons learned in the Netherlands	Stéphanie Ijff & Erin Hoogenboom	Wed PM1	Alsh 1
Ecosystem services and NBS	Flooding	12.5	Using nature-based solutions to manage flood risk – challenges, tools and experience.	Stéphanie Ijff	Wed PM2	Alsh 1
Monitoring and evaluation	Flooding	6.3	A tour of local adaptation in Europe	Ad Jeuken	Thur AM2	Boisdale 1
<b>Governance</b>						
Governance		4.1	A better understanding of adaptation governance	Robbert Biesbroek	Tue AM	Boisdale 1
Governance	Climate justice	7.3	Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development	Manuela Di Mauro	Wed AM	Lomond
Governance		8.2	Dealing with the complexity of multiple sectors, scales, stakeholders, risks and benefits	Henrik Carlsen	Wed PM1	Boisdale 1
Governance		8.3	Katharine Knox	Rolf Johnsen	Wed PM2	Boisdale 1
Governance	Monitoring and evaluation	4.9	Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments	Marco Pütz	Thur AM1	Boisdale 1
Governance	Monitoring and evaluation	4.3	Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban	Robbert Biesbroek & Marta Olazabal and Elisa Sainz de Murieta	Thur AM2	Boisdale 2
Climate justice	Governance	4.4	Making change happen: Learning from practical climate projects working across communities, governance, and policy	Katharine Knox & Ioan Fazey	Tue AM	Alsh 1
Participation and co-production	Governance	5.1	Co-production as a means of climate change governance	Tim Rayner	Wed AM	Morar + Ness
Participation and co-production	Governance	6.14	Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland	Barry O'Dwyer	Wed AM	Alsh 2
Economics and business	Governance	4.7	Institutional economics of climate change adaptation	Alexander Bisaro	Wed PM2	Leven
Participation and co-production	Governance	5.11	Exploring urban adaptation practice: a focus on co-production and multi-level governance	Jeremy Carter & Filip Lefebvre	Wed PM2	Boisdale 2

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Flooding	Governance	11.5	Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance	Peter Driessen & Dries Hegger	Thur AM2	Alsh 1
<b>Health</b>						
Health		13.1	Progress on adaptation in national health systems	Vladimir Kendrovski	Tue AM	Leven
Health		13.2	Implications for policy and planning of the impacts of climate change on health and wellbeing	Sari Kovats	Tue PM2	Leven
Urban, energy & infrastructure	Health	6.12	Objectives and guidelines in urban design to adapt to the risks of urban heat	Mendel Giezen & Lisette Klok	Tue PM1	Leven
Economics and business	Health	Business Day	Business solutions for climate readiness: Health	Marc Gramberger	Tue PM1	Forth
<b>Monitoring and evaluation</b>						
Monitoring and evaluation	DRR	6.9	Fostering dialogue and learning on monitoring and evaluation of climate change adaptation and disaster risk reduction policies	Eleni Karali	Tue PM1	Boisdale 1
Monitoring and evaluation		6.13	Monitoring and evaluating adaptation in practice: learning from (sub) national examples from Europe and beyond	Timo Leiter & Mike Harley	Tue PM2	Boisdale 1
Monitoring and evaluation	Flooding	6.3	A tour of local adaptation in Europe	Ad Jeuken	Thur AM2	Boisdale 1
Governance	Monitoring and evaluation	4.9	Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments	Marco Pütz	Thur AM1	Boisdale 1
Governance	Monitoring and evaluation	4.3	Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban	Robbert Biesbroek & Marta Olazabal and Elisa Sainz de Murieta	Thur AM2	Boisdale 2
<b>Participation and co-production</b>						
Participation and co-production		2.3	Making decisions with multiple stakeholders for long-term resilience	Calum Brown	Tue AM	Morar + Ness
Participation and co-production		2.4	Community-based adaptation planning	Robert Dunford	Tue PM1	Morar + Ness
Participation and co-production	Climate services	5.4	Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU	André Jol & Kati Mattern	Tue PM2	Alsh 2
Participation and co-production	Urban, energy & infrastructure	4.11	Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities	Kit England & Sophie Turner	Tue PM2	Alsh 1

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Participation and co-production	Communication, art and culture	2.6	Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty	Karianne De Bruin & Martin Drews	Wed AM	Alsh 1
Participation and co-production	Governance	5.1	Co-production as a means of climate change governance	Tim Rayner	Wed AM	Morar + Ness
Participation and co-production	Governance	6.14	Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland	Barry O'Dwyer	Wed AM	Alsh 2
Participation and co-production		6.6	Inclusive and local adaptation studies	Simona Pedde	Wed PM1	Dochart 2
Participation and co-production	Climate services	5.3	Learning from co-production of adaptation practice and climate services	Saskia Werners	Wed PM1	Dochart 1
Participation and co-production		5.5	Participatory modelling in climate change adaptation – methods and experiences	Sadie McEvoy	Wed PM2	Carron 2
Participation and co-production		6.11	Evaluating participatory social change processes for adaptation	James Butler	Wed PM2	Morar + Ness
Participation and co-production	Governance	5.11	Exploring urban adaptation practice: a focus on co-production and multi-level governance	Jeremy Carter & Filip Lefebvre	Wed PM2	Boisdale 2
Participation and co-production		5.6	Integrated research methods for co-creating adaptation solutions	Katharina Hölscher & Simona Pedde	Thur AM1	Dochart 2
Participation and co-production		6.2	Tools for inclusive and local adaptation options	Rob Swart	Thur AM2	Dochart 2
Communication, art and culture	Participation and co-production	5.2	Novel methodologies & tools for knowledge co-production	Kirsty Lewis	Tue PM2	Dochart 2
DRR	Participation and co-production	5.7	Constituting Local Knowledge of Natural Disasters in Climate Adaptation	Lisa Van Well	Tue PM2	Carron 2
<b>Pathways and transformation</b>						
Pathways and transformation		4.8	Local adaptation pathway design in practice. Gaining flexibility and managing uncertainty in the long-term climate resilience planning	Maddalen Mendizabal, Efren Feliu & Kristen Guida	Tue PM1	Carron 2

Topic 1	Topic 2	Number	Session name	Chairs	Time	Room
Pathways and transformation		8.1	Adaptation, Mitigation and Transformation: The high-end context, synergies and trade-offs	Diogo de Gusmão-Sørensen	Wed AM	Carron 2
Pathways and transformation		6.10	Horses for courses: adaptation pathways for different contexts	James Butler	Thur AM1	Boisdale 2
Urban, energy & infrastructure	Pathways and transformation	2.9	Pathways to climate-ready infrastructure: progress and challenges	Erika Palin & Mike Keil	Wed PM1	Carron 2
<b>Urban, energy &amp; infrastructure</b>						
Urban, energy & infrastructure		9.1	Urban development toward sustainability and resilience: from mega-city to dwelling	Jill Jaeger	Thur AM1	Alsh 1
Urban, energy & infrastructure		9.2	Energy and Transport Infrastructure under Climate Change: Adaptation, Mitigation and Resilience	Olivier Dessens	Thur AM2	Lomond
Urban, energy & infrastructure	Health	6.12	Objectives and guidelines in urban design to adapt to the risks of urban heat	Mendel Giezen & Lisette Klok	Tue PM1	Leven
Urban, energy & infrastructure	Pathways and transformation	2.9	Pathways to climate-ready infrastructure: progress and challenges	Erika Palin & Mike Keil	Wed PM1	Carron 2
Participation and co-production	Urban, energy & infrastructure	4.11	Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities	Kit England & Sophie Turner	Tue PM2	Alsh 1
Climate services	Urban, energy & infrastructure	6.5	How climate services can enable successful urban adaptation	Kit England	Wed AM	Carron 1
Flooding	Urban, energy & infrastructure	11.6	Managing rainfall to control flooding and improve water quality	James Murray	Wed PM2	Dochart 2
Ecosystem services and NBS	Urban, energy & infrastructure	12.3	The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas	Pam Berry and Nicolas Faivre	Thur AM2	Alsh 2
Economics and business	Urban, energy & infrastructure	<b>Business Day</b>	Business solutions for climate readiness: Infrastructure and water	Marc Gramberger	Tue PM1	Dochart 1

### 1.7 Rising seas and changing marine storminess: evidences from model projections and assessments of coastal hazards and risks in view of climate change

*Michalis Vousdoukas, Joint European Research Center and Piero Lionello, Disteba*

#### Climate services

#### Coastal

1. Projections of coastal impacts along Europe's coasts in view of climate change (Michalis Vousdoukas, European Commission, Joint Research Centre)
  2. Evaluation of marine flooding impacts along the coast of Emilia-Romagna (Italy): new methods and comparison with user-driven assessments (Enrico Duo, Università Di Ferrara)
  3. Use of a Bayesian Network for the evaluation of Disaster Risk Reduction (DRR) alternatives for overwash and erosion hazards (Theocharis Plomaritis, University of Algarve)
  4. Storm impacts and barrier recovery on southern North Sea coasts (Susan Brooks, Birkbeck, University Of London)
  5. Assessing the effectiveness of DRR measures to reduce coastal impacts: results from the RISC-KIT project (Ap van Dongeren, Deltares)
  6. Future sea-level rise along the European Atlantic Coastline in a 5°C world (Svetlana Jevrejeva, National Oceanography Centre, Liverpool)
  7. Climate change scenarios for the North Sea storm surge and wave extremes (Lidia Gaslikova, Helmholtz-Zentrum Geesthacht)
  8. Multi-hazard estimate for future climate conditions along the Mediterranean coastline (Piero Lionello, Disteba)
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**Keywords:** Sea level rise; waves; storm surges; coastal hazard; coastal impact assessment; coastal protection; climate projections

Climate change adaptation and disaster risk reduction have been recognized as a priority worldwide, exemplified by global frameworks such as the Paris Agreement and the Sendai Framework for Disaster Risk Reduction, and European actions like the EU Climate Change Adaptation Strategy and the Floods Directive. It has been highlighted that reliable risk assessments are essential to take effective mitigation and adaptation actions.

Coastal impacts in view of climate change emerge from the complex direct and indirect interactions between several natural and anthropogenic factors. Coastal flooding is driven by extreme sea levels, being the result of several components, namely the Mean Sea Level (MSL), astronomical tide and episodic water level fluctuations due to climate extremes (waves and storm surges). Rising seas alone are an alarming phenomenon, but future coastal hazards will also depend on the shape of the coast; constantly changing from natural, and anthropic factors. Socio-economic development is another key element for future coastal impacts; there are several possible scenarios on how our societies will evolve in the decades to come, and in particular on whether investment at nearshore areas will continue, considering or not coastal flooding risks.

This session includes the presentation of a large set of model simulations describing the different physical factors (sea level rise, waves, storm surge) responsible for risks posed by climate change at the coastal zone, describing



long-term statistics, concentrating especially on extremes. It further, deals with several open challenges related to projecting coastal risk: linking the changing weather with extreme sea conditions and coastal erosion/inundation hazard; developing impact assessment methodologies from local to continental scales; assessing uncertainty in coastal impact projections; presenting and evaluating adaptation and risk mitigation strategies.

A set of contributions to this session are based on the results of the EU-FP7 project RISES-AM

### **Significance to adaptation practice, policy and/or business**

This session is interdisciplinary covering concepts at the interface between oceanography, meteorology, coastal engineering, coastal management and impact assessment; and has extensions to disaster risk reduction and climate change adaptation. This session shows the information (and its uncertainty) that is available to coastal managers and policymakers for deciding adaptation measures to contrast the impacts of climate change on the coasts. The analysis of the future evolution of waves, storm surges and sea level is described, with a focus on extreme values. It is therefore informative on different hazards and on different geographical areas. It also deals with a societal problem of widespread importance, since there is consensus that societies in Europe and worldwide will have to deal with even more frequent coastal hazards in the years to come. Assessing the anticipated risks is a matter of urgency, as it is essential to design and implement efficient and socially fair adaptation and mitigation measures.

### **1. Projections of coastal impacts along Europe's coasts in view of climate change**

Michalis Voudoukas, European Commission

This contribution aims to present preliminary results from efforts towards (i) the development of the integrated risk assessment tool LISCoAsT for Europe (Large scale Integrated Sea-level and Coastal Assessment Tool); (ii) the assessment of coastal risk along the European coastline in view of climate change; and (iii) the development and application of a robust methodology to evaluate adaptation options for the European coastline under climate change scenarios. Comprehensive projections of Extreme Sea Levels (ESL), that include mean sea level (MSL), tides, waves and storm surges, have been generated until 2100 in view of climate change, using dynamic simulations forced by GCM ensembles. We find that by the end of this century the 100-year event ESL along Europe's coastlines will on average increase by 57 cm for RCP4.5 and 81 cm for RCP8.5. The North Sea region will face the highest increase in ESLs, amounting to nearly 1 m under RCP8.5 by 2100, followed by the Baltic Sea and Atlantic coasts of the UK and Ireland. Relative Sea Level Rise (RSLR) is the main driver of the projected rise in ESL, with increasing dominance towards the end of the century and for the high-concentration pathway. Changes in storm surges and waves enhance the effects of RSLR along the majority of northern European coasts, locally with contributions up to 40%. In southern Europe, episodic extreme events tend to stay stable, except along the Portuguese coast and the Gulf of Cadiz where reductions in surge and wave extremes offset RSLR by 20-30%. By the end of this century, 5 million Europeans currently under threat of a 100-year ESL could be annually at risk from coastal flooding. The intensifying ESLs are also expressed in the projections of the expected annual damage (EAD) from coastal flooding, projected to increase up to 11 and 14 billion €/year by 2050 under RCP 4.5 and 8.5, respectively, and to 29 and 57 billion €/year by 2100 under RCP 4.5 and 8.5 (from a baseline value of 3.06 million €/year).

### **2. Evaluation of marine flooding impacts along the coast of Emilia-Romagna (Italy): new methods and comparison with user-driven assessments**

Enrico Duo, Università Di Ferrara

The Comacchio municipality, located in the northern part of the Emilia-Romagna region, northern Italy, is exposed to the impact of marine storms that can cause large inundations. The case study is represented by the coastal villages of Lido degli Estensi and Spina (Ferrara province) that are located in a low-lying area. The Adriatic Sea is generally low energetic, but significant storms can occur. The coast is highly urbanized and exploited for tourism,

therefore the exposure of different receptors is high. The presentation will focus on new tools developed in a recent EU-FP7 project specifically designed to provide end-users charged with managing flood protection and resilience. The tools include an impact-based database of marine storms, a series of numerical tools and an impact assessment tool. The tools could be used to increase resilience for the local communities as well as provide an example exportable to other European areas. The regional authorities have implemented a methodology to identify the extension of flood-prone areas in the framework of the EU flood directive. The regional maps, implemented with a simplified GIS-based methodology, are compared to the maps developed within the RISC-KIT project ([www.risckit.eu](http://www.risckit.eu)) in order to identify similarities and dissimilarities in terms of prediction of flooding extension. The RISC-KIT maps were produced with a modelling chain that includes XBeach (1D) and LISFLOOD-FP models. The impact to several identified receptors (households, structures and infrastructures) was assessed through the INDRA model and compared to the risk maps issued by the regional authorities.

### **3. Use of a Bayesian Network for the evaluation of Disaster Risk Reduction (DRR) alternatives for overwash and erosion hazards**

Theocharis Plomaritis, Oscar Ferreira, Susana Costas, University of the Algarve, CIMA, Faro, Portugal.

Coastal communities are threatened by the impact of severe storms that may cause significant loss or damage of property and life. The main processes behind such impacts are the combined action of overwash and erosion that specifically affect sandy coastlines and the coastal communities that reside close to them. Predicted coastal response under present and climate change conditions has been frequently based in the use of numerical models. Furthermore, the effectively evaluate Disaster Risk Reduction (DRR) measures can also be addressed with the same tool. However, detailed morphodynamic models are computationally expensive and not commonly used by coastal managers. The present work is proposing the construction of the probabilistic Bayesian Network (BN) as a surrogate for the numerical simulation. This BN is trained with a large number of morphodynamic simulations, under a variety of storm conditions and DRR measures that can serve as a front-end platform for visualising, analysing and evaluating combined results of the numerical model.

Such a system was built for a coastal sector of the Ria Formosa barrier island system (South Portugal), within the framework of the EU project Risc-Kit (Resilience-Increasing Strategies for Coasts - toolKIT). The BN received wave height, water level and wave period data as boundary conditions and it translates them in overwash and erosion hazard and impact for 4 sub-zones of the study area. The hazard receptors investigated were houses and infrastructures and the DRR measures evaluated were: beach replenishment and house removal. Results show that for a storm with wave characteristics of 50 years return period and spring tidal conditions; the removal of first line of houses from the beach reduces the overwash and erosion impact by 75%. Beach replenishment, for the same event, reduces the erosion impact by 80% while it has a smaller effect on the overwash impact. The combined effect of the above DRR is nearly reduces the impact to the study area to zero.

### **4. Storm impacts and shoreline recovery on southern North Sea coastline**

Sue Brooks, University of London

Storm impacts play a significant role in shoreline dynamics on barrier coastlines. Furthermore, post-storm recovery potential is a key parameter determining long-term coastal resilience to climate change, storminess variability and sea level rise. Over the last decade, four extreme storms, with strong energetic waves and high still water levels resulting from high spring tides and large skew surge residuals, have impacted the shoreline of the southern North Sea. The 5 December 2013 storm surge, with the highest runup levels recorded in the last 60 years, resulted in large sections of the frontline of the macro-tidal North Norfolk coast being translated inland by over 10 m. Storms in March and November 2007 also generated barrier scarping and shoreline retreat, although not on the scale of 2013. Between 2008 and 2013, recovery of the barrier position and elevation was spatially

differentiated alongshore. For the barrier island of Scolt Head Island, no recovery was seen and this section of the coast is being reset episodically landwards. By contrast, the study area at Holkham Bay showed considerable recovery between 2008 and 2013, in some sections developing seaward as well as showing foredune recovery. The third study area, Brancaster Bay, showed intermediate behaviour compared with the other two study areas, with partial recovery in barrier location and elevation. Data on cross-shore transects supports the hypothesis that the primary controls on the extent of recovery (or non-recovery) reside in high sediment supply and onshore intertidal bar migration, at rates of 40 m a<sup>-1</sup>, across low-gradient shorefaces. These processes bring sand to elevations where drying opportunity can enable subsequent aeolian processes to entrain and transport sand to foredunes. Tidal frame interaction with changing intertidal bar elevation and prevailing meteorological parameters determines the temporal and spatial variability in supply-limited and transport-limited conditions and, thus, whether or not foredunes can re-establish. Further research is needed to elucidate the conditions under which foredune growth is established, allowing barrier recovery, and inform future management planning against sea level rise and storminess variation.

## **5. Assessing the effectiveness of DRR measures to reduce coastal impacts: results from the RISC-KIT project**

Ap van Dongeren, Coordinator, RISC-KIT, Deltares, Delft, The Netherlands

High-impact storm events have demonstrated the vulnerability of coastal zones in Europe and beyond. These impacts are likely to increase due to predicted climate change and ongoing coastal development. In order to reduce impacts, disaster risk reduction (DRR) measures need to be taken, which prevent or mitigate the effects of storm events. To drive the DRR agenda, the UNISDR formulated the Sendai Framework for Action, and the EU has issued the Floods Directive. However, neither is specific about the methods to be used to develop actionable DRR measures in the coastal zone. Therefore, there is a need to develop methods, tools and approaches which make it possible to identify and prioritize the coastal zones which are most at risk and assess the effectiveness of locally-appropriate DRR options for these coastal areas. The latter is the subject of this paper.

This paper will discuss the use of a Bayesian Network (BN) which has been used to evaluate the effectiveness of DRR measures in stakeholder meetings. This BN connects three elements: offshore hydraulic boundary conditions, characteristics of the coastal zone, and onshore impacts such as erosion, flooding extent and depth, and damages. The data on which the BN relies is produced by a large number of process-based model simulations which use as input the extreme event statistics of offshore wave and water levels, bathymetry and topography of the coastal zone, land use and receptor information, as well as the nature and location of DRR measures. The measures can include physical measures such as nature-based flood defences and sea walls, as well as flood-proofing of houses and even non-qualitative measures such as raising flood-awareness and education. In this way the impacts for a range of extreme events can be visualized in a webviewer, including the reduction effect of DRR measures. This forms the basis for discussion with end-users and stakeholders on preferred and effective measures.

In the project this method has been developed and tested in ten case study areas in Europe. The results have been discussed in dedicated end-user and stakeholder meetings. The paper will discuss the method development, application and lessons learnt.

## **6. Future sea-level rise along the European Atlantic Coastline in a 5°C world**

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Significant amounts of infra-structure and people lie along the European Atlantic coasts, thus any future sea-level rise is likely to have major cost implications through erosion, flooding and storm surges. Whilst a global scientific,

and now political, consensus exists that a 2°C warming of global air temperature is a threshold beyond which climate change risks significantly increase, it is important to assess the possible impact of sea-level rise in a world where warming increases markedly.

We present projections of future sea-level change for a High-end scenario that has a future warming of 5°C by 2100. By 2040, this scenario shows a 2°C warming for which global sea-level is projected to rise by 20 cm. Since the pattern of sea-level rise varies geographically most European Atlantic coastlines will exceed the global value, with up to 40 cm in Norway. By 2100, global sea level will have likely risen to 90 cm though a low probability exists of a 180 cm rise. The coastal communities and infrastructure of European cities will have limited time to adapt after mid-century, because of the increasing rate of sea-level rise.

## **7. Climate change scenarios for the North Sea storm surge and wave extremes.**

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Storm surges and extreme sea states represent a major threat in the North Sea coastal areas. In case of anthropogenic climate change, storms and storm-related extreme sea levels may enhance coastal risks and may endanger marine industry. Long-term statistics, especially behaviour of extremes, is relevant for numerous applications including coastal protection, adaptation, management and various off-shore activities. Unlike the projections for the CO<sub>2</sub> concentrations or global mean sea level rise, where the confidence in general increasing tendency is quite high, the future evolvement of regional storm climatology associated with climate change is rather ambiguous; it is not gradual and continuous in time, can imply positive as well as negative changes and is strongly region dependent. Moreover, large uncertainty between model realizations is superimposed on the uncertainties due to scenarios of future development. We demonstrate this problematic and try to discover commonalities and assess uncertainties using several transient hydrodynamic and wave projections for the North Sea based on various scenarios from IPCC AR4 and AR5. We analysed the storm surge and wave climatology in terms of statistics of extremes, return values and trends for the 21st century with respect to present-day conditions. Along with statistical analysis of extremes, characteristics of single storm events are also assessed. Additionally, changes in driving wind characteristics as a key factor for the surge and wave development and extremes were also investigated. Projections for a possible future climate display strong multi-decadal fluctuations in frequency and intensity of extreme events. Moreover, the results are rather location specific and towards 2100 some projections show intensification of storm activity in the German Bight and different rates of decrease along the British North Sea coast. It will be shown that these tendencies may change, however, when sea level rise additionally comes into consideration.

## **8. Multi-hazard estimate for future climate conditions along the Mediterranean coastline**

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This contribution shows the information on the different hazards posed by marine storminess on coastal areas that model projections can provide. It is, in fact, important to make available integrated estimates of the different factors (wind waves, storm surges, mean sea level variations) impacting the coastal areas, of how they will evolve in climate change scenarios, and, subsequently to combine these estimates with that on vulnerability and exposure of the coastal areas. Though the hazard level posed by marine storms along the Mediterranean coastline may appear smaller than that in many other areas of the world, the limited tradition in coastal defences in this region may determine comparatively higher risks in the presence of a significant climate change signal. This contribution summarizes results based on ensembles of CMIP5 (RCP4.5 and RCP8.5 emission scenarios) and CMIP3 (SRES A1B emission scenario). Wind, waves and storm surge models have been used to simulate future

conditions covering the full period 1950-2100 and corresponding estimates of sea level have been considered. The analysis shows a remarkable consensus on future decrease of marine storm intensity, which would reduce the hazard intensity, but it is contrasted by the future projected increase of mean sea level. The latter will very likely be the dominant factor. Therefore, climate change should be expected to increase future hazards in terms of extreme water levels reaching a higher value with respect to the present condition.

## 12.1 Ecosystem service provision, biodiversity and ecosystem function under a changing climate

*John Haslett, Division of Animal Structure and Function, University of Salzburg, Austria*

### Ecosystem services and NBS

1. Holistic European Ecosystem Service Futures: exploring the potential of hybrid integrated assessment and matrix-based approaches (Robert Dunford, University of Oxford/ Centre for Ecology & Hydrology)
  2. Ecosystem based adaptation and mitigation in developing countries: lessons learnt from coastlands, forests and farmscapes (Will Simonson, UNEP World Conservation Monitoring Centre)
  3. Plants for water: impacts of climate change on plants linked to water provisioning in the highlands of the Tropical Andes (Mauricio Diazgranados, Royal Botanic Gardens, Kew)
  4. Glorious Mud – the need for a new coastal adaptation blueprint which includes nature-based solutions (Jim Densham, RSPB Scotland)
  5. Melting revenues in Quebec’s alpine skiing industry: can economics help to tackle the climate change challenge? (Laurent Da Silva, Ouranos Inc.)
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**Keywords:** cross-sectoral; developing and developed countries; ecosystem service provision; flooding; modelling; parks and gardens; urban; water quality.

The long term, sustainable supply of ecosystem services that are provided by present biodiversity and intact, functioning ecosystems underpins many aspects of human well-being throughout the world. Climate change can impact upon the delivery of ecosystem services in a multitude of different ways, influencing entire social-ecological systems at local to global scales. This session illustrates how the continued provision of ecosystem services must be considered as an essential aspect of environmental and socio-economic policy in climate change adaptation and mitigation. The examples addressed by the papers in this session encompass the modelling of combined socio-economic and climate scenarios in Europe; the problems of negative impacts of climate change in developing countries (parts of Africa, South-East Asia and Central and South America) where the livelihoods of the inhabitants often depend directly on ecosystem services from functioning ecosystems; water provisioning services from plant biodiversity above the timberline at the top of the tropical Andes and the implications for all those living lower down; ecosystem services provided by an urban park in Tokyo, with particular emphasis on flood regulation and run-off from extreme rainfall events; the ecosystem services provided by domestic gardens as part of the green infrastructure of the urban environment of Manchester, England. Taken together, the papers of this session should underline the importance of incorporating biodiversity and ecosystem services into climate change adaptation and mitigation strategies.

### Significance to adaptation practice, policy and/or business

This session reports on research that illustrates the importance of ecosystem services to human well-being and how such services may continue to be delivered sustainably under conditions of climate change. A variety of approaches is covered, from modelling climate and socio-economic scenarios to practical examples using projects and case studies over a wide range of geographical scales. The examples presented are relevant to governments, non-governmental organisations, business and civil society and may apply to many situations in both the developing and developed world.

## **1. Holistic European Ecosystem Service Futures: exploring the potential of hybrid integrated assessment and matrix-based approaches.**

Robert Dunford, University of Oxford/ Centre for Ecology & Hydrology

Policy and decision makers are increasingly recognizing the importance of the role played by biodiversity and ecosystem services in underpinning human wellbeing. However, within the sectors managing land use and the environment, each individual sector, be it agriculture, forestry, urban growth, water supply has its own demands: many of which conflict. This conflict will only be exacerbated with climate change and as societies modify themselves to attempt to adapt to these changes. Ultimately, these combined climatic and socio-economic changes will significantly influence the availability and quality of habitats, species and the ecosystem services biodiversity provides in ways that cannot be understood without taking an integrated approach.

Integrated assessment modelling provides a mechanism by which the impacts of combined climate and socio-economic change can be assessed across a range of linked environmental and land use sectors. However, to date, integrated assessment models only address a limited number of Ecosystem Services, many of which are directly derived from land use parameters. Conversely, matrix-based approaches (e.g. Burkhard et al., 2012) use expert-based matrices to link land use classes to expected levels of supply or demand for a broad range of ecosystem services and underlying biophysical properties. Here we address the clear policy need for better information on the future of Europe's ecosystem services by presenting the results of a hybrid between integrated modelling and land use matrix approaches that allows future changes in the full range of ecosystem services to be calculated for a range of possible European futures.

To do this the CLIMSAVE integrated assessment platform is used to model combined socio-economic and climatic scenarios. The model takes cross sectoral interactions into consideration and quantifies environmental parameters. These spatially explicit, model-driven, quantifications of land use extent (e.g. forest cover, agricultural area) and additional modelled details (e.g. irrigation usage, NPP, crop type) are combined with expert-based, land-use-linked values to extend the range of ES considered to cover a wide range of provisioning, regulating and cultural services. This allows a fuller picture of a holistic suite of ecosystem service indicators to be produced for integrated, cross-sectoral futures. The results for range of futures are presented, with low- and high-end climate change combined with utopian and dystopian socio-economics. The presentation assesses the range of potential future ecosystem service provision. It highlights trade-offs that occur between ES bundles and stresses the importance of socio-economic change and adaptation even under worse-case scenarios. It makes clear the importance of considering cross-sectoral implications across sectors and between regions when managing individual sectors to preserve future ecosystem service delivery.

## **2. Ecosystem based adaptation and mitigation in developing countries: lessons learnt from coastlands, forests and farmscapes.**

Will Simonson, UNEP World Conservation Monitoring Centre

The livelihoods of many people in developing countries directly depend on intact, functioning ecosystems, whether mangroves and coral reefs providing nursery areas for fisheries, forests providing fuelwood, timber and non-timber forest products, or agro-ecosystems supporting the production of food for local consumption and export. These same communities are often those that are being most adversely affected by climate change, including through the negative impacts of climate-related hazards on the ecosystems that underpin their well-being and economic activity.

For this reason, the conservation and restoration of ecosystems needs to be central to adaptation strategies in developing countries, and mainstreamed into sectoral and development plans and policies. Actions to protect ecosystems can also have significant climate change mitigation benefits, through the additional carbon sequestered and stored in soils and biomass. UNEP-WCMC is active in developing approaches, tools and capacity

for ecosystem-based mitigation and adaptation in Africa, South-East Asia, and Central and South America, from community-level activities to national adaptation strategies. Three areas of experience have been: spatial planning for the delivery of mitigation, adaptation and multiple other benefits from REDD+ activities under the UN-REDD program; integrating coastal ecosystem-based adaptation into the national policies and plans of Small Island Developing States; and planning for the achievement of joint adaptation and mitigation objectives in the agricultural sector. The presentation will focus on lessons learned from these projects with regard to approaches for identifying and planning ecosystem-based solutions. We highlight in particular the importance of: systematic consideration of the dependencies of communities on ecosystem functions and services, and the impacts of climate change on these relationships; robust planning for EbA involving communities in data-poor situations; and ownership of the adaptation process by beneficiaries from the outset, including involvement in monitoring and evaluation, for ensuring long-lasting success.

### **3. Plants for water: impacts of climate change on plants linked to water provisioning in the highlands of the Tropical Andes.**

Mauricio Diazgranados, Royal Botanic Gardens, Kew

Climate change impacts on biodiversity are widespread and are likely to be as dramatic in the high elevations as in the high latitudes. From an ecological perspective, the projected effects are multidimensional and have been studied for individual species as well as for interacting species in simplified communities, but rarely for ecosystem services. Approximately 20–30% of all species are likely to be at increased risk of extinction with a rise in global average temperature of 1.5–2.5 C, and widespread extinctions are predicted for the upcoming decades. Plants are paramount ecosystem services providers, and the impact of climate change on them can cause declines or changes on our natural capital assets. What would be the consequence for the water provisioning if plants related to this ecosystem service face changes in population size, distribution, or even extinction? Some plants, for instance, can act as living sponges, preserving the water in their tissues and slowly releasing it during the dry seasons. Therefore, reduced populations or habitat changes can alter the water availability in different ways. Because of its sensitivity to climate change, its incredibly high diversity and endemism, and its long history of human presence, the Tropical Andes are considered a global Biodiversity Hotspot, and an excellent model system to study the impacts of climate change. The ecosystems located above the timberline on top of the Tropical Andes, i.e. the paramos, yungas and punas, play a key role in provisioning water for millions of inhabitants. A few integral studies have been carried out to estimate the impacts of climate change on the water provisioning service of these ecosystems, based on detailed climate models. But none of them have included modelling the impacts on the dominant plants related to water provisioning. This project is studying the impacts of climate change on the future distributions of species associated to water provisioning in the highlands of the Tropical Andes. Niche models with various GCMs based on an A1B scenario for 2080 show that climate change is threatening 31–51% of the species of frailejones (Espeletiinae), dominant plants of the paramo ecosystem in the northern Andes. Predictions suggest considerable changes in their total biomass and capacity for regulating water. Analyses for other dominant groups of plants are under way, as a first step to generate robust hypotheses about the potential impacts of climate change in these ecosystems.

### **4. Glorious Mud – the need for a new coastal adaptation blueprint which includes nature-based solutions.**

Jim Densham, RSPB Scotland

Scotland's wet, muddy coastal habitats are being lost as sea levels rise. Saltmarsh and other intertidal habitats have been lost in the past because of land claim for development and agriculture, and the remaining fragments are being squeezed further against hard sea defences. Saltmarsh is a vital wildlife habitat but is also effective at dissipating the power of waves and tides, buffering the communities against sea level rise and storms.

Not all the soft coasts can or should be defended by traditional methods of coastal defence, such as concrete or high embankments. Saltmarsh and intertidal habitats can play an important role in Natural Flood Management



(NFM) but need space and other land uses to change. Furthermore, saltmarsh habitat needs time to develop and become effective. A plan is needed to create new saltmarsh habitats further inland through managed coastal realignment to provide this nature-based adaptation solution.

With the soft coast in the front line of climate impacts we must ensure that it is ready for the future. A National Coastal Change Assessment for Scotland shows how our coasts have changed in the past and will change into the future, even without accelerated rates of sea level rise. In Scotland there is no long-term national plan for climate-proofing the coasts. The proposed Climate Change Bill for Scotland provides an opportunity to establish the legislation needed to sustainably adapt our coasts for future conditions and the next iteration of Scotland's Climate Change Adaptation Programme is a key Government policy in which to formalize an action plan.

RSPB Scotland has highlighted 4135ha of coastal land in 4 main areas of Scotland which have the potential for managed realignment now (RSPB, 2016). However, there are few policies in place to make realignment happen. Flood Risk Management Plans and Scotland's Rural Development Programme are limited in the support they provide to coastal NFM.

It is time that a holistic and comprehensive approach to active coastal adaptation is developed with coastal NFM and nature-based solutions as a key part of the toolkit. The RSPB has highlighted the need for a new blueprint for the coasts and recommends 10 actions to make this happen.

RSPB, 2016. GLORIOUS MUD – homes for nature, protection for people. [http://www.rspb.org.uk/Images/glorious-mud\\_tcm9-415616.pdf](http://www.rspb.org.uk/Images/glorious-mud_tcm9-415616.pdf)

## **5. Melting revenues in Quebec's alpine skiing industry: can economics help to tackle the climate change challenge?**

Laurent Da Silva, Ouranos Inc

The alpine skiing industry in Quebec (Canada) generates more than \$ 800 million in economic activity every year and employs more than 12 000 full-time equivalent across a number of regions in the province. Many ski resorts contribute to the regional economic activity by massively attracting visitors coming to enjoy a broad range of activities offered at the mountain all year round.

Until the 60s, Quebec ski resorts relied exclusively on natural snow. Over time, the industry has modernized and set up efficient snowmaking systems to ensure a season lasting more than 100 days. Nevertheless, ski resorts are affected by interannual climatic variability that affects both the operating conditions and skier visits. The unpredictability and variability of climate affects decision-making mechanisms, clientele and revenues. Adverse weather conditions during peak periods, such as the Christmas holidays and the Spring Break, can result in a significant reduction in skier visits that in turn decreases revenues and raises operating costs, having a major impact on the profit margin of resorts and their capacity to invest. Last winter's experience revealed the vulnerability of the industry to climate. An extraordinary warm winter led to a drop of more than 30 % skier visits in some of the ski regions of the province. Considering the anticipated climate evolution in the next decades, it is clear that climate change is a serious threat to ski resorts and the profitability of the activities they support at the organizational level, as well as at the regional level.

This presentation will highlight the results of an applied research project built to evaluate the impacts of climate change on the alpine skiing activities at two scale of analysis. First, based on a case study approach, the project assessed the financial impacts of climate change on alpine skiing activities for three ski resorts, as well as the profitability of different adaptation measures available to ski resorts in a changing climate. Second, a regional cross-sectoral economic impact analysis estimated the effect of changes in the projected skier visits under different climate change scenarios on different socioeconomic parameters. These two levels of analysis helped to

highlight the opportunities and threats for the alpine skiing sector and provide decision making tools for the ski resorts and the regional and provincial actors to adapt the industry to climate change.

## 13.1 Progress on adaptation in national health systems

*Vladimir Kendrovski, World Health Organization*

### Health

1. Heat waves in Finland – how to prepare for a health risk not fully recognized (Reija Ruuhela, Finnish Meteorological Institute)
  2. Adaptation to flooding in the UK health system: a case study (Owen Landeg, Public Health England)
  3. How can we monitor climate resilience in the UK health and social care system? (Sari Kovats, LSHTM)
  4. Health aspects in national and local climate change adaptation plans in Mediterranean climate regions (Maya Negev, University of Haifa)
  5. Multi-level governance of public health adaptation to climate change in federal contexts (Stephanie Austin, McGill University)
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This session will examine how health systems are responding to climate change with case studies from countries in Europe and the US. Extreme weather and other effects of climate change are known to effect population health and also the delivery of health and social care services. Many countries have adaptation plans but there has been a variable response within the national and local health sectors. Adaptation is also a complex process due to the multiple agencies that are involved in delivering health and social care. The session will also address how adaptation within health systems can be monitored.

### Significance to adaptation practice, policy and/or business

The resilience of health and social care systems to extreme weather events (hospitals, clinics, pharmacies, etc.) has direct relevance for national and regional health service providers and commissioners, and also those involved in commissioning social care.

#### 1. Heat waves in Finland – how to prepare for a health risk not fully recognized

Reija Ruuhela, Finnish Meteorological Institute

Heat waves in Finland pose a real risk to health even though this is not yet widely recognized by decision-makers or laypersons. The temperature dependence of mortality in Finland clearly shows an increase in relative mortality during heat waves, especially among the elderly (75 years and older). Based on mortality data of different age groups from national hospital districts over four decades (1972-2014), we found a decreasing trend in relative mortality during heat waves, suggesting that sensitivity of Finnish population to heat waves has decreased over time in all age groups. The heat wave with the most severe excess mortality during the study period took place in 1972, while several other notable events occurred during subsequent decades. However, discussion on how to prevent heat-related mortality and to prepare for an increasing number of hot days and heat waves under a changing climate is still quite limited in Finland. The Finnish Meteorological Institute (FMI) started to issue heat wave warnings in 2011, but no proper heat-health-warning-system (HHWS) to trigger preventive actions in health care institutions has been launched, to date. Nevertheless, practical experience points to a real need for a HHWS. Studies of the 2003 and 2010 heat waves in Finland show that the increase in mortality is especially high in health care facilities, and those especially at risk are people with cardiovascular and respiratory diseases, mental disorders or nervous system diseases. Finland is a sparsely populated country, and distances to health centres can be long, especially in northern Finland, which enhances the risk to vulnerable groups during heat waves.

In our presentation, we will discuss the differences in heat-related mortality in different parts of the country. We will also demonstrate the U-C-IAV vulnerability tool in the national portal Climateguide.fi, which can help to identify regional vulnerabilities of elderly people to climate hazards based, for example, on the size of the elderly population or their access to health care.

Feedback received on the FMI heat wave warnings has been mixed. Some has been negative, stating that people want to enjoy the warm weather, whilst people belonging to the risk groups have been grateful for the service. Issuing warnings has provided an opportunity to increase awareness about this under-estimated health risk and as such it may help in preventing some heat-related mortality. In the presentation, we will also report on feedback concerning the vulnerability tool in Climate guide.

## **2. Adaptation to flooding in the UK health system: a case study**

Owen Landeg, Public Health England

Flooding is the highest impact/likelihood natural risk identified in the UK Government's National Risk Register. Health and social care services are disrupted and infrastructure damaged by floods, but there is very limited scientific evidence on the extent of these impacts or the effectiveness of emergency planning and response. This is a key evidence gap identified in the UK's second Climate Change Risk Assessment. Major coastal flooding occurred in Lincolnshire in December 2013 affecting health and social care facilities and service delivery.

Face-to-face (n=7) and telephone (n=11) semi-structured interviews were conducted in June-July 2016 with frontline professionals and strategic decision makers in Lincolnshire. This included flooded health infrastructure and those services disrupted. The data was thematically analysed, using Nvivo 10. Three key themes emerged:

### Preparedness

A high level of preparedness was reported amongst strategic decision makers; most participants stated their organization received flood alerts directly, with an adequate warning time.

In contrast, some frontline services had not been registered for direct flood alerts and the consequences of the flood were worse than expected. Furthermore, participants reported a lack of public knowledge of the actions to take following flood warnings, despite a public Coastal Communication Campaign.

### Vulnerability

Different organisational approaches hindered compilation of a comprehensive list of vulnerable people; many were identified after the event. Vulnerability to flooding was described as complex and determined by factors beyond event magnitude, e.g. health/social circumstances and behavioural choices.

Bariatric and community palliative care patients were considered vulnerable, alongside other more recognized groups (e.g. children). Risk communication and public messaging was reportedly hindered by language barriers among migrant workers and those with English as a second language.

### Service Disruption

Health services required relocation, elective surgery was cancelled, travel was disrupted, staff and patient access proved difficult. Winter service pressures compounded difficulties and mutual aid arrangements across the health sector were required.

Medical staff and equipment were relocated to support rest centres, wherein evacuees arrived without their regular medication; stress related conditions were also reported. Sourcing medication and tracking patients was reportedly difficult.

This study provides an insight into the experiences, views, and reflections of strategic decision makers and frontline professionals involved in flood planning, response and recovery. The findings improve understanding of the damage and disruption to healthcare infrastructure, services and delivery during and after flood events. The lessons learned highlight the opportunities and challenges associated with effective flood resilience and adaptation within the healthcare sector.

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### **3. How can we monitor climate resilience in the UK health and social care system?**

Sari Kovats, LSHTM

The National Adaptation Programme makes specific reference to climate resilience in the health and social care system with stated objectives to 'promote climate resilience within the NHS, public health and social care system to ensure continuity of services and resilient assets/estates including the ability to deal with the increased demand for services associated with severe weather events'.

Health and social care systems in England and the devolved administrations are complex networks, with multiple local actors, and a range of differing responsibilities. Many parts of the health system are at risk from severe weather with evidence relating to the impacts of coldspells, flooding, snow storms, and heatwaves. A range of different partners are involved in preparation and response to severe weather in order to ensure continuity and accessibility of health and social care services, and adequate response to changes in the need for health services in the population.

It is extremely difficult to assess the current capacity of health and social care system to manage climate risks. An evidence review was undertaken for the UK Second Climate Change Risk Assessment. Floods and storms have a significant effect on health system infrastructure and service delivery through effects on staff, buildings and equipment. Heatwaves affect the functionality of hospitals and care homes. Health services will be vulnerable to an increase in the frequency and intensity of heatwaves. Care homes are at risk of overheating, and care management practices may not sufficiently address heat risks. Flood risks to NHS and social care assets are likely to increase under climate change. Future projections indicate an increase in the number of GP surgeries, care homes, emergency service stations and hospitals in the flood risk zone, with the largest change in risk generally shown for care homes. England and Wales show bigger increases in risk than Scotland and Northern Ireland. Cold spells and snow storms interrupt travel for patients and staff. Fewer cold events in future will benefit health system management. In England, there is evidence of gaps in planning. Overall capacity is also likely decrease due to increased fragmentation of services which increases the complexity of risk management.

### **4. Health aspects in national and local climate change adaptation plans in Mediterranean climate regions**

Maya Negev, University of Haifa

The Mediterranean region and other areas with Mediterranean climate type are vulnerable to climatic changes. A warming trend exists with an increase in warm days and nights, longer and warmer summers, an increase in the frequency and the severity of heat waves and a reduction in rainfall amounts. Worldwide, cities with Mediterranean-climate type are particularly susceptible to health risks from climate change since they are located in biogeographical hot-spots that experience some of the strongest effects of the changing climate. Nations and cities worldwide are starting to adapt for climate change, including preparedness of health systems and adaptation of urban planning and infrastructure. We present two studies that examined how Mediterranean Countries and cities with Mediterranean climate adapt to climate change.

The first study analyzed national adaptation to the threat of vector-borne diseases (VBD), expected to increase in the Mediterranean region due to climate change since the ecology, development, behavior, and survival of insects and the transmission dynamics of the diseases they transmit are strongly influenced by climatic factors. For some

disease emergence in the Mediterranean basin (i.e. West Nile virus) the linkage with climate change was proven recently; for others (such as dengue) the risk for local transmission is real. Nine representative Mediterranean countries were analyzed for adaptation to this threat. It was found that all have started to prepare, but the preparation levels differ greatly and are often limited and basic. Policy mechanisms at the regional level are limited, and often depend on international organizations.

The second study examined local climate adaptation plans in five cities with Mediterranean climate: Adelaide, Barcelona, Cape Town, Los Angeles and Santiago. Each plan was analyzed according to how it addresses climate change-related drivers of health impacts among city dwellers. For each driver, the policy tools that address it in the urban adaptation plans were identified. Most of the fundamental climate change-related drivers of health were found in the surveyed cities, including rising temperatures, floods and drought, but the policy measures to reduce negative impacts vary across cities.

While public health systems worldwide are starting to be prepared for climate change impacts, the integrated results of the current studies show that currently adaptation is not a priority. Furthermore, gaps in preparedness levels exist across countries and cities, and across different health risks. Many countries and cities in climate-sensitive areas do not have an adaptation plan. When adaptation plans exist, they vary greatly in scope and quality.

## **5. Multi-level governance of public health adaptation to climate change in federal contexts**

Stephanie Austin, McGill University

Climate change is the greatest threat to public health globally this century (Costello et al., 2009). Current and projected direct impacts of climate change on health include increasing magnitude and frequency of extreme weather events, declining air quality, and increasing incidence, prevalence and range of infectious diseases (Séguin, 2008; Smith et al., 2014; Warren & Lemmen, 2014). Adaptation will be necessary to protect public health from these impacts. Adaptation is commonly assumed to be necessarily a local issue (Corfee-Morlot et al., 2011; Measham et al., 2011). This paradigm is increasingly being questioned, in particular considering that local governments have the least capacity to adapt compared to other levels of government (Baker et al., 2012; Nalau et al., 2015). Multi-level governance arrangements may be used to make local-level adaptation more effective, although to date national adaptation policies have often been disconnected from the local-level (Amundsen et al., 2010; Corfee-Morlot et al., 2011; Nalau et al., 2015).

The overarching aim of this research is to examine how upper-level governments could contribute to enabling and supporting the health adaptation landscape. To fulfil this aim, we pose the following two research questions: (1) How is health adaptation enacted in federal systems? (2) How do upper-level governments influence local-level health adaptation?

This research is based on qualitative semi-structured interviews with key informants from national, regional and local public health officials and municipal governments through nested case studies in Canada, Germany and the United States.

We find that the roles and responsibilities for public health adaptation have not been formalized across all three countries. Upper-level support for local-level public health adaptation is varied between the three case studies, and include formalized funding and capacity building initiative (United States), regulated mandatory consideration of climate change in local public health planning (Canada), and ad-hoc training and information provision (Germany). In the sampled Canadian and German regions, formalized top-down support for climate change adaptation is primarily channelled through the environment sector to municipal governments, while local health authorities sometimes lack access to such support. Policy capacity for climate change adaptation among local health authorities is overall relatively low, and faces competing prioritization with other public health issues.

These findings suggest that public health requires greater leadership for adaptation to ensure populations' health is protected from the health impacts of climate change

## 2.3 Making decisions with multiple stakeholders for long-term resilience

Calum Brown, University of Edinburgh

### Participation and co-production

1. Robust decision making principles and current decision making practices for adapting to climate change: results from five case studies (Annika Carlsson Kanyama, KTH)
  2. Seizing the Moment - Unplanned Resilience Planning (Camille Manning-Broome, Center for Planning Excellence)
  3. Designing, building and operating a railway to stand the test of time: The HS2 approach to climate change resilience (Christopher Harris, High Speed Two (HS2) Ltd)
  4. Exploring potential impacts of climate change upon international shipping and strategies for maintaining the resilience of supply chains (Sarah Mander, Tyndall Centre, University Of Manchester)
  5. Socio-economic risk mapping for informed decision-making (Jonathan Leonardsen, Rambøll)
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**Keywords:** Robust decision making, infrastructure, long-term planning, resilience

Achieving resilience to climate change is a complex problem that spans many sectors. As a result, a variety of different approaches have been adopted, often in an *ad hoc* manner. This has generated a diversity of useful methods, but also of understandings and practices, limiting the scope for building upon past experience and obscuring the shared nature of many major challenges. These shared challenges include decision-making under uncertainty, and the necessity of gathering the views of multiple stakeholders, utilising their knowledge and balancing their preferences.

This session explores current practice and future prospects in ensuring long-term resilience in climate change adaptation and infrastructure planning. Case studies are used to explore successful and unsuccessful handling of tensions between competing objectives, risks associated with uncertain climate impacts, and stakeholder involvement. Together, these case studies are intended to build towards an improved understanding of complementary methods for achieving resilience.

### Significance to adaptation practice, policy and/or business

This session deals specifically with challenges of adaptation planning and practice, and explores existing and potential solutions to these challenges. The case studies presented span a range of sectors and approaches, relevant to practice, policy and business. In particular, the session highlights examples of methods that have been successful in handling uncertainty and multiple-stakeholder requirements in resilience planning.

#### 1. Robust decision making principles and current decision making practices for adapting to climate change: results from five case studies

Annika Carlsson, Kanyama, KTH

Methods for making “robust decisions” have increasingly been proposed as a solution for improving planning in a world where climate outcomes are highly uncertain. While many methods have been proposed, three principles are central in this literature; I) embracing uncertainty (taking into account the full range of uncertainty including worst-case scenarios), II) using a bottom-up approach (starting with identifying vulnerabilities in the decision situation), and III) aiming for robust solutions (finding static or flexible solutions that are acceptable over the uncertain outcomes).

Using these three principles as a lens for analysis we examined recent decisions involving adaptation to future sea level rise and precipitation changes in five case studies in Sweden. For each case study, we interviewed key persons and analysed documents related to the decision-making processes. Our case studies were:



comprehensive plans in two coastal municipalities, the Swedish national final disposal of the spent nuclear fuel, a local plan in a municipality for new housing in a flood prone area and a railway tunnel in a flood prone and coastal area.

The results were that uncertainties in climate variables were often characterized by a single scenario or a likely range. In only one case we found an explicit aim to take into account the full range of uncertainty (by use of worst-case scenarios). The decisions generally depended on previously defined information about climate scenarios (often produced by national or regional authorities), and thus represented a top-down rather than bottom-up approach. Regarding the final solutions chosen we did not find an explicit aim to choose robust solutions, but there were examples of both static and flexible solutions. An example of a flexible approach was the recommendation of the lowest foundation level for new buildings that are to be adjusted over time according to recommendations from the regional authorities.

None of the studied cases used any specific methods for the purpose of robust decision making, which can explain why they did not adhere to the three principles. Also, climate change adaptation is a relatively new feature in the studied organizations and not as well integrated as mitigation planning. Possibilities and constraints for adopting robust decision making principles in practice will be further analysed.

## **2. Seizing the Moment - Unplanned Resilience Planning**

Camille Manning-Broome, Centre for Planning Excellence

Natural disasters in Louisiana, USA are typically associated with hurricane landfall and Mississippi River flooding. Both are events that residents and officials have at least a few days in which to prepare. In 2016, Louisiana experienced two rain events, described as 1,000-year storms, that impacted millions of residents and caused billions in damages. Neither were hurricanes or associated with the Mississippi River. Both caught the region by surprise. While advanced warning may have helped avoid loss of life, the storms revealed that much of Louisiana's infrastructure, building stock, and development practices are woefully inadequate to deal with the uncertain and more extreme future in a changing climate that predicts an increase in extreme drought and precipitation events. As recovery plans are being developed and recovery dollars are being allocated and doled out, CPEX is working to promote and support a resilient recovery throughout the impacted areas and beyond. Retrofitting the built environment takes many years of education, investment, and commitment. CPEX has begun this work by advocating resiliency efforts that leverage the recovery effort with long term planning needs. While structural elements such as culverts, sewers, and levees will always be part of the solution, the magnitude of these rain events highlights the reality that they will not be enough in the future and that there will be many necessary pieces to a resilient future in a climate change era. To support and promote more resilient design, CPEX also incorporates model policy and regulatory measures that municipalities can adopt to codify the long-term commitment to resilience. CPEX will present on its work to towards a systematic approach to a build environment that is compatible with the natural environment and incorporates yet unmeasured (in US) ecosystem services.

## **3. Designing, building and operating a railway to stand the test of time: The HS2 approach to climate change resilience**

Christopher Harris, High Speed Two (HS2) Ltd

HS2, the proposed new railway connecting London, the Midlands and the North, is being designed to be 'resilient for the long term and seek to minimise the combined effect of the project and climate change on the environment'. This represents an opportunity to design a transport megaproject with the impacts of climate change taken into account, therefore setting a new standard in what climate change-resilient infrastructure looks like.

HS2 is not being designed and built only to function upon opening in 2026, but to stand the test of time and perform to the standards we expect despite the impact of climate change far into the operational life-time of the

project. This means not only increasing the resistance of the initial design, but ensuring that the infrastructure is flexible and adaptable for changes in the future.

This presentation will outline how the key factors of climate change resilience (resistance, reliability, redundancy and response and recovery) are being put into practice in the design of HS2. Specifically, it will provide an overview of:

- The policy that underpins HS2 Ltd's approach to climate change resilience
- The strategy that is employed to embed resilience across design, construction and operation.
- How increased climate change resilience enables HS2 to provide additional benefits and meet its strategic objectives.
- Specific design features, including those relating to flood risk.
- Innovation projects relating to climate change resilience at HS2.
- Research undertaken in collaboration with academic institutions.
- Best practice in building the adaptive capacity of the organisation.

#### **4. Exploring potential impacts of climate change upon international shipping and strategies for maintaining the resilience of supply chains**

Sarah Mander, Tyndall Centre, -University Of Manchester

Most of the research that considers shipping in the context of climate change focuses on shipping as a source of greenhouse gas emissions and consequently on mitigating the emissions from the sector. The Shipping in Changing Climates project has not only focused on mitigation but, importantly, has investigated the many, complex ways in which climate change impacts may affect shipping.

Some impacts, such as changing sea storms, will have a direct impact on vessels at sea; shipping, however sits within a wider and more complex socio-technical system, therefore impacts will arise from the interactions between this wider shipping system and climate change. Conceptualising shipping as a socio-technical system highlights that the shipping sector is made up of elements such as technology, infrastructures, policy, consumer practices, markets and cultural meanings, aligned and maintained by a diverse set of actors including engineers, policy makers, industry and consumers, all of which will have a role to play in maintaining the resilience of the sector in face of an uncertain future.

The shipping sector provides a service to other sectors of the economy, and must therefore respond to the dynamics of both commodity supply and demand. Although highly uncertain, climate change is likely to bring both opportunities and risks to actors within the shipping sector through changing trade patterns, with a knock-on effect on port and logistical infrastructure, the need for new technologies and new market developments. At the same time as contending with the more immediate impacts of climate change, the shipping sector will support climate change adaptation strategies through the provision of shipping services, and linking consumers and producers.

The aim of this paper is therefore to explore the potential interactions between climate change and the shipping sector. It identifies key impacts upon the system through means of analysis of recent disruptions to shipping. Combining data from interviews with shipping sector actors, and documentary analysis, it provides an overview of the strategies adopted to maintain the resilience of supply chains.

#### **5. Socio-economic risk mapping for informed decision-making**

Jonathan Leonardsen, Rambøll

Facing climate change and urbanization, decision-making is increasingly made in unfamiliar and uncertain territory. Ramboll has developed a risk mapping tool (RMT) to facilitate informed decision-making in climate change adaptation planning. The RMT output is:

- risk map for visual planning,
- total sum of damages for a cost-benefit analysis
- total sum of co-benefits for a cost-benefit analysis.

The RMT has been effectively applied in several European cities such as Copenhagen, as well as catchments in Australia and New York City, USA, from where we will draw examples. The tool produces a risk map in the form of a spatial grid of damage costs relative to climate hazard probability, and sums up the total cost of damages for each scenario. RMT:

- compares consequences of climate scenarios with the effectiveness of potential adaptation measures thus providing the needed input for decision makers to decide on a masterplan and investment-plan.
- combines statistical data on demography and geographical data on built environment and critical infrastructure with costs of damages, and overlays this information with a dataset describing probability of climate risks, e.g. urban floods.
- evaluates effects of adaptation measures by including their impact on the spatial probability of climate risks for a given scenario.

The model requires climate variables, damage costs and other model parameters of which insurance data and experienced losses from extreme weather events are among the most important in the tool. The thresholds are context and climate variable dependent and are calibrated in close cooperation between the stakeholders and Ramboll. RMT provides a visual planning facilitator for prioritizing measures and communicating spatial distribution of risk and damage costs to politicians and professionals for each scenario and proposed solution. The RMT also provides a complete sum of damage estimates, which can feed into a CBA, in order to choose the optimum adaptation measure when combined with the construction and operation costs.

We quantify costs and co-benefits to identify economic consequences of a project in monetary terms which is key for decision makers when deciding on short and long term investment plans. Parts of the inputs are readily identifiable through e.g. avoided costs or a higher productivity. However, a large part of the costs and benefits arise from changes in incentives, externalities or other indirect effects. A comprehensive analysis takes these effects into account - such as increased aesthetic values, health, air pollution, traffic, local business etc.

## 10.1 Projections of climate change vulnerability in the agriculture and forestry sectors - decision support to guide adaptation strategies

*Marcus Lindner, European Forest Institute*

### Agriculture & forestry

1. Can we be certain about future land use change in Europe? (Ian Holman, Cranfield University)
  2. Yield based assessment of agricultural vulnerability factors in Sweden (Lotten Wiréhn, Centre for Climate Science and Policy Research)
  3. Climate change Impacts and adaptation options in Mediterranean islands' Agriculture – ADAPT2CLIMA (Konstantinos Varotsos , National Observatory Of Athens)
  4. Climate change, adaptation and management of abiotic risks to boreal forests (Heli Peltola, University of Eastern Finland)
  5. Integrating Adaptation Considerations into the Forest Planning Process: Experience and Lessons Learnt in the New Forest (Gail Elizabeth Atkinson, Forest Research)
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**Keywords:** Weather extremes; uncertainty; vulnerability factors; resilience, integrated assessment; decision support tool, forest bioeconomy, risk mitigation

This session focusses on scenario assessments and decision support in the land use, agriculture and forestry domains as a basis for development of adaptation strategies. Several of the presentations address uncertainties, extreme weather events and disturbances, which are crucial factors influencing the vulnerability of these sectors to climate change. Scientific knowledge derived from integrated assessments and scenario analysis with projections of simulation models are necessary tools to guide decision making and adaptation to climate change. A red line through the session will be the question how evidence-based decision support can inform land use planning, adaptation practice in agriculture and forestry, and policy making as well as planning at regional to national level. The session begins with a pan-European land use change assessment, followed by case studies with examples from the Mediterranean, the boreal and the Atlantic regions in Europe.

### Significance to adaptation practice, policy and/or business

We will discuss how land use policy can steer adaptation practices in the agricultural and forestry sectors. The identification of factors that shape agricultural vulnerability can specifically contribute to knowledge on relevant adaptation measures. We will explore how the deployment of decision support tools can contribute to mainstreaming agricultural and forestry adaptation measures into relevant national and regional policies and management plans. A study from the boreal region will highlight how to adapt forest management under increasing abiotic risks and how to balance forest based bioeconomy development and climate change mitigation.

### 1. Can we be certain about future land use change in Europe?

Ian Holman, Cranfield University

The global land system is facing unprecedented pressures from growing human populations and climatic change. Understanding the effects these pressures may have is necessary to designing land management strategies that ensure food security, ecosystem service provision and successful climate mitigation and adaptation. Given the number of complex, interacting effects involved in land systems, integrated models that allow for the exploration of the co-development of human and natural systems are needed. Here, we use one such integrated modelling framework (the CLIMSAVE Integrated Assessment Platform) to investigate the range of projected outcomes in the European land system across climatic and socio-economic scenario space for the 2050s. We find substantial consistency in locations and directions of change of each land use class (intensive agriculture, extensive agriculture, forest and unmanaged) across Europe, even under highly divergent conditions. Results suggest that

climate change will lead to a contraction in the agricultural and forest area within Europe, particularly in southern Europe. This is partly offset by socioeconomic changes in the demand for agricultural production (through changing food demand and net imports) and in the efficiency of agricultural production. Projected extensification and abandonment in the Mediterranean region is driven by future decreases in the relative profitability of the agricultural sector in southern Europe, owing to decreased productivity as a consequence of increased heat and drought stress and reduced irrigation water availability.

Nevertheless, approximately 20% of the simulated cells across Europe are very likely (90-99% probability) or virtually certain (99-100% probability) to maintain their baseline proportions of all land uses despite the effects of climate change on land suitability and crop and timber yields. These stable cells include significant areas within the UK, northern France, northern Spain, Germany, The Netherlands, Republic of Ireland and Scandinavia. The introduction of the socio-economic scenarios decreases the extent of areas very likely or virtually certain to retain baseline land use proportions from 20% to about 12 % of the simulated grid cells, but still suggests a considerable degree of predictability in future land use at the European scale.

Our presentation will therefore address three questions:

1. To what extent can highly uncertain futures lead to certain outcomes for land use across Europe in the 2050s?
2. Where in Europe are the current distributions of land uses unlikely to change significantly in the medium term?
3. What are the implications for rural policy and adaptation practice?

## **2. Yield based assessment of agricultural vulnerability factors in Sweden**

Lotten Wiréhn, Centre for Climate Science and Policy Research

This study explores the relationship between crop yield and heavy precipitation and aims to identify indicators of adaptive capacity and sensitivity related to agricultural exposure to extreme weather events in Sweden. Research on crop yield and weather interactions, as well as the effect of extreme weather events on production has been recognised for various regions and crops. However, such studies seldom account for sensitivity and adaptive capacity factors and their relation to crop yield. Factors that create sensitivity or build adaptive capacity need to be identified in order to minimize the negative impacts of extreme weather events on agricultural crop production through no-regret adaptation strategies.

The question on how to identify and understand the underlying factors of agricultural vulnerability to extreme weather has shown to be a challenge due to statistical data constraints. For this reason, to obtain a comprehensive picture of the factors determining whether a weather event causes a yield loss or not, this study divides the analysis into three different parts. First, we study historical time series data (1990-2013) of heavy precipitation and yield loss for different crops and geographical units to explore relationships that may serve as a base for assessing vulnerable regions. Secondly, we study historical yield loss and statistical relations with adaptive capacity and sensitivity factors for Swedish counties. Due to data constraints, this analysis is based on the spatial differences between factors – i.e. the differences between counties, and not change over time. The third part of the analysis assesses specific cases with either particular yield losses or extreme weather. We identify years when there have been yield losses in almost all Swedish counties, or the vice versa. Local documentation of these cases of deviations from the trend are used to further assess the reason/s why a yield loss occurred or not. It is assessed whether the deviation could be related to variations in exposure or to aspects of adaptive capacity or sensitivity for the specific county. In conclusion, this study combines statistical analyses and qualitative assessment of factors which can be associated with yield loss. Combined, these analyses identify potential vulnerability of extreme weather events and factors that shape adaptive capacity and sensitivity.

We present preliminary results of this study and relate these to the scientific discussion on vulnerability indicators and the complexity of assessing agricultural vulnerability to climate change.

### **3. Climate change Impacts and adaptation options in Mediterranean islands' Agriculture – ADAPT2CLIMA**

Konstantinos V. Varotsos, National Observatory of Athens

Agriculture is one of the economic sectors that will likely be hit hardest by climate change, since it directly depends on climatic factors such as temperature, sunlight, and precipitation. The EU LIFE ADAPT2CLIMA (<http://adapt2clima.eu/en/>) project aims to facilitate the development of adaptation strategies for agriculture by deploying and demonstrating an innovative decision support tool. The project is expected to contribute significantly to increasing climate resilience of agriculture at Mediterranean and EU level by:

- Developing, implementing and demonstrating an innovative and interactive decision support tool (ADAPT2CLIMA tool) for adaptation planning in agriculture that estimates future climate change impacts on local water resources, as well as the climate change vulnerability of the agricultural crop production in the project areas;
- Evaluating the technical and economic viability of the implementation of the ADAPT2CLIMA tool;
- Developing climate change adaptation strategies for agriculture (including a monitoring plan) for the three project areas and presenting them to the competent authorities for adoption;
- Simulating the effectiveness of the implementation of certain adaptation measures to address climate change impacts on agriculture;
- Developing a stakeholder engagement strategy;
- Increasing the knowledge of the impacts of climate change on the agricultural areas covered by the project, thus enabling well informed decision-making and enhancing readiness for early action in order to address the potential damages and minimize threats posed by climate change;
- Developing a framework for mainstreaming agricultural adaptation measures into relevant national and regional policies;
- Promoting the replication of the proposed methodology in order to ensure proper coordination of national and regional policies and between authorities.

The ADAPT2CLIMA tool will make it possible to simulate the impacts of climate change on crop production and the effectiveness of selected adaptation options in decreasing vulnerability to climate change in three Mediterranean islands, namely Crete (Greece), Sicily (Italy), and Cyprus. In particular, the tool will provide: i) climate change projections; ii) hydrological conditions related to agriculture; iii) a vulnerability assessment of selected crops; iv) an evaluation of the adaptation options identified. The tool construction will be closely monitored by the project steering committee comprising of climate and crop scientists, government policy makers as well as farm association executives who will be interacting to tailor make the final product perfectly suited to their needs.

### **4. Climate change, adaptation and management of abiotic risks to boreal forests**

Heli Peltola, University of Eastern Finland

Under the projected climate change, the mean annual temperature is expected to increase in Northern Europe until 2100 by 3–6 C° and mean annual precipitation by 11–18% compared to the current climate, depending on the scenario used for the concentration of greenhouse gases. As a result, the carbon sequestration and wood production are in general expected to increase in boreal forests. This is because currently short growing season, relatively low summer temperatures and small supply of nitrogen limit them. The carbon sequestration and wood production are also expected to increase in relative sense more in northern than in southern boreal conditions, where the growth and success of tree species like Norway spruce with shallow rooting may suffer drought especially on sites with low water holding capacity. In all, the future development of forest resources is affected both by the current forest structure (age, tree species), intensity of forest management and projected climate

change together with associated increase of various abiotic and biotic damage risks to forests. Climate change is expected to increase the risk of forest damages, e.g. by wind storms, bark beetles and fungus, and especially in Norway spruce. Risk of wind damages are also expected to increase despite of increase of windiness, due to the increase of duration of unfrozen soil during the most windy season of year, i.e. from late autumn to early spring. This is because frozen soil improves tree anchorage. However, various damage risks to forests (e.g. by wind storms) may be decreased at least in some degree by considering them in forest management and planning. The process-based forest ecosystem and mechanistic risk models could also offer useful means to study how current forest structure together with intensity of forest management and projected climate change may affect future development of forest resources and various abiotic and biotic risks to forests. As a result, proper adaptive management strategies needed in different regions and time spans could be developed, considering also the uncertainties related to the projected climate change and the need to mitigate it.

### **Significance to adaptation practice, policy and/or business**

Boreal forests provide different ecosystem services, including forest biomass for the growing needs of forest based bioeconomy. This presentation discusses about potential impacts of projected climate change on managed boreal forests and need to adapt forest management to the projected climate change in order to properly consider increasing abiotic risks to forests and to mitigate the climate change as well. These results should be of interest to various stakeholders in forest based bioeconomy, policy makers and forest authorities.

## **5. Integrating Adaptation Considerations into the Forest Planning Process: Experience and Lessons Learnt in the New Forest**

Gail Elizabeth Atkinson, Forest Research

In the UK, adaptation of forests to the changing climate is an important objective of government policy. Increasing adaptive capacity in a timely manner is critical to minimise the risks of climate change to forestry and realise benefits. Adaptation is necessary to maintain and enhance the ability of UK forests to provide essential ecosystem services, such as timber production, recreation, flood retention capacity and habitat for wildlife.

Forest plans are mandatory for publically managed forests, setting the vision and objectives for the next decade, and directing the management and operations required to deliver these objectives (e.g. timber harvesting, habitat restoration and new planting). The plan is essential to optimise the service provision of the site. Integrating climate change considerations into forest management is critical at the planning stage, however, the risks of climate change to forestry are not always recognised and mixed messages about climate projections, a complex stakeholder network and fixed timeframes can lead to adaptation being overlooked when plans come up for renewal. The resulting 'business as usual' approach which fails to fully integrate adaptation measures into forest plans is a missed opportunity to prepare our forest resource for future climate conditions and to continue to deliver ecosystem services.

This research aimed to better understand opportunities and barriers to integrating adaptation measures into forest plans, using a case study in the New Forest in England, whilst raising awareness of the need for adaptive practice with those involved. Using co-production, engagement and process modelling, a range of potential forestry adaptation measures were identified and mapped alongside adaptation concerns to reveal opportunities to better integrate adaptive practices.

The research highlights that the planning stage provides the opportunity to catalyse action through engagement on climate change, and to increase the potential adaptive capacity of a forest. The lessons learnt can support others with the integration of adaptation measures, optimising the likelihood of continued or improved ecosystem service provision.

## 11.2 Tools for understanding the economic impacts of floods and droughts

*Florian Gallo, Met Office*

### Flooding

### Drought

1. Main drivers of flood damage in different company sectors – towards an understanding of flood-related vulnerability (Kristin Vogel, Gfz German Research Centre For Geosciences)
  2. Flooding and businesses in urban areas – analysing damages costs, responses and the role of climate change in Kigali (Christian Kind, adelphi)
  3. Understanding the influence of private precautionary measures on Flood Vulnerability (Nivedita Sairam, GFZ German Research Center for Geosciences)
  4. Groundwater floods and climate change – the frequently forgotten flooding topic (Steffen Bender, Climate Service Center Germany (GERICS))
  5. EUPORIAS: Added value of using a regional climate model for seasonal forecasting in eastern Africa (Florian Gallo, Met Office)
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### 1. Main drivers of flood damage in different company sectors – towards an understanding of flood-related vulnerability

Dr. Kristin Vogel, GFZ (German Research Centre for Geosciences)

Financial damage caused by floods increased during recent years. Thus, appropriate adaptation and risk mitigation strategies get more and more important in order to reduce this damage. However, the understanding of the damage processes and the driving forces is still weak. Many flood damage models only consider flood impacts such as the water level in their estimations for the damage. Yet, a more detailed picture of flood risk requires information and understanding not only about the hazard but also about the vulnerability of the exposed objects.

Our study focuses on direct, tangible damage of single companies. The objective is the identification of variables driving the damage of different business assets (buildings, equipment, goods) in individual company sectors. This is an important step to understand the damage processes, which consequently deepens the knowledge about vulnerability.

The data sets used are taken from two surveys conducted after the floods in the Elbe and Danube catchments in the years 2002 and 2013 in Germany. Each data set comprises information about the flood damage and various potential damage drivers like water level, the degree of contamination, flood duration, precaution and emergency measures undertaken by the companies, the number of the employees and the spatial situation of the companies.

An ensemble of tree-based classifiers, so called Random Forests, is used to analyse the data and to identify relevant predictor variables for the response variable flood damage.

The results indicate that different variables can be identified as important drivers of flood damage for the individual company sectors as well as for different business assets. For instance the building damage of manufacturing companies is, besides the water level, strongly influenced by precautionary measures undertaken before the flood event, while the building damage of companies from the commercial sector is strongly driven by spatial circumstances of the company (i.e. company with several buildings or company with only one floor). Consequently, a better understanding of the vulnerability of companies can be reached by the consideration of individual company characteristics. This might enable the application of appropriate adaptation strategies for



different company sectors and assets. One step in this direction could be an asset-related data acquisition, e.g. by asking specific questions for the single company sectors.

## **2. Flooding and businesses in urban areas – analyzing damages costs, responses and the role of climate change in Kigali**

Christian Kind, Adelphi

Globally, extreme precipitation events that can trigger floods have caused considerable economic and social costs in recent years. With progressing climate change, the likelihood of such events will increase further. When looking at past flooding events across the globe it becomes apparent that most research as well as most governmental activities with respect to prevention and compensation focus on a few large-scale events. The vast amount of smaller but more frequent floods receives relatively little attention from researcher and policy-makers even though such events in their sum can be of greater importance for economic development in general and small businesses in particular.

Using flooding in the City of Kigali, Rwanda, as an example, the presentation will provide an overview on methods for assessing the damages of small but frequent flood events for small businesses. The presentation will touch both on direct and indirect damages for businesses as well as on determinants of vulnerability, the perception of climate change among business owners and the efficacy of private flood protection measures. Kigali is an interesting case for applying methods on assessments of floods damages for small businesses: the city has frequently been affected by floods in the past and around 98% of Rwanda's companies can be classified as small and medium-sized enterprises (SMEs); therefore, it is of high relevance for the climate resilient development of the country's economy to understand businesses' specific vulnerabilities and damages they face through extreme weather events.

The presentation will touch on the results of an empirical investigation of flood damage costs for businesses in a commercial part of Kigali: it can be shown that the average annual flood damages seriously threaten the businesses' survival: On average, each affected business in 2013 suffered direct and indirect flood damage costs of at least 1,030 USD which is more than the annual net profit of around 25% of the businesses in the area. Given that extreme precipitation events are likely to become more frequent and intense with the changing climate, there is an urgency to take actions both by public authorities and businesses to ensure climate compatible growth in Kigali. Based on the analyzed effectiveness of private flood protection measures of businesses in the area, the presentation will outline ways to reduce future damage costs from flooding. The research presented was funded by the Climate and Development Knowledge Network (CDKN).

## **3. Understanding the influence of private precautionary measures on Flood Vulnerability**

Nivedita Sairam, GFZ German Research Center for Geosciences

The implications of floods are dependent on several factors concerning the vulnerability of the exposed population, in addition to the physical aspects of the hazard. Losses due to floods are commonly estimated using the only parameter - water depth. However, flood loss also depends on other factors such as preparedness of the exposed population, precautionary measures undertaken and technological advancements to provide emergency information to the affected people. A large number of study reports have been published in the domains of public awareness towards natural disasters from sociology and economics perspectives. However, it is important to quantify several cognitive and private precautionary practices that help to abate the consequences of floods. This research aims to analyze parameters concerning flood warnings and adaptation of precautionary methods in order to determine temporal changes in flood vulnerability.

A Graphical Model - Bayesian networks implying causal inference will be implemented in order to study the changes in vulnerability when different private precautionary measures are undertaken. The causal relationship

helps in identifying the interferences (precaution methods) and their implications. This process also helps to determine most effective precautionary methods that reduce the loss due to flood damages. Bayesian Networks have been increasingly used in the domains of several risk assessments scenarios. These provide an advantage over deterministic approaches in dealing with highly random processes where relationships between variables involve higher level of uncertainties. Traditional statistical models may result in either an over-fit which turns out inconsistent or an inaccurate fitting with higher bias. In the case of natural disasters, the dataset is always expected to have a number of uncertainties and missing observations which are indeed a concern while constructing Bayesian Networks. Complementing expert knowledge with data driven methods of network building results in hybrid networks. These help in obtaining deeper insights on relationships between the variables under study. Flood Vulnerability in this context is identified by the expected loss to building and contents during a flood event. It is evident that precaution parameters have a strong influence on the relative loss. Hence, these results are crucial to determine the motivation for the exposed groups to take up similar precautionary activities and the underlying economic benefit to the society.

#### **Significance to adaptation practice, policy and/or business**

An insightful understanding of different population groups vulnerable to Flood damage is essential for policy makers, social organisations and insurance industry. This research helps in understanding how different private precautionary measures influence the loss caused due to flood damage. From an overall perspective, the results help in determining the efficient precautionary measures that reduce flood loss. This might be of interest for government and non-governmental organisations to spread awareness and/or allocate funds for implementation of precautionary measures. Further, the characteristics of population groups implementing these precautionary methods can be of further interest to insurance industry to decide on appropriate insurance schemes and premiums.

#### **4. Groundwater floods and climate change – the frequently forgotten flooding topic**

Steffen Bender, Climate Service Center Germany (GERICS)

When talking about flood risks, regardless of today or in future, mainly coastal flooding during storm surges or as a result of sea-level rise, river flooding due to land use change or intense rainfall or urban flooding after a heavy rain event are considered. A still missing feature is the flooding due to high groundwater levels, e.g. as a result of heavy precipitation or prolonged rainfall, river flooding, anthropogenic activities or a mixture of all of them. The key features of this long-time overlooked challenge with its surprising effects mainly in urban areas are as follows: a) flooding usually occur with a time delay after the initial rain events or river floods, b) the flooding remains several weeks, c) the water mostly appears at unexpected places, d) the water may rise up through floors and walls rather than coming through doors, and finally e) the risk potential seems to be quite “unexciting” for media coverage. However, the financial damages might be considerable. For example in 2002 in Germany the damage caused by high groundwater levels at properties of the federal state Saxony reached over 29 Mio €. For the future climate projections show impacts on parts of the hydrologic water cycle such as changing precipitation patterns, a frequently higher number and more intense heavy rain events for some regions, and higher mean temperatures that will increase evapotranspiration and reduces the water storage in form of snow and ice. Due to higher surface runoffs and higher recharge rates in winter, there is a high probability for an increase of the highest groundwater level. But the extent of this trend will vary from place to place.

Unfortunately, precautionary measures against groundwater flooding are mainly a private responsibility, whereas in Germany for example this kind of damage is not covered by any insurance. Therefore it is urgent to draw attention to this challenge and to raise awareness addressing private house owners, businesses as well as urban planners – especially focussing on regions, where high groundwater levels might become a new issue in the future.

### **Significance to adaptation practice, policy and/or business:**

Adapting buildings or properties to rising groundwater levels is in practice a highly context specific issue, especially in regions far away from water courses where high groundwater levels currently are unfamiliar. Therefore the paper is of relevance to pay attention to this specific kind of flooding that can cause serious damage to buildings or infrastructure elements, but is at the same time still overlooked. These results will therefore be useful for property owners as well as planners and decision makers in cities

### **5. EUPORIAS: added value of using a regional climate model for seasonal forecasting in eastern Africa**

Florian Gallo, Met office

Weather and climate information on a seasonal timescale is vital in many developing countries around the world. In particular, information on monsoon characteristics is of primary importance for planning and adaptation for rural population in tropical regions. For this reason, the demand for seasonal data is growing in developing countries. However, the ongoing climate change is having an impact on interannual variability, increasing the difficulty for decision-making on such timescales.

In recent decades, significant progress has been made in seasonal forecasting skill, enabling seasonal forecasting to become an operational activity in some regions and providing information for planning and risk assessment across a range of sectors. This approach uses global climate models (GCMs) at relatively low resolution to generate seasonal averages. However, users require more and more detailed, regional/local information for planning. GCMs are for example unable to capture the most extreme events or to detect the influence of complex regional characteristics (Frei et al., 2006). Climate information can be provided at a higher resolution by downscaling the GCM. Two downscaling methods are commonly used: statistical downscaling uses empirical, statistical relationship between large and local scale, whereas dynamical downscaling connects global scale predictions and regional dynamics to generate regionally specific forecasts, using a regional climate model (RCM) driven by the GCM. This enables to provide a large number of variables, physically consistent with the global model.

As part of the EUPORIAS project, this work aims to assess the added value of using RCM to generate seasonal climate information over eastern Africa, focusing on the rainy Kiremt season (JJAS). The Met Office global seasonal model, GLOSEA5 (see Arribas et al., 2011; MacLachlan et al., 2014 for technical details) is used first to generate the regional climate model (RCM) climatology for the JJAS season of interest with a three-member stochastic physics ensemble for the years 1991-2012. Secondly a 15-member ensemble for four years of interest: two wet years (2006 and 2007) and two dry years (2002 and 2009) is generated. These hindcasts are dynamically downscaled by passing boundary conditions to a 25-km RCM, HADGEM3-RA, which uses the same atmospheric and land-surface configuration as GLOSEA5.

User-oriented climate indices were estimated, such as the time of monsoon onset and cessation or the cumulated rainfall during the season. A skill comparison has been performed in order to assess the added value of a downscaled seasonal forecast for the region.

## 4.1 A better understanding of adaptation governance

*Robbert Biesbroek, Wageningen UR*

### Governance

1. The multi-level governance of adaptation policies: comprehensive strategy processes at and across levels of government (Reinhard Steurer, University of Natural Resources and Life Sciences, Vienna)
  2. The roles of private actors in urban climate change adaptation – emerging patterns of public-private cooperation and citizen involvement (Johannes Christoph Klein, Aalto University)
  3. Devolution of Responsibility for Climate Action in Pittsburgh, Pennsylvania, USA (Kimberly Lucke, Chatham University)
  4. Developing climate adaptation strategies in the EU's Eastern Neighbourhood: New champions for new challenges? (Maria Falaleeva, Ekapraekt)
  5. Common governance challenges for adapting to the hydrological impacts of climate change: An analysis of six regions across Europe (Emmy Bergsma, KWR Watercycle Research Institute)
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**Keywords:** Adaptation strategies; Adaption plans; policy; practice; multi-level governance; coordination

This session presents and discusses some of the key governance challenges associated with the development and practical implementation of adaptation policies. The analysis of a set of selected real-life examples provides the background for a better understanding of how such challenges play out in practice. The session is expected to provide insights into the necessary reflection on how the multiple actors involved in adaptation policy-making and practice are successfully dealing (or not) with such challenges.

**Significance to adaptation practice, policy and/or business:** The session is expected to provide novel information on how adaptation-related policies and practices are currently taking shape in real-world and amidst existing and new governance challenges.

### 1. The multi-level governance of adaptation policies: comprehensive strategy processes at and across levels of government

Reinhard Steurer, Boku - University Of Natural Resources And Life Sciences Vienna

Adaptation to climate change is a complex issue that has to be addressed at different levels of government. This suggests that all kinds of adaptation policies (ranging from comprehensive adaptation strategies to specific measures) would benefit from vertical coordination across different levels of government because this could help maximizing synergies and minimizing trade-offs. In the present paper, we review how well comprehensive adaptation strategies from different levels of government are linked with each other in terms of governance processes and contents, and we analyse in how far barriers to adaptation vary across levels of government. We analysed 14 adaptation strategy processes at different levels, namely two supranational (Baltic Sea Region, and EU), six national (Australia, Canada, Denmark, England, Finland, the Netherlands), and six local ones taken from the six countries (i.e. Copenhagen, Helsinki, London, Melbourne, Rotterdam, Vancouver). We selected nation states that were known as frontrunners in climate change adaptation and published national adaptation strategies at a relatively early stage. Also, the cities we chose are known as relatively pro-active compared to other cities in their countries. This embedded case study design allows us to conduct a meaningful analysis of vertical integration across two (outside of Europe) to three levels of government (within Europe). We combined desk research with a total of 35 semi-structured interviews. For most cases, we interviewed the responsible strategy coordinator, one representative of a sector that is targeted by the strategy process, and one non-governmental adaptation policy expert).

The paper briefly introduces the literature on the governance of adaptation policies at and across different levels of government. After describing our case methodology, we give a brief overview of our 14 cases. We then synthesize and analyse our findings on how adaptation processes at different governmental levels build on and interact with each other. In addition, we summarize benefits and problems of existing multi-level interactions as well as demands of involved actors.

Overall, we find that interactions between levels of government are surprisingly sparse. Both supranational adaptation strategy processes are still in search of their role in adaptation policy-making. So far, they are no major factor for any of the national or local adaptation processes we examined. The national level is often expected to support local adaptation via guidance, (scientific) expertise and resources. However, we found that adaptation in all cities we analysed is far ahead of national adaptation (in particular in terms of implementing adaptation measures). It seems that major cities set the pace for adaptation policy-making also for higher governmental levels rather than the other way around.

## **2. The roles of private actors in urban climate change adaptation – emerging patterns of public-private cooperation and citizen involvement**

Johannes Christoph Klein, Aalto University, Department Of Built Environment

The call for more private action and public-private cooperation in adaptation is made by research and national strategies. It is, however, yet unclear, what type of public-private relation is envisaged and how modes of cooperation could be applicable across state concepts and administrative traditions, given that significant differences can be observed, for example, between Northern Europe and the United States. The presented study uses cases from two urban administrations (New York City and Helsinki) in two different political traditions to explore how private action and public-private interaction in urban climate change adaptation has emerged.

Our study shows that both cities, Helsinki and New York, aim for an increased state-market-civil society interaction for climate change adaptation. Their points of departures, however, are in different administrative traditions and governance approaches. While New York City's administration is within the Anglo-American tradition with state-market dualism, Helsinki's administration has its roots in a welfare state administration with a strong stand of the public administration. This means the shifts in governance approaches follow distinctively different trajectories. In the US, a shift toward state-market-civil society synergism in adaptation means more civil society and less private sector in the US, but in Finland, it means less state, more private sector and more civil society.

Models for more private engagement (companies as well as citizens) in adaptation are not readily transferable between administrative traditions and governance approaches. Therefore, moves towards private action and public-private cooperation have to be scrutinized, how they affect existing governance structures, prevailing ideas and values, as well as relations between public administration, private sector, and citizens.

## **3. Devolution of Responsibility for Climate Action in Pittsburgh, Pennsylvania, USA**

Kimberly Lucke, Chatham University

Within the United States, there is a growing trend of shifting responsibility for climate action from larger to smaller scales of governance (Toly 2008). One major shift has been from the national to the local, urban scale of governance, seen by the proliferation of city specific climate action plans (Bulkeley 2010). This shift to the urban scale has largely been seen as a positive due to the oft-localized complexity of climate change impacts, the inherent vulnerability of cities and the relative weakness of state-led action to address these complexities within the United States (IPCC 2013; Baker et al. 2012; Bulkeley 2010; Dodman 2009). However, coordination between this mix of actors/scales of governance is essential for effective, efficient, and timely mitigation and adaptation strategies (Satterthwaite 2008). Therefore the question remains as to how urban climate actions are coordinated

between various urban actors/scales. Our research seeks to gauge the level of coordination between different urban actors in the rust belt city of Pittsburgh, PA, USA. Our research suggests a lack of coordinated climate action between different actors within the city. This lack of coordination raises concerns about the overall effectiveness of urban climate action plans. We argue that this lack of coordination has resulted from a downshift in responsibility to smaller scales of governance, which is a consequence of economic frameworks put in place after the collapse of the city's dominant industry in the 1980s. As Pittsburgh seeks to address climate change, this lack of coordination between urban actors, as well as its post-industrial legacy needs to be acknowledged for effective plans to be produced.

#### **4. Developing climate adaptation strategies in the EU's Eastern Neighbourhood: New champions for new challenges?**

Maria Falaleeva, EKAPRAEKT

Ratification of the Paris Agreement gave a strong signal for developing national adaptation strategies. This call have special significance for the countries of the EU's Eastern Neighbourhood (Armenia, Azerbaijan, Belarus, Georgia, Moldova, Russia and Ukraine), where international obligations was always a major driver for national climate policies, and adaptation policies are still at the inception stage. As EU's political and economic partners and recipients of international assistance, these countries are influenced and informed by the EU's multi-level approach to adaptation governance. However, the political, institutional and social realities in the Eastern Neighbourhood vary from EU and need to be considered by national actors and international donors.

The research analyses actors and driving forces in developing national and local climate adaptation policies in Belarus (with examples from the Eastern Neighbourhood), and argues that complex challenges of climate adaptation may significantly alter the landscape of actors involved in climate decision-making. It analyses limitations and opportunities for traditional institutions and new "champions" (such as expert-led NGOs). The analysis is based on monitoring of national adaptation decision-making in Belarus and EU's Eastern Neighbourhood, practical experience of developing local adaptation strategies (Climate Forum East project, EU / ADA / Austrian Red Cross), series of interviews with NGOs in the region and official actors in Belarus.

Belarus is accountable for less than 1% of the global GHG emission; the negative impacts of climate change (droughts, floods, forest fires, changing conditions for agriculture, changing in ecosystems, impacts on human health) are estimated as low to moderate, and successful adaptation may bring positive effects (e.g. new opportunities for agriculture). Significant potential for the country's climate policy lies in adaptation which however remains "shadow area" of the national climate policy. Alongside with the general lack of experience, existing top-down institutions often unable to support flexible administrative approach based on local initiative, knowledge integration, multi-level distribution of power and responsibility.

In this situation, non-state actors (e.g. independent expert-led NGOs, international organizations and experts) start to play a key role in initiating and developing adaptation strategies. These actors often have capacities lacked by the state agencies e.g.: good knowledge of international expertises (theory and practice of adaptation governance), access to external funding sources, freedom of operation and possibility for experimentation, which also position them as effective bridging organizations. However in order to make an impact at the national level, non-state actor have to possess capacities equal or exceeding the expertise of state institutions. In the vacuum of experience and expertise the NGO-led adaptation initiatives start to receive attention and endorsement from the official actors.

#### **5. Common governance challenges for adapting to the hydrological impacts of climate change: An analysis of six regions in Europe**

Emmy Bergsma, Kwr Watercycle Research Institute

Climate change changes weather conditions: it increases the risk of flooding, leads to more instances of extreme rainfall and prolonged periods of droughts. Through its impacts on the hydrological cycle, climate change poses major challenges to current water management practices. But is contemporary water governance robust and flexible enough to adapt to the impacts of climate change?

This paper comparatively analyses the governance context of six regions across Europe that will be affected the hydrological impacts of climate change. These are the Badelona region in Spain, the Veluwe area in the Netherlands, the Troodos Mountains in Cyprus, the Wupper River Basin in Germany and the Lower Tagus basin in Portugal. In each of these regions, climate change poses different risks. Some areas will experience more storm floods, in other areas sewage overflow poses a major problem whereas particularly the southern regions face reductions in the quantity and quality of water. Based on a series of questionnaires and interviews with key stakeholders involved in water governance at each site, the paper analyzes the regional and national-level governance context of each region in order to identify the main strengths and weaknesses for adapting to climate change in these governance contexts.

The three layer framework for water governance – which distinguishes between a content, an institutional and a relational layer – is used as an analytical model. This model not only helps to better grasp the governance challenges posed at the six research sites by relating them to different ‘layers’ or ‘aspects’ of water governance (e.g., are challenges mainly related to the content of policy approaches, the institutional arrangements in water management, or its relational underpinnings?). Looking across regions, this model also contributes to a better understanding of common governance challenges for adaptation to climate change in the water sector, as well as of the challenges related to the governance of certain types of water-related risks.

## 5.9 US NOAA Sea Grant Program Facilitates Coastal Adaptation Planning Efforts

*Libby Carnahan, Florida Sea Grant*

### Coastal

1. Case study 1: Florida (Libby Carnahan, Florida Sea Grant)
  2. Case study 2: Building resiliency in a Great Lakes Coastal Community in Erie, Pennsylvania (Sara Stahlman, Pennsylvania Sea Grant)
  3. Case study 3: North Carolina (Jessica Whitehead, North Carolina Sea Grant)
  4. Case Study 4: Climate resilience planning and watershed restoration for coastal communities on the Eastern Shore of Maryland (Jennifer Dindinger, Maryland Sea Grant)
  5. Facilitated discussion (All)
- 

**Keywords:** NOAA, Sea Grant, Sea Level Rise, Great Lakes, Adaptation, Capacity Building,

Coastal communities across the United States are experiencing impacts from climate change and associated sea-level rise. There is a lack of coordinated state and federal guidance for climate adaptation, which underscores why local entities are initiating their own planning efforts. However, communities frequently lack staff, fiscal, and scientific resources to identify risks and plan for adaptation. The objective of this session is to share how Sea Grant and Extension Agents working in climate change adaptation help communities convene appropriate stakeholder groups, identify climate stressors, assess vulnerability, and plan for appropriate adaptation strategies.

Founded in 1968, a network of 33 Sea Grant programs in the coastal and Great Lakes United States and territories promotes stewardship of coastal resources through research, education and outreach. Our close connections with the people of the coasts, and commitment to sharing the best science to inform decisions, places us in an ideal position to both partner and lead efforts to assess climate change vulnerability and plan for targeted adaptation strategies.

This session focuses on the commonalities of diverse Sea Grant adaptation planning efforts around the U.S. that include (1) trusted Sea Grant Agents convening community conversations that lead to increased resilience; (2) availability of locally-relevant scientific tools and resources from partner Universities, government agencies, and nonprofit organizations; and (3) partnerships and regional networks that foster collaboration and information sharing between programs and stakeholders, such as the Sea Grant Climate Network and various regional Communities of Practice. Case studies include Tampa Bay, Florida; Erie, Pennsylvania; Hyde County and the Town of Nags Head, North Carolina; and Maryland's Eastern Shore.

Sea Grant programs around the USA have demonstrated responsiveness and dexterity to help coastal communities plan for short and long-term impacts of climate change and sea-level rise. This work translates usable research into useful and relevant information and products for many audiences and is delivered to those who need it. This model is flexible and transferable to other regions around the world.

### Session Overview:

- Introductions and Audience Assessment
- Who is in the room
- What adaptation work is each participant currently conducting
- What does each participant want to take away from the session
- Presentations of Case Studies by Panelists
- 4 Talks, 10 minutes each



- Facilitated Discussion (sized as appropriate)
- Q&A for Panelists
- Group discussion of how participants will use what they learned to move adaptation planning forward in their region

### **Significance to adaptation practice, policy and/or business**

Many coastal communities in the United States face challenges to adaptation planning. However, NOAA Sea Grant is working around the nation to identify and overcome these barriers and move communities from the first steps of adaptation (assessment of impacts, vulnerabilities, and risks) all the way to creating action strategies. Other regions that face similar barriers and restrictions could benefit from learning about these adaptation practices and utilize similar strategies in their own communities.

### **Case study 1: Florida**

Libby Carnahan, University of Florida IFAS Extension, Florida Sea Grant Agent

Coastal communities surrounding Tampa Bay, Florida, are low-lying, densely-populated and therefore vulnerable to sea-level rise. In response to requests from local governments in the Tampa Bay region, Florida Sea Grant (FSG) and the Tampa Bay Regional Planning Council (TBRPC) are facilitating coordinated efforts to guide sea-level rise adaptation planning in the region.

The FSG Agent is facilitating the Tampa Bay Climate Science Advisory Panel (CSAP), a scientific advisory group whose goal is to provide scientific support to local governments planning for a changing climate. The group is comprised of local experts researching and implementing adaptation projects related to climate change. The TBRPC is convening a network of planners, developers, emergency managers and policy makers through the ONE BAY: Resilient Communities Working Group in order to improve the regional capacity of the area to withstand uncertainty and adverse impacts associated with sea level rise and other coastal hazards.

Under the facilitation of the FSG Agent, the scientists participated in a year-long iterative process of literature review, expert speaker presentations, and facilitated discussion, and in September 2015 published the final “Recommended Projection of Sea-Level Rise in the Tampa Bay Region”. With this shared projection, the TBRPC is leading area governments to coordinate, develop, and implement appropriate coastal adaptation and risk reduction strategies. Since the adoption of the SLR Recommendation, local governments are increasing their awareness of climate change and sea-level rise issues and incorporating adaptation strategies into their planning processes. Some such efforts that will be discussed.

### **Case Study 2: Building resiliency in a Great Lakes Coastal Community in Erie, Pennsylvania**

Sara Stahlman, Pennsylvania Sea Grant

Over the last several years, Great Lakes communities have faced an increase in the frequency and severity of climate-related impacts such as extreme temperatures, severe storm events, drought, and flooding. While these impacts are becoming more evident throughout the region, coastal communities residing on the Great Lakes continue to face unique barriers associated with responding to these challenges, including a lack of understanding about climate science, specific local impacts, which features of their community are at the most risk, and how to focus limited resources towards their climate adaptation goals.

The Community Resiliency Workgroup (CRW), made up of partner organizations in Erie, Pennsylvania (Pennsylvania Sea Grant, Environment Erie, the Northwest Pennsylvania Green Economy Taskforce, and the Erie County Sustainability Office), have come together to assist Erie in moving forward with climate adaptation. This talk will highlight several of the projects the CRW has undertaken to increase resiliency in the community. Over the past three years, the CRW has hosted a series of climate symposiums targeted towards climate vulnerabilities in the region, including hazardous weather, impacts to tourism, and impacts to agriculture. These summits gather

various sectors of the community such as local businesses, municipal leaders, planners, non-profit groups, state agencies, and members of the general public to learn and discuss climate change impacts through various methods including films, panel discussions, presentations, and focus groups. Colorful and informative infographics were developed for each summit that highlight regional challenges to consider with each topic, as well as potential adaptation and mitigation strategies for each. In addition, the CRW was instrumental in identifying climate action planning as a key priority in long-term regional planning efforts. This talk will also highlight the results of a focus group that identified barriers to climate action in Erie, and what the CRW and Erie region are doing to address those barriers. The overall goal of this work is to take the information learned from the summits and develop a county-wide climate action plan which would build knowledge and resiliency in Erie by prioritizing local climate vulnerabilities and providing coordinated action strategies for each. A key component of this effort is broad public participation and engagement with representation from each sector of the community. This work provides a regional strategy for building hazard resilient communities that can be used throughout the Great Lakes and in other similar coastal communities around the world.

### **Case study 3: North Carolina**

Jessica Whitehead, North Carolina Sea Grant (video presentation)

Decisions about climate change adaptation are complex, requiring decision-makers to synthesize multiple data types, consider direct and indirect consequences, and generate a variety of response options on multiple time scales requiring both public and private sector action. Additionally, in North Carolina, USA, local willingness to engage on building resilience and adapting to climate change varies significantly from one local government to another, with limited support from the State of North Carolina's government and little United States federal government assistance for small suburban and rural communities beyond that available through extremely competitive grant processes. How can you help decision-makers to get critical adaptation conversations started? North Carolina Sea Grant partnered with the South Carolina Sea Grant Consortium, Social and Environmental Research Institute and the Carolinas Integrated Sciences and Assessments Program to develop and implement the Vulnerability, Consequences, and Adaptation Planning Scenarios (VCAPS) process as a discussion and decision support engagement strategy for initiating adaptation conversations and planning in local governments. VCAPS has now been implemented in more than 17 coastal communities throughout the United States and counting as a flexible, facilitated participatory methodology based in the causal structure of hazards and vulnerability assessment. It gives a diverse group of decision-makers a structure for discussions about resilience, supported by real-time computer-aided diagramming, that helps increase their understanding of scientific information, impacts in their communities, and adaptation actions they can take to reduce or prevent undesirable consequences. Participants can use the diagram produced during the process as a discussion and reporting aid to generate adaptation options that both public entities and the private sector can take to increase their communities' resilience. This presentation will compare and contrast North Carolina Sea Grant's use of VCAPS in two coastal local governments: agriculture-dependent Hyde County in North Carolina's Inner Banks, where farm fields are beginning to transition to salt marsh, and tourism-dependent Town of Nags Head, a barrier island community in North Carolina's Outer Banks, where beach erosion and water table heights have been increasing. In Hyde County, willingness and agency for engagement on sea level rise are low, but the VCAPS process has enabled them to pursue no regrets strategies for flood resilience that will also improve resilience to sea level rise. In Nags Head, a large public VCAPS exercise is leading to the long-term inclusion of sea level rise in Town comprehensive planning processes.

### **Case Study4: Sea Grant Extension's role in climate resilience planning and watershed restoration for coastal communities on the Eastern Shore of Maryland**

Jennifer Dindinger, University of Maryland Sea Grant Extension

The Eastern Shore of Maryland (USA) is a unique, rural, coastal plain peninsula that borders the Chesapeake Bay to the east. It is experiencing both sea level rise due to climate change and land subsidence due to glacial ice

sheet melting during the last ice age. Relative sea level rise is increasing as a result. The peninsula is low lying and flat, thus exacerbating the impact of rising seas on vulnerable coastal communities. Other impacts the region is facing due to climate change are increased heavy precipitation events leading to nuisance flooding, increased temperatures, and a change in the growing season. Large scale efforts at the federal, state, and local level are also underway to restore the health of the Chesapeake Bay, the nation's largest estuary.

Against this backdrop, the Eastern Shore's regional watershed restoration specialists for Sea Grant Extension work at the federal, state, and local level to assist communities with adaptation planning and watershed restoration. These Extension agents are uniquely positioned to provide this assistance because of their connection to University research, their location within the community at County Extension offices and research centers, and their mandate to provide sound science to decision-makers as an honest broker of information.

This presentation will highlight 3 case studies in which the Extension agent is working at the federal and local levels and with the research community to provide unique and useful assistance to communities for climate change adaptation planning and local water quality improvement efforts. Some "lessons learned" will also be shared so that attendees will leave the session with specific action items to pilot in their own communities.

## 4.4 Making change happen: Learning from practical climate projects working across communities, governance, and policy

*Katharine Knox, Joseph Rowntree Foundation and Ioan Fazey, University of Dundee*

### Climate justice

### Governance

1. The role of practical knowledge for making change happen in a world with a rapidly changing climate (Ioan Fazey, University of Dundee)
  2. The Scottish Borders Climate Resilient Communities Action Research Project: concept, approach, outcomes and lessons (Esther Carmen, University of Dundee)
  3. Weathering Change: Action Research Exploring Community Resilience in the Face of Climate Change (Russell Jones, Glasgow Centre For Population Health)
  4. Urban Heat: action research and policy engagement for social change: a multi-level perspective (MLP) (Ben Fagan-Watson and Kevin Burchell, University of Westminster)
  5. Facilitated group discussion (Ioan Fazey, University of Dundee)
- 

Climate change presents a critical challenge: how can we accelerate desirable and transformative social change? While research has excelled at identifying problems and solutions, it has had much less impact on developing 'know how' – practical knowledge and skills – for social change. At the same time practical interventions that seek to enact social change are often uninformed by theories of social change or governance. This session therefore brings together key insights and learning from action-oriented projects that have worked at the interface of research and practice in theoretically-informed and systemic ways to enact social change in relation to climate change. The session aims to: (1) Examine how different kinds of practical projects for social change have been conceptualised and implemented; (2) Explore how knowledge from practice can contribute to making social change happen; and (3) draw out key lessons learned to inform future practices of social change.

The session will include an introduction by the session chair, Katharine Knox, who leads the Joseph Rowntree Foundation's Climate Change programme, which has a strong emphasis on climate justice. This will be followed by four presentations, including three case studies which seek to drive social change – in the form of enhanced resilience and adaptation to climate change – by working across diverse stakeholders, policy sectors and communities. Finally the session will include facilitated discussion with participants. The presentations include:

- Framing presentation: The role of practical knowledge for making change happen in a world with a rapidly changing climate;
- Case study 1: The Scottish Borders Climate Resilient Communities Action Research Project: concept, approach, outcomes and lessons;
- Case study 2: Weathering Change: concepts and practices for action;
- Case study 3: Urban Heat: action research and policy engagement for social change: a multi-level perspective (MLP).

Professionally facilitated dialogue (led by Prof Fazey) will then draw on the lessons from the projects to critically examine the kinds of research or knowledge flows needed to make change happen in a context of climate change. This will involve breakout groups and then sharing findings with all participants. Overall, the session will be of direct interest to academics and practitioners interested in learning about making change happen.

## **1. The role of practical knowledge for making change happen in a world with a rapidly changing climate**

Ioan Fazey, Centre for Environmental Change and Human Resilience (University of Dundee)

In a world with a changing climate significant societal change is inevitable. This will be either through rapid intentional transformative change implemented to meet globally agreed climate targets or through forced changes from increasing climate impacts. This raises a critical challenge for humanity: how can learning be accelerated about making transformative and desirable change happen? While research has excelled at identifying problems and solutions, it has had much less impact on developing 'know how' practical knowledge necessary for making societal change happen.

This presentation outlines the need, challenges and opportunities for engaging with more practical forms of knowledge for doing change in practice. A massive upscaling of approaches that focus on addressing 'how to' questions are urgently needed given the urgency of the climate problem. Three significant challenges are: (1) traditional separation of 'legitimate' knowledge production institutions (e.g. universities) from the domain of learning and practice; (2) the reluctance of research to engage in the messy world of politics, values and ethics that is naturally part of making change happen; and (3) lack of appreciation that practical know how knowledge is distinct from much of academic knowledge (e.g. getting hands dirty to develop experiential knowledge is more likely to develop knowledge about doing adaptation in practice than watching a powerpoint presentation).

Many of these challenges emerge, however, from assumptions about knowledge, knowing and action. For example, reluctance to engage in the world of action by scientists stems from assumptions that a researcher can be independent from what is observed. All scientists are, however, already actors of change. Their work inevitably shapes society in some way, and what they or their funders choose or do not choose to focus on has major implications. Given the urgency of climate change and the need for action, this issue can no longer be ignored: much greater focus on action and making change happen is urgently required.

Emphasis on boundary organisations and alternative forms of action-oriented projects that engage with different kinds of knowledge are rapidly increasing, in part because of societal demands for greater relevance of research to policy and practice. This provides exciting opportunities for shifting emphasis that recognises the importance of practice for informing how to make change happen. This also provides opportunities for wider shifts towards framing research in societal terms rather than research framing society.

## **2. The Scottish Borders Climate Resilient Communities Action Research Project: concept, approach, outcomes and lessons**

Esther Carmen, Centre for Environmental Change and Human Resilience (University of Dundee)

In the face of the multiple challenges directly and indirectly linked to climate change, it is essential that we work together to shape process to make change happen in different contexts and across scales. A holistic approach embedded within these processes is critical to improve community resilience in the long term. This framing for the development of change processes explicitly focuses attention not only on local issues but also the links between them, between practice and policy and the centrality of strengthening relationships from the outset. In this presentation we outline a process of change applied in three communities in the Scottish Borders and the learning gained to feed into the development of change process more broadly. By taking experiences of flooding as an entry point and by bringing together stakeholders from the local authority, other relevant organisations and local communities in a series of interactive workshops, local challenges directly and indirectly linked to climate change were explored and collaborative actions developed. Outcomes involved increasing community participation to develop wider community benefits including adaptation and mitigation actions in the design of a flood protection scheme and the development of new community groups supported by the local authority to respond to immediate challenges, such as weather related events, and to reduce local impacts in the longer term to support and strengthen communities. Through the process understanding about who is more affected by

climate change locally and how improved, as did recognition of the importance of broader issues that influence community resilience in the longer term, for example relating to rural development and urban regeneration, and the role of policy frameworks in helping and/ or hindering action at the local level. Furthermore, understanding between communities and organisations and about how more collaborative, action-orientated processes can be shaped at the local level also increased. Overall, the capacity of those involved in the process to continue to develop collaborative actions for improving community resilience has increased. By drawing on this process of change in the three communities, through interactive discussions with policy experts suggestions to strengthen policy and practice were identified to better shape local change processes for improved community resilience more broadly. Finally, key factors that may help accelerate change in future processes were identified, for example developing an effective transdisciplinary coordination team, the role of intermediaries and linking the process with existing local concerns and organisational initiatives.

### **3. Weathering Change: concepts and practices for action**

Russell Jones, Glasgow Centre for Population Health

‘Weathering Change’ is a collaborative action research project in north Glasgow, a part of the city which faces a wide range of social, environmental and economic challenges. A changing climate is likely to be a stress multiplier for residents already living at the sharp end of social and structural inequalities. The overarching aim of the project is to facilitate conversations between organisations and communities in order that they align existing activities and work together to respond positively to climate change.

An initial scoping exercise identified challenges and opportunities, existing community-led and public sector organisations, key strategies and initiatives and potential funding opportunities for the area. This was followed by several workshops to create a Theory of Change for increasing community resilience to climate change. The change model includes pathways for the concepts of individual capacity, community capacity, organisational capacity and urban regeneration, recognising there are linkages between all.

The project then developed into three work packages. Work package 1 involved engaging residents and community-led organisations to identify key local issues and opportunities to improve conditions through the lens of climate change. In work package 2, the findings from local communities were presented to organisations with a responsibility for regenerating the area and key themes were populated with current or planned initiatives. The third phase will seek to build consensus and commonality between community organisations, public agencies and local residents in developing climate adaptation initiatives. Success will rest in part on perceptions of organisational responsiveness to the aspirations and concerns of the community.

This presentation will discuss the change model, highlight the project’s findings and outline the facilitators and barriers to working together to address climate change for residents, community groups and organisations. Key learning includes the need to understand local community concerns and identify where addressing climate change sits alongside more immediate local priorities. Where activities are already taking place to address climate change, facilitating conversations between groups can be an important way of identifying shared priorities and opportunities to work together to support the climate change agenda. Encouraging greater community involvement in climate adaptation projects may be best achieved through highlighting its potential to address more immediate local concerns.

### **4. Urban Heat: action research and policy engagement for social change: a multi-level perspective (MLP)**

Ben Fagan-Watson and Kevin Burchell, Policy Studies Institute, University of Westminster

In this paper, we discuss two issues. First, we make the case that the multi-level perspective (MLP) (Geels) offers a model of change that can be used to both understand and inform practical interventions. Second, we comment on the ways in which ongoing policy engagement throughout Urban Heat was valuable.

The MLP views change as the interplay of developments at three levels: niche innovations, regimes (stable practices and rules in policy, science, technology, markets and society), and an exogenous landscape. In the context of this Session: action research projects can be understood as niche innovations; existing approaches to resilience and adaptation are the regime; and climate change itself is an exogenous factor. The MLP is useful because it identifies a range of actors, domains, relationships and processes that shape change. In the context of the 'Making change happen' session, by highlighting the stability of the regime, the MLP both offers an explanation for why many action research projects are internally successful but fail to have a wider impact, and emphasises the need for action researchers to also act on the regime directly, for example through policy engagement.

In many action research projects, policy engagement is at best a footnote. By contrast, in Urban Heat – with the objective of examining the potential role of the voluntary and community sector in local heatwave planning – both action research and local, regional (London) and national policy engagement were specified as central objectives and approaches. We undertook policy engagement while we were developing the project and in the early stages; this was invaluable because it enabled us to learn about the domain and to develop relationships to support later dissemination. As the project progressed, we shifted to dissemination. We conducted engagement through: research interviews, telephone conversations, email exchanges, our advisory board meetings, and presentations at other meetings. Through these activities, we were able to – within the project period – 'broker' new policy relationships across domains and levels, contribute to the design of a major policy workshop, contribute to the design of public communication materials, and introduce new ways of thinking into institutions which will hopefully be reflected in forthcoming policy strategies. Emphasising the importance of our action research, many policy stakeholders have told us that the value of our work specifically lies in its emphasis on practical action and giving voice to the 'community'.

## 2.5 Foresight in Climate Change Adaptation and Disaster Risk Reduction

*Rob Swart, Wageningen UR and Markus Leitner, Environment Agency Austria*

### DRR

1. Introduction (Rob Swart, Wageningen UR)
  2. What can foresight bring to the adaptation table - megatrends and surprises (Guillaume Rohat, UNIGE and Rob Swart, Wageningen UR)
  3. Foresight in action: Considering climate change impacts in the project planning practice in Austria – Scenario techniques and backcasting (Markus Leitner, Environment Agency Austria)
  4. Interactive discussion (Tiago Capela Lourenço, University of Lisbon)
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**Keywords:** Climate Change Adaptation, Disaster Risk Response/Reduction, Foresight, Scenarios, Megatrend

The session will address the question: How can foresight help to reduce vulnerability to climate-related hazards? In 2015, the Paris Agreement at COP21 on climate change and the Sendai Framework for Disaster Risk Reduction formed major steps towards increasing resilience to climate-related extreme events. Long-term risk and response analyses in support of these agreements and the IPCC assessments tend to be dominated by the development and formal analysis of Representative Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs). While such analyses are an important mechanism to advance analytical knowledge about future risks, they constrain creative analysis and there is a complementary role for more qualitative foresight developed by diverse experts and stakeholders to explore future risks and opportunities. Such foresight can strengthen both climate change adaptation and disaster risk reduction in terms of science, policy and practice, and also link with other international mechanisms such as the Sustainable Development Goals and explore the implications of the global agreements for European, national and local action. In this context, this session will:

- Explore the potential role of foresight methods, tools and processes to inform the implementation of the UNFCCC adaptation and Sendai disaster risk reduction mechanisms;
- Identify relevant long-term trends (global mega-trends) and surprise events and developments which would have implications for DRR and CCA
- Explore the needs and priorities of connecting climate change, disaster risk response, sustainable development and other communities with respect to foresight.

The session will start with two plenary presentations about the implications of megatrends for climate change adaptation and disaster risk management and about the potential role of foresight in supporting related policy development. It will then move to a world café setting addressing the three bullet points above, followed by a plenary wrap-up session. The convenors are interested to consider integrating submitted abstracts in the session programme.

### Significance to adaptation practice, policy and/or business

The session will explore opportunities to strengthen climate change adaptation and disaster risk response institutions and policy- and decision-makers to navigate a challenging and uncertain future, benefiting from each other's expertise and skills and supported by knowledge and experience from institutions, services and researchers in the area of foresight. It may be easier to integrate DRR and CCA in a more qualitative foresight kind of way than through the formal scenario analysis with large data sources to be connected that is the current practice dominating scientific policy support. It can provide complementary insights.



## **1. Introducing the session**

Rob Swart, Wageningen Environmental Research

Foresight in general is being used to learn from the past and for the future to avoid repeating mistakes today. So foresight means using the past and the future to inform strategic decision making today, the ability to take a forward view and use the insights gained in useful ways for disaster risk reduction (DRR) and climate change adaptation (CCA).

Very often we think that tomorrow is going to be more of today, and assume a “linear” future, but we are not prepared for the unexpected or the unfamiliar. Usually we do not systematically and deeply explore the long term future (beyond 20-30 years) to identify possible futures. Also we usually prefer quantitative over qualitative information and do not challenge assumptions about the future. Thus there is a potential of foresight in the field of climate change adaptation and disaster risk reduction that shall be explored in more detail, aiming for a reduction of vulnerability to climate-related hazards. In the field of climate change adaptation and disaster risk reduction we do see things happening. Now we need to analyse in more detail what seems to be happening, followed by the interpretation of what is really happening, but also looking at what might happen. This leads to more future-oriented thinking, when we have to decide what we might need to do. Based on this analysis, we will be better prepared and know about what we will do and how we will do it. The outcomes will enable institutions, practitioners, decision- and policy-makers to navigate a challenging and uncertain future.

## **2. What can foresight bring to the adaptation table - megatrends and surprises**

Guillaume Rohat (UNIGE) and Rob Swart (Wageningen Environmental Research)

This presentation synthesizes the results of a workshop on foresight in support of climate change adaptation and disaster risk management that was held in October 2016 in Vienna in the context of the PLACARD project (EU Coordination and Support Action in the Horizon2020 programme aiming at advancing collaboration between the two areas). The presentation will cover how current megatrends affect the risks of/vulnerability to climate change and extreme weather events and enhance the capacity to reduce these risks in three areas: Living and working (urbanization, technological change, magnitude and distribution of economic growth); Health and wellbeing (demographics, changing disease burdens and risks of pandemics, environmental pollution, pressures on ecosystems, climate change) and Safety and security (global competition for resources, migration, nationalism/polarization). In addition, in foresight it is important to think beyond megatrends: which surprise events or development could occur that would break or add to the megatrends that are currently considered? Finally, the presentation will cover the various methods and tools that are available to use foresight in the analysis of risks and opportunities for climate change adaptation and disaster risk management. If no relevant abstracts will be provided by the scientific abstract pertaining to the topic of this session, this presentation will be broken up in two 15 minute presentations.

## **3. Foresight in action: Considering climate change impacts in the project planning practice in Austria – Scenario techniques and backcasting**

Markus Leitner, Environment Agency Austria

This presentation synthesizes the results of a workshop on foresight in support of climate change adaptation and disaster risk management that was held in October 2016 in Vienna in the context of the PLACARD project (EU Coordination and Support Action in the Horizon2020 programme aiming at advancing collaboration between the two areas). The presentation will cover how current megatrends affect the risks of/vulnerability to climate change and extreme weather events and enhance the capacity to reduce these risks in three areas: Living and working (urbanization, technological change, magnitude and distribution of economic growth); Health and wellbeing (demographics, changing disease burdens and risks of pandemics, environmental pollution, pressures on ecosystems, climate change) and Safety and security (global competition for resources, migration,

nationalism/polarization). In addition, in foresight it is important to think beyond megatrends: which surprise events or development could occur that would break or add to the megatrends that are currently considered? Finally, the presentation will cover the various methods and tools that are available to use foresight in the analysis of risks and opportunities for climate change adaptation and disaster risk management. If no relevant abstracts will be provided by the scientific abstract pertaining to the topic of this session, this presentation will be broken up in two 15 minute presentations.

### **Facilitated interactive session on 3 key questions**

Tiago Capela Lourenço, Faculty of Sciences, University of Lisbon (FCUL)

An active discussion will be organized with the speakers and the audience on three questions:

1. Can you provide other examples (besides the ones presented already in the session) where foresight was used in the context of CCA-DRR, in particular developing or applying common methods and tools?
2. What are the characteristics of 'good' or promising foresight methods that can help integrate CCA-DRR (what, for whom, why)?
3. What are future research priorities to foster the development and use of foresight methods in CCA and DRR? How can PLACARD help?

### **Wrap-up and follow-up**

Markus Leitner, Environment Agency Austria

In the final plenary wrap-up session the conclusions from the world café session will be reviewed with an eye upon the potential follow-up. Is foresight a useful tool to support decision-making on for climate change adaptation and disaster risk management, and if so, how can the implementation in Europe be organized, improved and sustained? Which institutions and networks provide opportunities for follow-up?

## **1.2 Compiling adaptation-relevant data for climate services**

*Svetlana Jevrejeva, National Oceanography Centre, Liverpool*

### **Climate services**

1. Mapping tourism stakeholders' weather and climate information seeking behaviour in Fiji (Johanna Nalau, Griffith University)
  2. Impact of Climate Change on Pluvial Flash Floods in Austria (Simon Lumasegger, University of Innsbruck)
  3. Vulnerability and adaptation of cultural heritage to climate change: Case studies in UNESCO heritage sites in Scotland and Italy (Elena Sesana, University of The West of Scotland)
  4. Food security outcomes under a changing climate: impacts of mitigation, adaptation and development on vulnerability to food insecurity (Katy Richardson, Met Office)
  5. Climate risks and adaptation in cities: what does the self-reported data tell us? (Sara Telahoun, CDP)
- 

**Keywords:** information data, vulnerability, adaptation, decision-making, management

Every situation in which adaptation decisions may be required is unique, and frequently requires the application and interpretation of specific types of data and information. Climate services are increasingly being provided to cater for such information. In this session, presenters will illustrate how certain types of data and information have been compiled to facilitate straightforward application in impact and adaptation studies. Acquiring adaptation-relevant data is often considered somewhat difficult to achieve as such data may not be readily available or even some times protected by private or public companies as these may be seen as either controversial, unethical or of high economic value.

### **Significance to adaptation practice, policy and/or business**

The session will offer examples of how adaptation-relevant non-climatic data for impacts research can be compiled and used in support of adaptation measures. Some of the information has been missing in previous studies and hence now provides a new basis for applying adaptation measures; other information is still incomplete, making adaptation less practical in a practical implementation. The examples span multiple sectors and focus on widely diverging geographical settings.

### **1. Mapping tourism stakeholders' weather and climate information seeking behaviour in Fiji**

Johanna Nalau, Griffith University

Tourism is inherently dependent on the weather and climate and the sustainability and resilience of tourism is greatly enhanced by providing tailored climate services to tourism sector stakeholders. In particular, climate services need to integrate standard weather forecasts, with early warning systems, seasonal forecasts and long term projections of climatic changes - based on both scientific and traditional/local knowledge in order to meet the information needs of the sector. Recognizing the climatic vulnerability of tourism in marine environments, this research collected information on the weather and climate information systems of tourism stakeholders in the Republic of Fiji. The aim of the research was to better understand why stakeholders need weather and climate information, how they seek information and from where, and the kinds of constraints and enablers in this process in the context of private sector business planning in the Pacific. The research employed both deductive (top-down) and inductive (bottom-up) approaches in exploring the research themes. A literature review focused on tourism and climate services was undertaken, which guided the development of a semi-structured interview protocol. 15 interviews were undertaken with public and private sector operators and providers of climate

services in Fiji. The inductive data analysis identified three different models of information seeking behaviour that are of relevance to climate services and adaptation: Mediator-dependent, Independent, and Observational. These models were found to differ between stakeholders due to differences in users' lifeworld including professional responsibility, level of climate literacy, and information and digital competency. Understanding these diverse weather and climate information systems is necessary in order to better target different stakeholder groups within the tourism sector and their needs for climate services. Especially in the context of small island developing states (SIDS), more focus needs to be on the inclusion of traditional, local and scientific knowledge as information sources for climate change adaptation.

## **2. Impact of Climate Change on Pluvial Flash Floods in Austria**

Simon Lumassegger, University of Innsbruck, Unit of Hydraulic Engineering

Within in research project SAFFER-CC (Sensitivity Assessment of critical condition for local Flash Floods - Evaluating the Recurrence under Climate Change) the impact of climate change on local heavy precipitation events and the resulting flash floods is investigated. Pluvial flash floods are triggered by short, local convective cells with high precipitation intensities. The main difference to floods originating from rivers is that they can occur anywhere. Pluvial flash flood victims are usually surprised as they don't expect to be hit by a flood far away from rivers. Climate change influences pluvial flash flood generation through change of convective cell characteristics and change of antecedent catchment conditions for individual heavy rainfall events. Enabling the implementation of adequate and lasting adaptation measures to cope with pluvial flash floods requires assessing the risks not only for the present but also for the climate changed future.

The flash flood simulations were realized within a 2D hydraulic surface runoff model which can reproduce the behaviour of a hydrological model. Therefor a 2D-hydraulic model has been enhanced to define loss model and rain hydrograph at each mesh node (Klar et al. 2014). For the calibration of the flash flood models irrigation experiments on typical test plots were made, covering the most dominating land cover/soil type combinations in the catchments. To consider different preconditions in the pilot regions the same area was irrigated on two consecutive days and the measured discharge varied greatly depending on the preconditions. This underscores the relevance of considering altered preconditions in the climate change induced flash flood simulations.

Due to local characteristics, the small spatial scale and the sudden nature, pluvial flash floods are best managed by local authorities including the involvement of people at risk. In close cooperation with the state authorities in Upper Austria (Department Water Management and Flood Protection and the correspondent water districts) SAFFER-CC creates a precedence how the Austrian climate change adaption strategy can be implemented on municipal level. One of the main goals is to develop a standardized process for local flash flood assessment. The conservation of natural inundation areas is seen as one measures to manage the flood risk supported by zoning.

*Klar R., Achleitner S., Lumassegger S., Aufleger M., Hofer M. (2014): Extension and testing of a 2D hydrodynamic model for direct rainfall runoff simulation. HIC 2014 – 11th International Conference on Hydroinformatics New York, USA; 17 – 21 August 2014*

## **3. Vulnerability and adaptation of cultural heritage to climate change: Case studies in UNESCO heritage sites in Scotland and Italy**

Elena Sesana, University of The West of Scotland

Climate change already poses a challenge to the conservation of cultural heritage. Moreover, with climate change our cultural heritage will potentially be exposed to more pressures and new risks not previously experienced. Thus, management practices will need to be adapted to include those additional risks and vulnerabilities. Previous research investigating the connections between climate change and cultural heritage has focused on producing climate change risk maps at the European scale. However, for climate change to be incorporated into preservation frameworks and management practices from government policy level down to the practice in the

field, data, information, and assessment methods need to be available at a scale relevant to decision-makers. This paper reviews current structures in heritage management and identifies opportunities, barriers, and information requirements for mainstreaming climate change into conservation frameworks. For this purpose, semi-structured interviews were conducted with academics, professionals and experts in institutions associated with the management of cultural heritage as well as with the managers of two UNESCO heritage sites: New Lanark in South Lanarkshire, Scotland, and Crespi d'Adda in Capriate San Gervasio in the province of Bergamo in Italy. The data collected reveal gaps in knowledge on the relationship between the impacts of climate change, the management of the sites, and the best practice of conservation. Information requirements are highlighted and recommendations for best practice in considering climate change in the management of cultural heritage are suggested.

#### **4. Food security outcomes under a changing climate: impacts of mitigation, adaptation and development on vulnerability to food insecurity**

Katy Richardson, Met Office

Achieving and maintaining global food security is threatened by our changing climate, particularly in the most food insecure regions. However, effective translation of the impacts of climate change into food security outcomes is challenging. The Hunger and Climate Vulnerability Index framework (HCVI; Krishnamurthy et al 2014) was designed to address this challenge through evaluating the impacts of weather events (e.g. floods and drought) on national scale vulnerability to food insecurity in developing and least-developed countries.

Updates to the HCVI methodology have enabled the calculation of future projections of vulnerability to food insecurity under a range of emission, adaptation and development scenarios (Richardson et al, *in prep*). These updates to the framework enable direct translation of climate model projections into food security outcomes. The results provide evidence for the dual requirement of both mitigation and adaptation in order to avoid the worst impacts of climate change. They are directly applicable for use in adaptation and policy planning and are available on an interactive website designed for policy makers ([www.metoffice.gov.uk/food-insecurity-index](http://www.metoffice.gov.uk/food-insecurity-index)).

This talk will discuss the challenges faced in updating the index framework to enable future projections from climate model output, and also the development of scenarios of adaptation and development. Results from the future projections will be presented and discussed, along with limitations of the index output.

#### **References:**

Krishnamurthy, P. K., Lewis, K. and Choularton R. J. (2014) A methodological framework for rapidly assessing the impacts of climate risk on national-level food security through a vulnerability index. *Global Environmental Change*, 25, 121-132.

Richardson, K. J., Lewis, K., Krishnamurthy, P. K., Kent, C., Wiltshire, A. and Hanlon, H. Food security outcomes under a changing climate: impacts of mitigation, adaptation and development on vulnerability to food insecurity. *In preparation*.

#### **5. Climate risks and adaptation in cities: what does the self-reported data tell us?**

Sara Telahoun, CDP Worldwide

What risks are cities telling us are the most serious? Do the trends we are seeing in perception and city-level planning match up with the models? CDP's presentation will summarise key findings from their cities disclosure in 2016 and previous annual cycles from 2011, including key findings of the global analysis published in October 2016. It will go on to cover the highlights of self-reported 2016 data on climate risks and adaptation from over 500 cities spanning 89 countries worldwide, and a look at the data from 126 European cities that reported, comparing them to global trends.

CDP will also provide insight into what mechanisms are out there for cities to work with the private sector to get their projects funded, and what the city-investor program has learnt about helping investors navigate the climate investment opportunities that cities offer.

## 4.8 Local adaptation pathway design in practice. Gaining flexibility and managing uncertainty in the long-term climate resilience planning

*Maddalen Mendizabal and Efren Feliu, Tecnalía R&I and Kristen Guida, London Climate Change Partnership*

### Pathways and transformation

1. Integrated adaptation pathways in London (Tim Reeder, LCCP)
  2. Adaptation pathways in practice: mapping options and trade-offs for London's water resources (to be confirmed)
  3. Transferring the pathway approach in new local adaptation processes in the framework of the FP-Ramses project, experiences and outlook from Antwerp (Maddalen Mendizabal, Efren Feliu, Tecnalía R&I)
  4. Dynamic Adaptive Policy Pathways. Lessons learnt from the Rhine Delta case (Marjolijn Haasnoot, Deltares)
  5. Adaptation turning points: long-term sustainability of water supply under climate change in the Pearl River Delta, China (Saskia Werners, Wageningen UR)
  6. Adaptation tipping points for flood risk reduction actions in Europe (Laurens Bouwer, Deltares)
  7. Facilitated discussion (All)
- 

**Keywords:** dynamic adaptive strategy, policymaking, flexible-planning, route-map, actions, timing, decision points, uncertainty.

The session will focus in one important aspect for the adaptation planning which is the flexibility. That is, the adaptation planning need to be built in flexibility through a combination of different methods: consider measures to be implemented in near-term, while leaving open the option to scale up action in the future (Ranger et al., 2013). This “buys-time” to monitor and learn before making a major investment; incorporate “structural” flexibility; update with new climate and socio-economic information, provides an appropriate framework in situations where goals are many and broad, social-ecological systems are complex and highly dynamic and trajectories are unpredictable (O’Connell et al., 2015).

An adaptation pathways approach incorporates flexibility to cope with a variety of possible future conditions and therefore contributes to the development of dynamically robust plans (Kingsborough et al., 2016). The idea of the adaptation pathway is to design ‘packages’ of adaptation measures that can be implemented over time. A pathway not only lays out the options, but also provides information on when and how decisions should be made. Crucially, it is used to identify a set of a decision points, triggering specific options or pathways, conditional on observations of the selected indicators (Ranger et al., 2013; Reeder and Ranger, 2010).

However, pathway approach has been applied in few cases (e.g. London, New York, Rhine-Meuse delta, Lake IJssel) and need to be further developed to apply in different sectors and contexts. The session aims to answer important questions related to the adaptation pathway approach: would be reasonable and feasible for municipalities to develop integrated pathways covering various sectors at the same time? Is it possible to harmonized/standardized the pathway design? What we need to improve the actual pathway approach? Is this approach transferable and useful for the local authorities?

### Significance to adaptation practice, policy and/or business

This approach could help decision makers to identify timing and sequencing of possible adaptation pathways over time, allowing to define “decision points” (“triggers” or “adaptation tipping point”) when an action no longer meets the specified decision criteria (Haasnoot et al., 2013; Kwadijk et al., 2010b; Rosenzweig and Solecki, 2014;

Walker et al., 2013a; Werners et al., 2013). Therefore, by including this “triggers” or “decision points”, the plan would be adjusted or redefined (Haasnoot et al., 2013; Reeder and Ranger, 2010). The selected approach is appropriate to address the deep uncertainty inherent to climate adaptation and linked to other external factors like economy or societal trends.

### **Session introduction**

Maddalen Mendizabal<sup>1</sup>, Efren Feliu<sup>1</sup> and Kristen Guida<sup>2</sup>, <sup>1</sup>Tecnalia R&I, <sup>2</sup> London Climate Change Partnership –”

Introduction of the session, presenting a systematised framework and methodological approach based on the analysis of existing real operational adaptation pathways, as well as introductory research questions that should frame presentations and inspire reactions from different speakers of the sessions.

### **1. Integrated adaptation pathways in London**

Tim Reeder, LCCP

Adaptation pathways have demonstrated potential to contribute to developing a long-term plan for heat-risk, water supply and flood risk in London. Initial work has been carried out to integrate the pathways and the London Climate Change Partnership has the development of such integrated pathways as an important aim. The challenges and opportunities surrounding this will be outlined.

### **2. Adaptation pathways in practice: mapping options and trade-offs for London’s water resources**

(presenter to be confirmed)

Adaptation involves sequences of decisions that weigh up climate risks, costs and uncertainties. Analysis of sequential adaptation decision ‘pathways’ helps to demonstrate how climate risk can (or cannot) be managed, whilst retaining the flexibility to respond to future uncertainties. Whilst an adaptive planning paradigm has gained increasing attention, the uptake of such methods has been relatively limited compared to that of the scale of adaptation that is required around the world.

London’s ability to remain a world-leading city in an increasingly globalised economy is dependent on it being an efficient and low risk place to do business. However, climate risk from flooding, overheating, water scarcity and supply chain exposure is increasing. The Mayor of London has identified anticipatory adaptation as a cost-effective strategy to increase the long-term resilience of the city. However, in practice the allocation of scarce resources needs to be justified by the benefits of climate risk reduction.

We present a quantified assessment of how risk of water shortages varies dynamically for adaptation pathways through time, demonstrating how transient climate projections can be used to extend water resource planning horizons to 2100. The analysis identified a number of pathways capable of maintaining the probability of exceeding a target frequency of water use restrictions below a probability of 0.01 per year (which is thought of as the limit to tolerability), through to 2100 under a medium emissions scenario. Without further adaptation, the probability of water shortage will increase beyond what stakeholders are likely to consider tolerable.

This approach has helped to reconcile multiple decision timescales and demonstrate the value of strategic long-term planning for climate change adaptation to stakeholders by outlining long-term futures that may influence medium-term decision-making. Adopting a flexible approach to adaptation will be critical to the management of risk under uncertainty. This adaptation pathways approach demonstrates an effective framework for informing such decision processes.

### **3. Transferring the pathway approach in new local adaptation processes in the framework of the FP-Ramses project, experiences and outlook from Antwerp**

Maddalen Mendizabal<sup>1</sup>, Efren Feliu, Tecnalia R&I, and Gerardo Sanchez Martinez, World Health Organization



Adaptation cannot be solved through a single action, but is rather a process to be managed over time. Extending and consolidating this thinking, the idea of adaptation pathways has recently emerged as a way to guide adaptation decisions into the future and widely applied in London (to handle heat-risk, water supply and flood risk in a climate change context). These experiences have served to improve the methodological definition of the adaptation pathway, but still some questions remain open: Would be this approach applicable in other city-context (e.g. cities with different climatic, socio-economical and institutional conditions)? Therefore, how can we transfer the London's Adaptation Pathways experiences to other local adaptation processes? To answer this question a transferability exercise is conducted in the Antwerp municipality. Previous research suggests an increase in heat-related health outcomes in the absence of adequate preventive action. Adopting a long-term approach is a specific recommendation of the WHO guidance on HHAPs (Heat Health Action Plans). Taking this recommendation, the process towards a HHAP framework will be guided by the adaptation pathways approach in the case study. One important element of the heat-health adaptation pathway is the timeframe of the actions: to effectively protect health from heat, some actions need to be implemented periodically, once a year or several times a year (e.g. training, public health advisories, etc.). There are also short and medium term strategies that aim to reduce the indoor heat exposure, increase the care for vulnerable population groups and the preparedness of the health and social care system. Importantly, there are necessary long-term actions such as adapting the built environment and ultimately reducing the settings' own GHG emissions to mitigate climate change. All of these perspectives (short, medium and long term perspectives) are covered in the HHAP, and the adaptation pathway approach helps organising their deployment.

#### **4. Dynamic Adaptive Policy Pathways. Lessons learnt from the Rhine Delta case**

Marjolijn Haasnoot, Deltares

#### **5. Adaptation turning points: long-term sustainability of water supply under climate change in the Pearl River Delta, China**

Saskia Elisabeth Werners, Dan Yan, Mingtian Yao, Ronald W. A. Hutjes (Wageningen UR), HUANG Heqing, Institute of Geographic Sciences and Natural Resources Research in China.

Concerned decision-makers increasingly pose questions as to whether current management practices are able to cope with climate change and increased climate variability or whether alternative strategies are needed. Climate research has typically focussed on assessing the extent of climate impacts. Yet, at least equally important is the question for how much longer current policies and management are expected to suffice and when adjustments will be required.

In this paper, a methodological approach for identifying the policy implications of climate change is first presented and then applied to coastal management in the Pearl River Delta, China. This approach focuses on the identification of situations where policy objectives and societal preferences are compromised by climate change. We call this situation an 'adaptation turning point'. The assessment of adaptation turning points translates uncertainty about the extent of climate impacts into a time range over which it is likely that specific impacts occur and which can be used to take adaptive action. This paper will discuss the theoretical basis (how to define, identify and quantify adaptation turning points) and case evidence of adaptation turning points in China. The paper hopes to contribute to the ongoing debate on adaptation to climate change in the Pearl River Delta by focusing on the specific situation where, due to climate change, the long-term sustainability of water supply is at risk. We aim to identify when safe water supply may be compromised by climate change, and the time window available for adaptation. Next, we map adaptation pathways. Here we will bring in experience from the Netherlands and other Deltas around the world where responses to climate change are under preparation. We discuss the appropriateness of these responses in the Chinese context.

Experience so far is that expressing uncertainty in time (when will a critical point be reached) is easier to understand for stakeholders than the more typical presentation of the amount of change in a certain projection

year. In addition, the assessment allowed for a meaningful dialogue between stakeholders and scientists about the amount of change that is acceptable, when conditions could be reached that are unacceptable, how likely these conditions are and what adaptation pathways to consider.

## **7. Adaptation tipping points for flood risk reduction actions in Europe**

Laurens M. Bouwer (Deltares), Marjolijn Haasnoot (Deltares and TU Delft), Andreas Burzel (Deltares), Hessel C. Winsemius (Deltares), Philip J. Ward (IVM, VU University Amsterdam), and Ad Jeuken (Deltares)

Large scale flood risk analysis could inform priority setting within and between countries for international finance institutions, as well as intergovernmental organisations. For this reason, risk models at the global scale are increasingly developed to assess current and future flood risk at scales large than the typical (national) domain. The problem of flooding at the European scale has received much attention in research by ways of modelling impacts of projected changes in precipitation, as well as impacts and costs of adaptation. Few studies however have analysed the timing of impacts in different parts of Europe, or compared costs and benefits of different flood risk reduction measures at the European scale.

Here we analyse riverine flood risk acceptability at the country level in Europe. Acceptability is measured using the adaptation tipping point (ATP) approach to assess ranges in the timing of reaching critical levels of flood risk and opportunities for action in the different European countries. Two types of tipping points are addressed, impact tipping points and economic opportunity tipping points. Impact tipping points occur if the flood risk exceeds a specified level. Additional or other actions are needed to achieve the specified objectives in terms of flood risk. Economic opportunity tipping points occur if the costs of the actions are less than the avoided damage. As such they are an indication that there is an opportunity to take action. To assess the timing of these tipping points for different climate change scenarios, the projected increase in flood risk under the RCP4.5 and RCP8.5 scenarios is used as an indicator for impact tipping points in a “do-nothing” scenario. The impact ATP is based on either flood risk (annual expected damages) as 0.2% of GDP, or an increase in risk of 50% or more. The assumption is made that if the risk (costs) – which may be actual or perceived, based on flood risk analysis – get higher a change of the current flood risk management strategy is necessary. We find that some countries already today have reached the 0.2% of GDP impact tipping point threshold for flood risk. Some countries will reach the absolute level of an increase in risk of 50% or more relatively late in the 21st century, which is mostly due to the already high risk that is estimated for these countries today.

Next, we estimate economic opportunity adaptation tipping points by finding the year in which the net present value of the benefits of two separate interventions are positive. The two measures that are explored are dike protection and adapted building. For dike protection, for the majority of European countries it is economically beneficial to adapt by investing in dike protection, already in the first half of the 21st century, assuming a discount rate of 1% per year for benefits and costs. These investments are more than just keeping up with increased hazard from projected climate change, and also include increasing current flood protection standards to a minimum of 100-year return period across Europe. Adapted building however is relatively costly, and is only economically beneficial for some countries. At discount rates of 3% and 6%, improved dike protection is not attractive until later in the 21st century for a considerable number of European countries. Adapted building is only attractive in a minority of European countries during the 21st century, when a discount rate of 6% is applied. This information provides a first order estimate of projected impacts as well as opportunities to take action, and can be used to develop adaptation pathways at the European scale.

### **Panel discussion**

Maddalen Mendizabal<sup>1</sup>, Efren Feliu<sup>1</sup> and Kristen Guida<sup>2</sup>

<sup>1</sup>Tecnalia R&I, <sup>2</sup> London Climate Change Partnership

Facilitated discussion involving the presenters, including questions and contributions from the audience, on pathway approach. Some questions will be:

- Most of the real pathway applications have sectorial approach (water supply, heat ...), would be reasonable and feasible for municipalities to develop integrated pathways covering various sectors at the same time?
- Which are the similarities between the different adaptation pathways presented? Is it possible to harmonized/standardized the pathway design?
- What do we need to improve the actual pathway approach?
- Is this approach transferrable and useful for other local authorities?

## 6.12 Objectives and guidelines in urban design to adapt to the risks of urban heat

*Lisette Klok, University of Applied Sciences Amsterdam and Mendel Giezen, University of Amsterdam*

Urban, energy & infrastructure

Health

1. Short introduction on the topic and aim of the session (Lisette Klok and Jeroen Kluck)
  2. Presentation from practice: Utrecht (Erwin Rebergen)
  3. Presentation from practice: London (Michael Forrester)
  4. Workshop 1: Interactive gathering of practical objectives and guidelines from the public
  5. Presentation from practice: Stuttgart (Silke Drautz)
  6. Presentation from practice: Milan. Measures to contrast the urban heat island in a consolidated urban environment: Towards effective and realistic strategies at city level (Eugenio Morello, Politecnico Di Milano)
  7. Workshop 2: Interactive discussion (All)
- 

**Keywords:** Urban resilience, urban heat, heat stress, guidelines, adaptation measures, green

Heat is one of the climate adaptation issues that is still rather unknown at the local governmental level in many countries. Many municipalities struggle with the question if and how to adapt to heat stress in cities. Moreover, clear objectives or guidelines for dealing with this aspect of climate change are lacking. Nevertheless, more and more cities feel the urgency to act and to address both the risks of rising temperatures in cities.

Different types of adaptation measures exist to reduce the impacts of heat stress in cities: soft adaptation measures (a heat action plan), adaptation measures focusing on indoor climate (ventilation, insulation) and measures in the urban environment. In this session, the focus will be on the adaptation to heat in urban design and planning, which is necessary to reduce the impacts of urban heat on longer timescales and to keep cities liveable at rising temperatures. A range of green and grey measures is available to adapt the urban space to urban heat: parks, trees, green walls, green roofs and urban shading elements. The next step is to actually implement these measures. But how do local governments design their urban spaces and adapt to heat in practice? Which measures are necessary? And how many green areas, trees and cool places need to be realized to become resilient to urban heat now and in the future? What are the maximum temperatures that are tolerable and what is the temperature reduction desired to keep cities liveable? Can adaptation to heat be translated into preconditions for urban design and into quantified standards?

The aim of this session is to discuss the need and objectives in urban design to adapt to the risks of urban heat. Together with professional from different climates and cities, we aim to answer the question if adaptation to heat can be translated into preconditions for urban design and into quantified standards. The session will start with presentations of four cities in Europe (Utrecht, London, Stuttgart, and Milan) about their aims and experiences on heat adaptation in urban design. After the presentations, we will gather experiences from the audience and engage a discussion on what is desirable and feasible in adapting cities to heat. Based on the results, we aim to come up with an overview of practical objectives and guidelines that cities could use as a starting point for adaptation to heat.

### **Significance to adaptation practice, policy and/or business**

Together with professional from different climates and cities, we aim to answer the question if adaptation to heat can be translated into preconditions for urban design and into quantified standards. Based on the results, we aim to create an overview of practical objectives and guidelines that cities could use as a starting point for adaptation

to heat. This session is significant for urban professionals from local governments dealing with adaptation to urban heat. Many of them struggle with the question if and how to adapt to heat stress.

### Format of the session

The format of the session will include four presentations and two small workshops:

- Short introduction on the topic and aim of the session (University of Applied Sciences Amsterdam) – 15 min;
- 1<sup>st</sup> presentation from practice – Utrecht – 10 min;
- 2<sup>nd</sup> presentation from practice – London – 10 min;
- Workshop 1: Interactive gathering of practical objectives and guidelines from the public (20 min);
- 3<sup>rd</sup> presentation from practice – Stuttgart – 10 min;
- 4<sup>th</sup> presentation from practice – Milan – 10 min;
- Workshop 2: Interactive discussion with audience and presenters to answer the question ‘Can adaptation to heat be translated into preconditions for urban design and into quantified standards?’ – 10 min; and to create an overview of practical objectives and guidelines for adaptation to heat. – 30 min.

### Presentation from practice 1: Utrecht

Erwin Rebergen, Municipality of Utrecht

The population of Utrecht will grow from 330.000 inhabitants to 400.000 in 2030. For this reason and to meet the ambition of the city to densify rather than enlarge the city, (industrial) sites will be transformed into residential areas. One of these sites is the City Island: an area with a perimeter of 11 km, surrounded by two canals. With an eye on climate change and quality of life – and within Utrecht’s vision of healthy urban living – the city aspires to optimise and utilise the green and blue infrastructure of the island as much as possible.

One of the pilot areas in the City Island is **Kanaleneiland**, a deprived neighbourhood characterized by social challenges. This area will be redeveloped by new buildings, renovation and refurbishment of buildings and public space. The main goals of this pilot-area is to strengthen the green infrastructure to counter the heat stress and to enlarge the infiltration capacity of the paved areas. The central area of the City Island is **Transwijk**. Part of Transwijk is highly paved, and belongs to the “hotspots” with regard to the Urban Heat Island effect in Utrecht. A big park area is situated in the southern part of Transwijk. This park is the central park of the City Island. The aim is to maintain and strengthen the important function of the park as a cool spot for the City Island, and to enlarge the positive effects of this to the surrounding areas by strengthening the green and blue infrastructure with the surrounding area. Both pilot areas have clear adaptation ambitions (see table below) in terms of heat and water resilience that will be presented and discussed.

Transwijk Area	‘Kanaleneiland’
100 trees and 2 ha less paved area by reduction of 3,5 km main roads	Redesign and ‘green’ the public space in four areas (400 trees)
Enhance the water storage capacity with 0,3 ha (600 m length by 5 m wide).	Redesign the public space to reduce the paved surface and enlarge the infiltration capacity (3 ha)
Reduce the paved area and enlarge the infiltration capacity, 5 ha of paved area.	Create green roofs on two locations (2,400 m <sup>2</sup> )
Create 5.000 m <sup>2</sup> of green roofs (4 roofs of flat	

buildings)	
Adding green parks and open soils (inner areas of 6 building blocks) and planting of 180 trees.	

### **Presentation from practice 2: London**

Michael Forrester, London Borough of Lewisham

The Greater London Authorities (GLA) Green Infrastructure Task Force Report mentions the cooling effect that green infrastructure can make and describes this effect as the reason for an urban greening policy in the current London Plan. As one of 32 London boroughs, officers from Lewisham Council will explore the impact of the report on current practice, the crossover with other disciplines and departments and whether there has been any noticeable changes to temperature in the area over the past few years.

Current local understanding is limited, yet the ongoing regeneration of Lewisham provides opportunities and challenges in balancing the built and natural environments. Can new green/blue spaces, living roofs and tree planting offset the impact of high density housing and transport projects?

Our presentation will look at the questions raised in delivering national or regional policy at a local level, how it is understood and how local actions deliver wider climate change objectives. In particular we will look at the following issues raised by the GLA Task Force Report;

How does the greening policy impact local practice and delivery?

- What is Policy 5.10? How is it implemented?
- What are the implications for Lewisham, and the desired effects?
- How is the Mayor going to increase the green cover in practice?
- What are opportunity areas, and what are the exact targets in greening the city?

Responding to these questions will give Lewisham staff the opportunity to explore the impact of heat islands in the borough and learn from others the best policies and methodologies to implement.

### **Workshop 1: Interactive gathering of practical objectives and guidelines from the public**

### **Presentation from practice 3: Stuttgart**

Mrs Silke Drautz, Department for Urban Climatology in the Office for Environmental Protection, City of Stuttgart

The municipality of Stuttgart has operated a Department for Urban Climatology within the Office for Environmental Protection since 1938. Its function is to take into account climate in city planning and to make sure that the local climatic situation will not be deteriorated by city planning. According to the German Federal Building Code climate and air pollution have to be taken into account in all kinds of planning. The anthropogenic changes of global climate underline the importance of these efforts. The Department for Urban Climatology enjoys an excellent international reputation and serves as a model.

The presentation first gives a short overview on the basic data and tools used by the urban climatologists in Stuttgart. These tools include measurements of climatic elements as well as calculations with numerical models and some spatial investigations such as tracer gas investigations and infrared thermography by airplane. To implement urban climatology in urban planning a climate atlas with maps of basic data and with recommendation maps for the planners was developed.

The presentation mainly focusses on how to adapt to heat in practice. To reduce the increasing number of days with heat stress and thermal discomfort in Stuttgart green areas, green roofs, green facades, trees in the streets and green rails of the public traffic are important. An important factor also is the construction of public spaces according to climatic needs. On the other hand it is important to take care of the local nocturnal cold and fresh air flows from the surrounding country into the city centre. Within the Stuttgart region with only low wind speeds these thermally induced winds very often are the only possibility for cooling ventilation. From the long-time experience in Stuttgart the presentation also outlines questions such as to prefer some large green areas or many small ones and the need for quantified standards which temperatures or number of days with heat stress are tolerable.

**Presentation from practice 4: Milan. Measures to contrast the urban heat island in a consolidated urban environment: Towards effective and realistic strategies at city level**

Eugenio Morello, Ph.D. , Polytechnic University of Milan

European cities are facing urgent challenges to contrast and adapt to climate change. If it is true that technical solutions are available in architecture and urban design to mitigate thermal discomfort in cities, nevertheless their application to the existing built environment is difficult. Both the building stock and the public space are hard to change because of economic issues, preservation rules, building code's limitations. Recently, numerous cities have launched ambitious programs to intervene to limit the effects of the urban heat island, mainly focusing on large scale applications of greening and cooling strategies. The question is if these measures are actually giving sound results, or if these visions risk to become greenwashing slogans in the long term.

On the basis of a real case study application on a mid-temperate urban area in Europe, this presentation has a threefold aim: firstly, it provides a general state-of-the-art on the local measures in place aimed at contrasting the urban heat island effect, both on new construction and existing built environment, in order to address the current engagement of the city on this urgent topic; secondly, it tries to quantify and assess the feasibility of urban greening and cooling strategies applied to the whole city, in order to assess the potential relevance in terms of quantification and distribution of such measures; finally, it proposes simplified tools and strategies for a feasible intervention to be proposed to the city governance to be included as part of the climate action plan and to the local building codes. A critical position for envisioning realistic measures that originate from the physical constraints and resources in the city is the final expected outcome.

**Workshop 2: Interactive discussion**

## 2.4 Community-based adaptation planning

*Robert Dunford, University of Oxford/ Centre for Ecology & Hydrology*

### Participation and co-production

1. Community based adaptation pathways to adaptation to salt intrusion in coastal Bangladesh (Saskia Werners, Wageningen UR)
  2. From “climate change vulnerability” to “climate risks” – implications of the new IPCC approach for research and adaptation planning (Marc Zebisch, Eurac Research)
  3. Processes for embedding the voluntary-community sector (VCS) in local community resilience planning in times of ‘austerity’: successes and challenges. (Kevin Burchell, University of Westminster)
  4. Assessing coupled social-climate dynamics to cope with High-End Climate Change (HECC) in Iberia. The case of the Tagus River Basin. (J. David Tabara, Autonomous University of Barcelona)
  5. Fairbourne: Adaptation beyond Engineering (Lisa Marshall, Gwynedd County)
- 

**Keywords:** Participatory approach, community, adaptation

Adaptation planning provides significant challenges and provides some new opportunities – but it raises a lot of questions. How do we (and can we) adapt to climatic and environmental changes? Who would need to do what and by when? To what extent are the suggested changes possible and do people agree? This session addresses many of these questions by drawing on real-world case studies at a range of scales and from different locations around the world. It highlights the role of participatory approaches as a means to prepare for uncertain futures and demonstrates how they have been applied to engage a range of users, adaptation challenges and resource conflicts. The session aims to draw out the case-based lessons learnt in terms of both challenges and opportunities, and identifying differences that result from different conceptual approaches to vulnerability and risk.

### Significance to adaptation practice, policy and/or business

The session provides practitioners, policymakers and businesses with a number of practical examples where adaptation planning has drawn on participatory planning in real case studies.

#### 1. Community based adaptation pathways to adaptation to salt intrusion in coastal Bangladesh

Saskia Werners, Wageningen UR

The country Bangladesh is situated in the Ganges-Brahmaputra-Meghna (GBM) delta. Sea level rise in combination with reduced dry season flows and river engineering are projected to add to salt water intrusion in the ground waters and soils. In the coastal areas salt intrusion makes it increasingly difficult for farmers to grow rice and farmers look for ways to cope. Among the adaptation measures are canal re-excavation, using salt tolerant crop varieties and crop diversification. Another option is to switch to shrimp culture, which farmers turn to due to salt intrusion as well as high economic return. This shift is causing social tension and poses a threat to the rice farmers, as shrimp cultivation requires brackish water and farmers are found to actively let brackish water into cultivated areas. The question arises which adaptations measures and farming systems will be sustainable under climate change. (When) should present farming systems shift? What are possible adaptation pathways and are these equitable?

In this paper, we use adaptation pathways to map how different actors would prefer to adapt to increasing salinity. We take data from Satkhira, one of the coastal districts of south-western Bangladesh and most vulnerable to salinity intrusion. Four villages of Satkhira district were selected as the study area and data was collected by household survey, semi-structured questionnaire, focus group discussions and expert interviews. Salinity level in this district rose sharply over the last few decades, which substantially affected rice cultivation, and shrimp



farming is on the rise. We observe that adaptation pathways vary among different water users depending on their socio- economic status and their capacity to participate in adaptation. There is disagreement among stakeholders about the salinity issue and desired adaptation pathway. Shrimp farmers are richer and more powerful than rice farmers and do not frame the salinity issue as a problem. They indicate crab cultivation as an option to cope with even higher salt levels. Expert's adaptation pathway focuses on sustainable land-use planning whereas small farmers and landless people prefer to continue to grow rice or feel forced to migrate from the area.

## **2. From “climate change vulnerability” to “climate risks” – implications of the new IPCC approach for research and adaptation planning**

Marc Zebisch, Eurac Research

The IPCC's approach to understand vulnerability to climate change as published in the Fourth Assessment Report (AR4) in 2007 has been used as conceptual basis for a large variety of studies dealing with climate change impacts and adaptation. Based on the conceptual progresses made through the IPCC report on managing the risks of extreme events (SREX 2012), the latest IPCC assessment report (AR5 published in 2014) has introduced a new approach using a revised terminology, particularly the notion of 'climate risk'. This new approach overlaps greatly with the traditional way to address risks to natural hazards. It represents an implicit transformation from a rather future oriented understanding of an all-encompassing 'vulnerability to climate change' towards a contemporary view of 'climate risk', in which 'vulnerability' represents (only) one of several crucial components. We argue that this conceptual transformation has a great impact on the overall approach to address climate related effects and adaptation activities. Consequently, studies that aim at assessing the risk to climate change need to consider this transformation when designing their research methods. Our analysis shows that there are strengths and weaknesses related to the old and the new IPCC approaches. We claim that the risk-related concept of the AR5 helps to overcome some of the typical pitfalls of the AR4 approach that were often hampering respective studies addressing climate change vulnerabilities. Finally, we propose some conceptual refinements related to the AR5 approach and recommend a list of issues to be taken into account when carrying out climate risk studies in practice.

## **3. Processes for embedding the voluntary-community sector (VCS) in local community resilience planning in times of 'austerity': successes and challenges**

Kevin Burchell, University of Westminster

The objective of this paper is to highlight the successes and challenges that we experienced when implementing an experimental action research process designed to more fully embed the voluntary and community sector (VCS) in local community resilience planning and implementation. The process was built around theory relating to: the importance of local and experiential knowledge, the distinctive capabilities of the VCS and the importance of relationships between the VCS and local statutory bodies. Due to its position as a relatively novel and neglected issue, the project focused on heatwaves; the results are more broadly applicable. We implemented the process in three one-year, London-based case studies. Three key outcomes can be identified:

Three participatory workshops. In workshops 1 and 2 we worked with a total of 42 local VCS groups to develop novel ideas for community resilience. In workshop 3, some of the VCS groups shared their ideas with local policy stakeholders. This element of the project was very successful. The VCS groups were able to meaningfully engage with the heatwaves and heatwave planning, were able to identify local resources and challenges, and develop novel ideas for community resilience (relating to local relationships, communications and resources). For their part, the local policy actors valued the ideas of the VCS groups, and were keen to develop deeper relationships

Local policy engagement designed to further embed the ideas of the VCS groups in local policy and practice. Although we experienced some successes, this was far more challenging. To a considerable extent, these challenges were not related to the ideas themselves, but rather to the question of who – from both the VCS and

statutory sides – could drive the agenda forward; everyone who we worked with spoke of reduced capacity and capability within the context of ‘austerity’ and budget cuts.

Ongoing national policy engagement designed to embed the ideas behind the project and the ideas of the VCS groups in national policy and guidelines. Although it obviously takes time for this to happen, this element of the project was also successful in terms of national policy stakeholders (for instance, in PHE, Cabinet Office, the GLA, Defra) responding with enthusiasm to our emerging findings and recommendations.

The project also illustrated the ways in which researchers can act as ‘honest brokers’, facilitating productive new relationships between: the local public and VCS sectors, different national policy organisations, and national and local policy actors.

#### **4. Assessing coupled social-climate dynamics to cope with High-End Climate Change (HECC) in Iberia. The case of the Tagus River Basin.**

J. David Tabara, Autonomous University of Barcelona

Latest trends in global GHG emissions and global mean temperatures show an increasingly possibility to enter into a trajectory of High-End Climate Change (HECC) which is bound to have strong negative effects on Iberian river basins. The Tagus River Basin is one of the most important strategic water and energy sources for Portugal and Spain. The over-regulation, the construction of new dams and abstraction channels, growing electricity and water supply demands, as well as large inter-basin water transfers, all of which is aggravated by aridity and strong natural climate variability, have already imposed significant pressures on the river. The substantial reduction of discharges, dropping to zero in some parts of the catchment are already being observed now, while projected global climate change is expected to alter the water budget of the catchment even further. In this research, we show the impacts of coupled moderate (RCP4.5) and high (RCP8.5) global warming scenarios with downscaled global Shared Socio-Economic Pathways (SSPs) in Iberia, which have been obtained in a participative way. We assess their coupled effects on the Tagus water availability and on water management infrastructure together with the potential strategies to cope with HECC. This research is part of the EU project IMPRESSIONS ([www.impressions-project.eu](http://www.impressions-project.eu)).

#### **5. Fairbourne: Adaptation beyond Engineering**

Lisa Marshall, Gwynedd Council

**Keywords:** Adaptation, climate change, coastal, flooding, sea level rise, social impact, economic impact, planning.

Fairbourne: Moving Forward is a multi-agency project addressing the complex issues and problems identified throughout the journey of the community over the next 40 years (from 2014) whilst implementing the Shoreline Management Plan (2).

It has always been recognised that the problems faced by Fairbourne push the boundaries of existing practice and as such the project has had to develop incrementally in developing a workable approach. While the situation at Fairbourne is at present quite unusual, it is not and will not in the future be unique. As such, and while recognising that the project must focus on the challenges faced by the community, the project raises many issues that need to be examined at a broader scale, offering the opportunity to learn from, discuss and resolve approaches to future sustainable management of coastal risk around the Welsh coastline. This is reflected in the recent publication of a report by the UK Committee on Climate Change (July 2016).

Using the five principles of sustainable development within the Wellbeing of Future Generations (Wales) Act 2015, the project initially addressed issues such as home insurance, house prices, supporting the economy and impact on health, all underpinned by a robust and highly effective and inclusive community engagement strategy.

The project now focusses on two key strands; the Masterplan (the plan to decommission the village over a long period of time) and the Community Interest Company.

The Masterplan takes an alternative look at adapting to climate change on the coast, broadly summarised as follows:

- a) Modelling of sea and groundwater levels over a period of 40 years (from 2014) including rainfall data.
- b) Analysis of the effect these natural processes will have on the built and natural environment in addition to economic and social infrastructures.
- c) Researching and devising solutions to the problems identified above.
- d) Producing a programme to implement solutions over a period of 40 years.

The Community Interest Company (CIC) is a social justice-based model, facilitating choice by allowing homeowners to leave the village by selling their home to the CIC and the CIC would then rent these homes to disadvantaged or vulnerable residents.

The technical, legislative, financial and moral challenges we have – and will face, are enormous, but by working together in an open and innovative manner, we know that the project, using Fairbourne as a springboard, will create a flexible model that can be replicated across the world.

## Business Day 1: Business solutions for climate readiness – Infrastructure and Water

*Marc Gramberger, Prospex*

Economics and business

Urban, energy & infrastructure

1. Paris Sansoglou, Secretary-General, European Dredging Association
  2. Pieter de Boer, representative of the Central Dredging Association, CEDA, Ministry of Infrastructure & Environment, the Netherlands
  3. Alan Hendry, Jacobs, Director of Sustainability
  4. Dr Mark Williams, Head of Environmental Science and Regulation, Scottish Water
  5. Peter Murphy, Operations Director, UK Water and Scottish Hydro Nation Water Innovation Service
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## Business Day 2: Business solutions for climate readiness – Bio-economy

*Marc Gramberger, Prospex*

Economics and business

Agriculture & forestry

1. Andy Griffiths, Sustainability Manager, Nestlé
  2. Liz Bowles, Head of Farming, Soil Association
  3. Dr. Marta Modelewska, Principal, Climate Resilience Investments, Energy Efficiency and Climate Change team, European Bank for Reconstruction and Development
  4. Ms. Morag Garden, Head of Sustainability and Innovation, Scotch Whisky Association
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## Business Day 3: Business solutions for climate readiness – Health

*Marc Gramberger, Prospex*

Economics and business

Health

1. Roxane Feller, Secretary-General, International Federation for Animal Health Europe
  2. Vladimir Kendrovski, Technical Officer, World Health Organisation
  3. Diane Duncan, Head of Low Carbon, Highlands and Islands Enterprise
  4. Dr. Sari Kovats, Associate Professor, London School of Hygiene & Tropical Medicine
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## Business Day 4: Business solutions for climate readiness – Risk management and consulting

*Marc Gramberger, Prospex*

Economics and business

1. Miroslav Petkov, Head of Financial Services Environmental and Climate Risk Research, Standard & Poor's
  2. John Firth, CEO and co-founder, Acclimatise
  3. Dr. David Viner, Global Practice Leader – Climate Resilience, Mott MacDonald
  4. Dickie Whitaker, Chief Executive, Oasis Loss Modelling Framework
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## 11.3 Strategies for managing flood risk and water quality

*Tom Spencer, University of Cambridge*

### Flooding

1. Adapting flood risk management to new climate information (Mark McLaughlin, Scottish Environment Protection Agency)
  2. Adaptive flood risk management in Austria: an analysis of risk reduction strategies under dynamic flood risk conditions (Reinhard Steurer, University of Natural Resources and Life Sciences, Vienna)
  3. Review of the flood risk management system in Germany (Annegret Thieken, University of Potsdam)
  4. Assessing water quality responses under climate changes: a multi-risk perspective (Anna Sperotto, Ca Foscari University)
  5. Impacts of Climate Change on hydrology and bed load transport in Alpine Catchments (Bernhard Eichner, University of Innsbruck)
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**Keywords:** adaptive flood risk management, probabilistic modelling, disaster risk reduction, multi-risks, climate change, communication strategies

Managing flood risk and water quality is a challenging task, an example of post-normal, or type 2, science where risks are high, decisions can be urgent but where the evidential base is often uncertain. Understanding and action is complicated by the interactions between climatic and non-climatic stressors (including anthropogenically-induced changes and/or intensification of land use and modification of flow regimes and sedimentation (**Eichner**)). The rise in social and economic damages associated with extreme events in many European countries is not a proxy for flood risk; rather, it is symptomatic of population growth, planning rules that allow increasing numbers of people to live in hazard-prone environments and growing affluence. At any point in time, the physical, social and economic landscape of flooding is a snapshot of processes which operate across a range of time and space scales. Furthermore, many climate-related drivers often occur simultaneously, or in swift succession, where antecedent land-use and hydrological conditions exert a strong influence – distance to threshold - on the resilience of coupled landscape-societal systems to cope with individual extreme events. Adapting flood risk management strategies to changing climate should move away from simple, single and large scale scenarios of flood hazard, often based on instrumented records of relative short (< 50 years) length, towards the development of regionally-variable, probabilistic scenarios, with all that entails for the proper communication of scientific uncertainty to both practitioners and more general audiences (**McLaughlin**). Such activity can form part of a general move away from response to anticipatory policies and from a focus on hazard reduction towards exposure and vulnerability reduction, including the adoption of non-structural, nature-based responses to flood risk management (**Steurer**), often in anthropogenically highly-modified, and thus far from natural, systems. More effective early warning systems and better crisis management also have important roles to play in these contexts and require continual review and updating as physical and societal drivers change (**Thieken**). The need to assess multiple risks (both climatic and non-climatic) against a range of different adaptation and management options requires the development of new tools of assessment, incorporating both quantitative and qualitative datasets (**Torresan**).

#### 1. Adapting flood risk management to new climate information

Mark McLaughlin, Scottish Environment Protection Agency

Climate change predictions indicate that Scotland is likely to experience warmer, wetter conditions in future with increased flooding likelihood as a consequence. The Flood Risk Management (Scotland) Act 2009 sets out a framework for a plan-led, catchment-based, approach to sustainable flood risk management. The Scottish Environment Protection Agency (SEPA) is a responsible authority and the key coordinating organization for

delivering flood risk management in Scotland, and publishes flood hazard and risk maps and Flood Risk Management Strategies. Being able to adapt to future changes in flood hazard and risk is an important aspect of sustainable flood risk management, and requires information on how flood hazard and risk is expected to evolve over time.

The UK Climate Projections (UKCP09) provided the first probabilistic climate projections for Scotland. To translate these projections into information suitable to support flood risk management SEPA has:

- Developed new national scale flood hazard maps using a combination of two-dimensional hydrodynamic modelling (fluvial and pluvial), rapid flood spreading (pluvial) and level projection modelling (coastal).
- Engaged the Centre of Ecology and Hydrology (2011) to develop probabilistic projections for peak river flows from the UKCP09 projections for temperature, precipitation, and evapotranspiration.
- Developed flood hazard maps for climate change scenarios showing the impact of climate change on fluvial, pluvial and coastal flood risk.

The maps show that currently 108,000 properties in Scotland are at risk of flooding; with an estimated increase of 60,000 by 2080 under a high emissions scenario.

Supporting flood risk management decision makers to move from the long-established and accepted approach of using a single, national climate scenario to using probabilistic, regionally varying scenarios is as challenging as developing the information. To support partners and decision makers in adapting to the new information SEPA is developing a range of guidance and a communication strategy to demonstrate the benefits of the approach. Guidance and communication is tailored to a range of users including engineers, land use planners and local authority flood prevention officers.

By ensuring that a consistent, well understood framework of climate change and flood hazard information is used across all flood risk management decisions Scotland will deliver flood risk management that is adapted to future climate and conditions.

## **2. Adaptive flood risk management in Austria: an analysis of risk reduction strategies under dynamic flood risk conditions**

Reinhard Steurer, Boku - University Of Natural Resources And Life Sciences Vienna

As across large parts of Europe, flood risk is likely to increase in Austria due to a combination of climatic and socio-economic drivers. While flood risk management can limit the adverse impacts of flood events, choosing the most effective strategy under dynamic flood risk conditions is a challenging task. Building on the notion of flood risk management as a continuous process of adaptive management we analyse in how far flood risk management in Austria has shifted (i) from responsive to anticipatory policies and, (ii), from hazard reduction to vulnerability reduction. The first point relates to how policy makers take long-term future-oriented flood risk management decisions in the wake of serious knowledge uncertainties. The second point refers to the strategies of risk reduction that are employed based on a set of structural and non-structural measures aiming at hazard and/or vulnerability-reduction. In our analysis, we distinguish four adaptive flood risk management strategies: (i) load reduction, (ii) flood protection, (iii) exposure reduction, and (iv) vulnerability reduction.

After discussing the major drivers of future flood risk in Austria we first evaluate recent developments in Austrian flood policy to show in how far the rhetorical emphasis on non-structural approaches and vulnerability reduction is reflected in flood risk management practice. Second, we determine the future-orientation of Austrian flood policy by assessing in how far expected developments in the natural and socio-economic risk environment shape policy decisions, and by reviewing the longevity and flexibility of the risk reduction strategies applied.

Our case study is based on desk research and interviews. We reviewed expected climate and land use-induced changes in flood risk, a national database on risk reduction projects (to evaluate recent trends in risk reduction), and national as well as provincial flood policy and land use policy documents. In addition, we conducted twenty semi-structured interviews with national as well as provincial policy makers and scientific experts.

Our findings show that flood risk management decisions are primarily based on historical data and status quo risk assessments. Future changes in flood risk and the related knowledge uncertainties are acknowledged, but they are rarely considered. However, recent developments indicate that flood risk management has become more future-oriented because exposure and vulnerability reduction measures are now a regular feature of Austrian flood policy, supporting a shift towards more adaptive and anticipatory flood risk management strategies.

### **3. Review of the flood risk management system in Germany**

Annegret Thieken, University of Potsdam, Institute of Earth and Environmental Science

In June 2013, a severe flood event hit Central Europe, particularly Germany, where it caused EUR 6 to 8 billion damage, and awoke many memories of the flood in August 2002. With a total damage of 11.6 billion euros, the event of 2002 has been the most expensive natural hazard event in Germany up to now. It also triggered many changes on all political and administrative levels and marks a reorientation towards more integrated flood risk management in Germany. Even though the course of every extreme event is unique, it is reviewed of how effective the measures were which politics, administration and civil society have implemented since 2002 and where there is still a need for action in flood risk management by using the flood of 2013 as an example.

The review highlights considerable improvements on many levels that deal with flood risk reduction and disaster response, in particular 1) an increased consideration of flood hazards in spatial planning and urban development, 2) comprehensive private precaution by property level mitigation measures and insurance, 3) more effective early warning and improved coordination of disaster response and 4) a more targeted maintenance of flood defence systems. During the flood in June 2013 these changes helped to deal with the event more effectively in many places and led to a reduction of the overall damage. Nevertheless, important aspects remain unclear and need to be clarified. This particularly holds for balanced and coordinated strategies for reducing and overcoming the impacts of flooding in large catchments, cross-border and interdisciplinary cooperation, the role of the general public in flood risk management as well as a transparent risk transfer system.

The recurring flood events show that flood risk management is a continuous task and at the same time a complex issue that requires personnel and institutional continuity. Risk drivers, such as climate change, land use changes, economic developments or demographic change and the resultant risks must be investigated at regular intervals, risk reduction strategies, processes and available resources must be reassessed as well as adapted and implemented in a dialogue with all stakeholders.

### **4. Assessing water quality responses under climate changes: a multi-risk perspective**

Silvia Torresan, Fondazione Centro Euro-mediterraneo sui Cambiamenti Climatici

Water resources and related ecosystems are threatened by multiple, co-occurring climatic (i.e. climate change) and non-climatic stressors (i.e. land use changes, water abstraction, agriculture, urbanization, tourism) acting at different spatial and temporal scales. However, yet, most risk assessment procedures typically study each stressor in isolation neglecting synergic or cumulative interactions. Understanding the relative role played by each of these threats and predicting their combined impacts on water quantity and quality is necessary for the development of efficient adaptation strategies.

Integrated Environmental Assessment models (e.g. Bayesian Networks, Agent based models, system dynamics) have been increasingly applied to support risk assessment and water resources management under uncertain conditions. They allow to overcome some of the main limitations of traditional risk assessment approaches (i.e.

single hazard assessment focus, representation and communication of uncertainty) enabling to model in a holistic way multiple stressors interactions and assessment endpoints. A multidisciplinary multi-risk approach, implementing Bayesian Networks analysis, was developed to combine existing qualitative and quantitative data (i.e. experts, local knowledge, models simulation, climate change projections, historical observations) allowing a stochastic analysis of the cascading impacts of climate change (i.e. irregularities in water regime) and land use changes (i.e. agriculture, urbanization) on water quality parameters in the Dese-Zero river estuary, one of the main tributaries of the Venice Lagoon (Italy). The result is a modelling tool for the simulation of potential alteration in ecosystem services provided by transitional systems (i.e. water availability, recreation, biodiversity), allowing the analysis of multiple climate and land use scenarios, as well as, the comparison of different typology of adaptation and management options (i.e. policy and economic instruments, nature based solutions).

Final outcomes include the development of multi-risk scenarios and indicators supporting the identification of tradeoffs between different water uses and ecosystems requirements under changing conditions thus promoting the implementation of adaptation strategies with ancillary co-benefits and cross-sectoral implications (i.e. tourism, fishing, biodiversity).

## **5. Impacts of Climate Change on hydrology and bed load transport in Alpine Catchments**

Bernhard Eichner, University of Innsbruck

Since discharges and sediment transport in alpine catchments are high variable, their influence of both, water and sediment availability, in the entire downstream river network is significant. While bed load transport in low gradient and large rivers could be estimated relatively well, due to transport formulas determined of flume experiments, the bed load transport in steep mountain streams is subjected to additional influences. On the one hand, morphologic structures such as cascades, step pool sequences or abrupt changes in cross sections and flow direction, lead to considerable energy losses, which is no longer available for bed load transport. On the other hand, the runoff regimes, which are lasting over a long period, and the broad grain size distribution contribute to a size selective mobilisation of several grains. This leads to an armouring of the surface layer caused by transport of smaller grains and results in a further resistance against initiation of motion. Furthermore, the existing sediment limitation in alpine catchments strengthens the effect, that bed load transport in this regions is not simply depending on discharge behaviour.

For an investigation of climate change impacts on bed load transport, the project DevoBeTA-CC (Development of Bedload Transport in Alpine Catchments under Climate Change) was founded by the ACRP (5<sup>th</sup> call). Based on long term data, an evaluation of 20 small catchments of the *Tiroler Wasserkraft AG* (TIWAG) was performed, regarding hydrology and annual bed load volumes (Kammerlander et al., 2016). Based on this data and supported by field measurements with bed load traps and line by number samples, 1D bed load transport models were implemented and calibrated for selected sites. As input data for the bed load transport model discharges are necessary, which are resulting out of hydrologic modelling. The hydrologic models have been calibrated by an evaluation of a Monte-Carlo simulation for each investigated catchment. These are driven by meteorological data, like temperature and precipitation, which are provided from the ZAMG in form of raster based INCA data. For predictions of hydrologic changes, a downscaling of climate change scenarios to INCA raster was applied. Run by different ECHAM5 and HADCM3 scenarios, a complete modelling chain from climate change over meteorology and hydrology to bed load transport was performed.

Kammerlander, J., Achleitner, S., Chiari, M., Hofer, B., Schöber, J., 2016. Annual variability of bed load transport in steep mountain streams (submitted). Geomorphology.

### **Significance to adaptation practice, policy and/or business:**

At moderate flow conditions bed load transport is a decisive component regarding channel morphology and therefore base of life for several species. Reaching transport capacity of low gradient downstream channels, it



also represents a risk at occurring flood events caused by decreased cross sections. Facing current developments in energy policies, water power plays a major role as renewable energy resource. Consequently, changes in hydrology and sediment transport are influencing water availability and usability.

## 6.9 Fostering dialogue and learning on monitoring and evaluation of climate change adaptation and disaster risk reduction policies

*Eleni Karali, Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici and Patrick Pringle, UKCIP*

### Monitoring and evaluation

#### DRR

1. Current state and key challenges of monitoring and evaluation of national adaptation policies in Europe (Eleni Karali, Fondazione Centro Euro-Mediterraneo sui Cambiamenti Climatici)
2. Austrian Monitoring & Evaluation System – Flexible, easy-to-manage and multi-purpose – informing the policy process (Markus Leitner, Environment Agency Austria)
3. A reflexive monitoring and evaluation framework for the Delta Programme (Willem Ligtoet, PBL Netherlands Environmental Assessment Agency)
4. The pitfalls and potential of measuring adaptation results: a review of frameworks and lessons learned (Patrick Pringle, UKCIP and Timo Leiter, GIZ)
5. Local adaptation at scale - what can we learn from BRACED? (Victoria Sword-Daniels, ITAD)

**Keywords:** climate change adaptation; disaster risk reduction; monitoring; evaluation; dialogue; learning

A growing number of countries attempt to address the challenges of climate change through the adoption of adaptation strategies and plans. Similarly, countries attempt to assess and reduce the risks that result from natural hazards, including climate change, through risk assessments and management plans. Among those, only a few acknowledge the need for monitoring and evaluation (M&E) at an early stage. Yet as the number of countries being at or reaching the implementation phase of such policies increases, setting mechanisms to track their progress and assess their impact becomes of utmost importance.

In the case of climate change adaptation (CCA) and disaster risk reduction (DRR) policies, evidence shows that interest and efforts in M&E are emerging. In Europe, for example, these processes are driven mainly by countries' obligations to report to European and international bodies (e.g. EU MMR Article 15, UNFCCC, EU Civil Protection Mechanism, Floods Directive) on the progress and effectiveness of their policies, national level administrative or legal requirements, or simply by countries' efforts to improve regulation. However, despite the progress that has been achieved so far, experience in this area is still limited and fundamental conceptual and methodological challenges remain.

This session aims to foster the dialogue and learning on monitoring and evaluation of CCA and DRR policies. Despite the common ground between CCA and DRR - in managing risks and reducing negative impacts of climate change and disasters respectively – they have evolved largely as separate fields, with limited opportunities for knowledge exchange. Consequences of this separation vary from the unnecessary duplication of work and the inefficient allocation of human and financial resources, to the creation of conflicts among different policy objectives. However, as climate change impacts and risk of natural hazards increase and resource constraints become more critical, it is important not only to understand what works and under what conditions, but also to support synergies when such opportunities exist.

The session will provide an overview of the practices used for CCA and DRR M&E and present practical examples from Europe and beyond. Discussion will revolve around the conceptual and methodological challenges that evaluators often encounter when attempting to develop meaningful and effective M&E procedures. Also, we will discuss if and how the current reporting obligations for CCA and DRR policies can be better coordinated and aligned, and how evaluation outcomes can be used further.

## **Significance to adaptation practice, policy and/or business**

This session will provide an overview of the M&E approaches that have been already developed and applied in the fields of CCA and DRR, using examples from Europe and beyond. The session aims to discuss some of the fundamental challenges faced in these fields and to facilitate knowledge sharing between the two communities. We expect that outcomes of this session will be insightful and relevant to the policy evaluation community, mainly policy actors involved in the development and application of M&E practices for CCA and DRR policies, scientists supporting them in these activities, and other professionals interested in the topic.

### **1. Current state and key challenges of monitoring and evaluation of national adaptation policies in Europe**

Eleni Karali, Fondazione Centro EuroMediterraneo sui Cambiamenti Climatici

MRE is becoming an increasingly important theme as countries across Europe develop and implement adaptation policies. Deciding what a MRE system for adaptation aims to accomplish (i.e. its purposes) has an impact on the way this can be achieved (i.e. the methods), the actors who are involved in the process (i.e. governance and participation) and the extent to which the results. While climate change adaptation policies and actions are on the rise across Europe, it is increasingly important to better understand what works, under what conditions and why, and transfer this knowledge to countries that are currently developing their MRE systems for adaptation and other relevant policy fields (e.g. Disaster Risk Reduction). This presentation will draw on the findings presented in the 2015 EEA report *“National monitoring, reporting and evaluation of climate change adaptation in Europe”*. It will provide an overview of progress on adaptation monitoring and evaluation in Europe up until now and discuss some of the weaknesses in current adaptation evaluation practice and other challenges that MRE scientists and practitioners need to overcome.

### **2. Austrian Monitoring & Evaluation System – Flexible, easy-to-manage and multi-purpose – informing the policy process**

Markus Leitner, Environment Agency Austria

Monitoring and Evaluation Systems (M&E) are crucial for measuring the success and implementation of adaptation strategies. Also, they can improve knowledge on trends of climate change effects, which are relevant for adaptation and learning about which adaptation interventions work or not.

An M&E approach was developed in Austria to investigate the implementation of the national adaptation strategy (NAS) and Action Plan (NAP). The process of developing an M&E system started in early 2013 and relates closely to the actions identified and proposed in the NAP. The system is effective in terms of providing sufficient information to monitor implementation activities, while still keeping it manageable with reasonable efforts.

The Austrian M&E system combines two different methodological approaches: i) self-assessment: a stakeholder survey will be carried out on adaptation actions (“first steps”) of the NAP; ii) data related criteria-catalogue: an “indicator-based approach” with qualitative and quantitative data will be developed. The joint consideration of both the stakeholder survey and the criteria catalogue provides a comprehensive picture of adaptation activities in the 14 areas for action defined in the Austrian NAS and showcase information on key trends in climate-sensitive sectors in Austria (changes in vulnerability, climate change impacts). The first “climate change adaptation progress report” was published in late 2015. It tracks the progress of implementing the recommendations of the NAP, highlights gaps and key challenges, and provides a basis for continued development (review) of the NAS.

The development of a national M&E system for climate change adaptation is a relatively new field, thus the Austrian framework needs to be flexible and open for new developments. The Austrian M&E approach is therefore designed as a “learning system” which is kept open for future amendments. The need for establishing a flexible system with an iterative development process became already apparent when (e.g.) identifying criteria (indicators) that should be clearly relevant for main adaptation aspects, make use of existing data (or data

collected with little effort), be robust and - if quantitative – based on statistically validated data, repeated in an appropriate timeframe and measurable at national level.

After introducing the overall set-up of the Austrian M&E system, the presentation will highlight the main challenges and gaps that already became obvious in the development process and our approach to address them. Further it will give some food for thought and discussion on how M&E systems may serve more purposes than “only” monitoring and evaluating progress.

### **3. A reflexive monitoring and evaluation framework for the Delta Programme**

Willem Ligtoet, PBL Netherlands Environmental Assessment Agency

The Delta Programme is in place to protect the Netherlands from flooding and to ensure a sufficient supply of fresh water. The Delta Programme Commissioner, a special government commissioner, is in charge of the Delta Programme. The main themes of the Delta Programme are flood risk management, fresh water supply and spatial adaptation. In the implementation stage, the Delta Programme aims at adaptive management — given the uncertainties that lie ahead — and seeks to ensure the participation of numerous parties and the adoption of a broad and integral approach which can coalesce the ambitions and efforts of a range of stakeholders. The Delta Programme is a nation-wide initiative with a complex network structure involving many parties, such as provincial councils, municipalities, district water boards, social organisations and private stakeholders. Together they form the delta community. In line with the characteristics of the Delta Programme and the request of the staff of the Delta Programme Commissioner, we present a design for a monitoring and evaluation framework based on a reflexive approach, in combination with the challenges with respect to adaptation. We present concrete recommendations for the set-up of a monitoring and evaluation system with respect to:

- Increasing the Delta Programme's capacity for systemic learning
- Integrating adaptive management
- Creating a basis for shared accountability
- Creating a basis for trust and transparency

The principles of the reflexive approach are; (a) joint efforts by all stakeholders to achieve adequate monitoring and evaluation during the implementation process, and (b) a focus on shared learning paired with a focus on shared accountability. Our presented frame work and reflexive approach provides an environment for ongoing policy improvement during implementation of the adaptation programme, while also tapping into the energy and the innovation drive of all stakeholders. In the dealing with uncertainties it is important that monitoring and evaluation procedures keep an eye on both implementation practice within the Delta Programme (internal dynamics) and the scientific and societal environment outside the programme (external dynamics). This form of monitoring and evaluation furthers adaptive delta management, allowing the Delta Programme to revise its strategies and actions in a timely fashion.

#### **Significance of the presentation to adaptation policy**

Worldwide, issues concerning flood risks, water scarcity, and spatial adaptation in the context of adaptation to climate change are high on the agenda. The Delta Programme operates on the frontline of developments around participatory, adaptive and integrated planning and policy implementation in delta areas. Until now, no experience has been gained of monitoring and evaluation approaches to these issues, according to recent surveys by several organisations, such as the European Environment Agency (EEA), The Organisation for Economic Co-operation and Development (OECD) and PBL Netherlands Environmental Assessment Agency. The Delta Programme incorporates our approach in their monitoring and evaluation system. Our approach and results will fuel the discussion and further studies on effective approaches in other regions and deltas.

#### **4. The pitfalls and potential of measuring adaptation results: a review of frameworks and lessons learned**

Patrick Pringle, UKCIP, and Timo Leiter, GIZ

This presentation draws upon an article produced for UNEP-DTU's forthcoming Adaptation Metrics Perspectives publication. The presentation will outline some of the pitfalls associated with the practice of applying adaptation metrics and will identify the potential for enhancing the assessment of adaptation. It aims to inform the discussion around the use and limitations of metrics and indicate where progress can be made to better understand adaptation. By acknowledging and learning from the pitfalls of adaptation metrics, practitioners, advisors and policy makers can avoid mismatches between what metrics are expected to do and what they can actually deliver in practice. There are also opportunities to make better and more coherent use of metrics which need to be grasped.

#### **5. Local adaptation at scale - what can we learn from BRACED?**

Victoria Sword-Daniels, ITAD

Despite the common ground between CCA and DRR - in managing risks and reducing negative impacts of climate change and disasters respectively – they have evolved largely as separate fields, with limited opportunities for knowledge exchange. This paper explores the use of an overarching approach to measuring climate change and disaster risk reduction at the local level, albeit at scale. It will draw lessons from the £140m DFID Building Resilience and Adaptation to Climate Extremes and Disasters Programme (BRACED) programme, which is presently the world's largest and most ambitious climate resilience strengthening programme. This programme aims to improve the lives of up to five million vulnerable people facing climate extremes and disasters. Over four years, this will be achieved through the efforts of 15 major consortia. An independent Knowledge Manager generates evidence and promotes learning across the programme, to understand what works and what does not in terms of strengthening resilience.

We will highlight lessons generated, in particular how we have translated conceptual resilience measurement into practice through an M&E system which is flexible and which ensures coherence:

- Of evidence and lessons across a diverse set of audiences and stakeholders and clarity of resilience strengthening conceptualisation
- Across scales – from household to project to programme and beyond;
- Across contexts and in the face of a complex set of external factors.

## 4.10 Living with coastal change: risk, resilience, adaptation and working with nature

*Larissa Naylor, University of Glasgow and Jim Densham, RSPB Scotland*

### Coastal

#### Ecosystem services and NBS

1. Scotland's Dynamic Coast – The National Coastal Change Assessment (Alistair Rennie, Scottish Natural Heritage)
  2. Coastal climate change adaptation: policy appraisal in Glasgow and Cornwall (Larissa Naylor, University of Glasgow)
  3. Delivering Coastal Adaptation (Bill Parker, Suffolk and Waveney Council)
  4. Can Scotland deliver coastal adaptation into the 21st century? (Jim Hansom, University of Glasgow)
  5. Living with coastal change - the long view. (Hannah Fluck, English Heritage)
  6. Working with nature to help coastal wildlife and communities adapt (Jim Densham, RSPB Scotland)
  7. Facilitated group discussion (Larissa Naylor, University of Glasgow)
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**Keywords:** coastal, risk, erosion, resilience, adaptation, policy, governance, working with nature

Lead session organiser: Dr Larissa Naylor, University of Glasgow  
Co-organisers: Dr Jim Hansom, University of Glasgow  
Dr Alistair Rennie, Scottish Natural Heritage  
Dr Jim Densham, RSPB  
Bill Parker, Head of the Coastal Special Interest Group for England

This session has been designed to draw together some of the leading research and practice on understanding and measuring coastal climate change flooding and erosion risks on the one hand and on the other hand understanding the perceptions of coastal risks. It thus aims to bring together scientists, social scientists, policymakers and practitioners to identify policy opportunities and constraints to facilitate coastal adaptation actions at strategic and local scales. The sessions will showcase projects where academics are working closely with government bodies to understand the risk, design effective tools and to identify policy and social challenges influencing the delivery of adaptation.

Crucially, it will also enable discussion of strategies for overcoming key challenges associated with delivering coastal climate change adaptation. National climate change policies requiring adaptation exist, but there is an urgent need to identify and create effective mechanisms to enable local delivery of adaptation. Recent national to local government responses to extreme storms and floods in the UK have shown that these events often lead to entrenchment of conventional flooding and erosion management methods (i.e. rebuild post storm) rather than use these as an opportunity to deliver adaptation. We urgently need to create funding, policy and social windows of opportunity to deliver adaptation as part of strategic planning, day-to-day decision making (e.g. development control) and in how we respond to extreme events. This session will explore these issues as part of a pre-conference workshop on 5<sup>th</sup> June 2017.

### 1. Scotland's Dynamic Coast –The National Coastal Change Assessment

Alistair Rennie<sup>1</sup>, Jim Hansom<sup>2</sup>, James Fitton<sup>2</sup>

<sup>1</sup>Scottish Natural Heritage; <sup>2</sup>School of Geographical and Earth Sciences, University of Glasgow

Coastal erosion has historically been an issue in many parts of Scotland and will continue to cause problems into the future. Scotland has many key assets located at the coast in addition to 3.5 million people who live within 10

km of the coast. In order to manage the coast in a sustainable manner and to ensure that all stakeholders benefit, coastal managers need to be aware of the areas that are physically susceptible to coastal erosion, as well as identify those groups of people who are the most vulnerable and are at risk from the impact of coastal erosion.

The Climate Change (Scotland) Act 2009 requires the development of an Adaptation Programme to take forward the risks identified within the UK's Climate Change Risk Assessment (UK-CCRA). The UK-CCRA anticipates increases in sea level, coastal erosion and coastal flooding to affect Scotland's soft coastlines and place at risk the assets found on these coasts. Accurate georectified historic coastal change rates allow the past and present coastline position to be established with confidence and provide the basis for future projections of coastline position. These projections, allow the early identification of coasts, hinterlands and assets that are inherently susceptible to erosion and which may become vulnerable in the future. Shoreline Management Plans have not been produced for all of the Scottish coast and so there is a need to provide accurate national scale information to coastal managers.

We report on the National Coastal Change Assessment (NCCA), a Scottish Government project aiming to establish historic rates of coastal change and project these into the future. This uses time series georectified coastline positions from Ordnance Survey (OS) 1:10,000 maps in comparison with current coastal positions as depicted by the Mean High Water Spring (MHWS) line extracted from the most recent Digital Surface Models (DSMs).

Using the historic coastal change rates, coastline positions can then be projected into the future, mediated by a GIS-based Coastal Erosion Susceptibility Model (CESM). The CESM limits potential erosion to areas where the hinterland is susceptible to erosion. At a 50 m raster resolution, the CESM models the physical susceptibility of the coast using data on elevation, rockhead elevation, proximity to the coast, wave exposure, coastal defences, and sediment accretion, amalgamated into a single raster dataset to reflect erosional susceptibility. Using the current erosion rates, and projected future position of the coastline, combined with a number of socioeconomic datasets, key assets at risk from future coastal erosion can be identified. The outputs of the NCCA include reports, GIS datasets, and web maps available at [www.dynamiccoast.com](http://www.dynamiccoast.com).

Areas of present and future erosion were used to identify vulnerable socio-economic, cultural and archaeological assets. Taken together this information aims to inform existing strategic planning (Shoreline Management Plans, Flood Risk Management Planning, Strategic and Local Plans, National and Regional Marine Planning) and to target support toward assets that may remain, or may become, vulnerable over the coming decades. This approach to coastal erosion enables the development of robust management policies and proactive adaptation strategies.

## **2. Coastal climate change adaptation: policy appraisal in Glasgow and Cornwall**

Larissa Naylor & Douglas Mitchell, <sup>1</sup>School of Geographical and Earth Sciences, University of Glasgow, UK.

Climate change is expected to threaten the safety and prosperity of urban human populations and property in coastal areas. Successfully adapting to these new conditions requires localised planning and action that is both informed and coherent. Creating and implementing strategies to enable adaptation is a challenge for legislators, planners and developers at a range of levels. Predicted risks to the current coastline strongly suggest that a much more radical approach to managing the land – sea interface will be required. Areas currently protected from coastal inundation may no longer be viable and land-based adaptation strategies will be necessary. This will require strategic planning of all sectors that currently operate on land fringing the coast – development control, infrastructure, health, education, heritage, industry, environment and open space. Thus a cross-sectoral policy appraisal is required to identify the current level of climate and coastal awareness of these cross-sectoral policies.

This paper presents results of a systematic policy review that provides insight into the current state of consideration of climate change and coastal risks and adaptation. We assess this in Glasgow and Cornwall, allowing us to compare differences in policy formulation between England and Scotland and rural and urban areas. This approach captures and evaluates key policy drivers, common objectives, the level of climate change

and coastal awareness, and the extent to which policies and strategies at the EU and national level vertically integrate with local planning directives. In doing so, blockages to and opportunities for most effective delivery of coastal climate change adaptation methods are identified. Preliminary results from Scotland shows that several policy sectors (e.g. environment, development and economy) with responsibility for the coastal zone, have very low levels of climate change or coastal awareness, thus serving to limit our capacity to mainstream coastal adaptation within these sectors. The paper also presents a 'policy appraisal' methodology that can be applied to identify complexities, scales of influence and institutional barriers in the context of adaptation strategies. This methodology adapts evidence based reviews of science to undertake robust, systematic reviews of policy.

### **3. Delivering Coastal Adaptation**

Bill Parker, Suffolk and Waveney Council

The completion of the 2009 Coastal Pathfinder projects has identified many issues that enable the delivery of successful coastal adaptation challenging. Whilst many lessons have been identified there has to date been not been a comprehensive approach at resolving some of these issues. The Local Government Association Coastal Special Interest Group (representing 60+ of the leading local authorities in England) has recognised that local authorities are central to resolving these issues. For no other reason that having responsibility for spatial planning a dynamic coastline will impact on the communities and planning locally. They have identified a range of issues that local authorities on their own cannot solve alone and have been working over the past 18 months to try and resolve the policy, practice and funding issues faced in delivering effective coastal adaptation.

Funding and finance often inhibit any progress on these issues and the latest think on these issues and are fundamental to progress on adaptation. The overall progress made by key partners including Defra, DCLG, Environment Agency and many others will be shared with the conference and there will be an opportunity to contribute to resolving some of the outstanding difficult issues yet to be resolved.

### **4. Can Scotland deliver coastal adaptation into the 21st century?**

Jim Hansom<sup>1</sup>, Alistair Rennie<sup>2</sup>, James Fitton<sup>1</sup>, Kat Ball<sup>3</sup>, Debbie Garft<sup>4</sup>, Alistair Cargill<sup>3</sup>, Larissa Naylor<sup>1</sup>.

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The Climate Change (Scotland) Act (2009) gives Scotland a key policy framework for adapting to climate change. Implemented through the Scottish Climate Change Adaptation Programme in parallel with the Flood Risk (Scotland) Act, Marine (Scotland) Act, National and Regional Marine Plans, Land Use Strategy and Biodiversity Strategy, Scotland now has collaborative policies that enhance awareness of the risks of coastal flooding and erosion that will guide our strategies for adaptation and improve resilience to change.

The UK Climate Change Risk Assessment (2012) identified that Scotland had no national datasets of coastal change, which undermined implementation. However, this has been addressed by the National Coastal Change Assessment that has established historical and recent coastal change for Scotland's soft (erodible) shores ([www.dynamiccoast.com](http://www.dynamiccoast.com)), and undertaken vulnerability assessments of society's assets.

This paper outlines how the evidence base and policies might be translated into meaningful adaptation proposals for Scotland's coast in order to improve on the past lacklustre delivery of sustainable results on the ground. Non-statutory Shoreline Management Plans (SMPs) (and their derivations) have been the basis for policy development and implementation but new approaches now more closely link coastal erosion with flood risk. For example, the National Flood Risk Assessment, in support of future (statutory) Flood Risk Management Strategies aims to include the role that natural coastal defences currently deliver, and will continue to do so, as climate change



progresses. Since much of the Scottish coast is unsuited to an SMP sediment cells approach, this new approach places Natural Flood Risk Management at the core and offers a new, statutory alternative to non-statutory SMPs.

In Scotland, the length of natural coastal defences vastly exceeds the length of artificial defences and yet only 41% of Scotland's soft coast is protected by nature conservation designations and subject to the Adaptation Principles of Scottish Natural Heritage. For the remaining 59%, the benign manipulation of natural processes, landforms and habitats can offer considerable benefits to society yet where these approaches are inappropriate then further tough choices will result.

Scotland's track record of delivering on these overarching policies has been lacklustre. This may be because Local Authorities have not the financial resources or political commitment to deliver national policies. It may also result from a lack of awareness of the need to implement change on the scale required, leading to adaptation options not being fully considered and coastal developments continuing to be permitted in unsuitable locations.

## **5. Living with Coastal Change: The long view.**

Hannah Fluck, English Heritage

Our coastline has always changed and we have always adapted; the development of settlement patterns founded upon the expectation of environmental stability is a relatively recent phenomenon. By taking a long view of our relationship with the coast, there are a number of ways that historic environment specialists can make an important contribution to how policymakers, planners, landowners and communities adapt to these changes.

Taking the long view contextualises change and can help to better communicate them. The historic environment is about people and their stories, therefore it can provide ways of humanising changes.

As well as challenges, coastal change presents many opportunities: for discovery and for loss. There are numerous examples of how coastal change has enabled significant discoveries about our past and opportunities have been taken to involve local communities in identifying and recording these. The potential loss of known heritage sites also presents opportunities not just for new information about these but also for new uses.

Finally, there are opportunities to learn from the past. The historic environment is a source of information about adaptive solutions and thinking of it this way can contribute to solving the challenges we face.

This presentation will explore these issues from the perspective of Historic England – the public body that looks after England's historic environment.

## **6. Working with nature to help coastal wildlife and communities adapt.**

Jim Densham, Senior Land Use Policy Officer, RSPB Scotland, Edinburgh, Scotland

Climate change is a key threat to our coasts and coastal habitats in the UK. 28% of Scotland's coasts are soft coasts, consisting of mudflat, saltmarsh, sand and shingle, and almost half of this is eroding. With sea level rise and an increasing frequency and intensity of storms, more of our coastal habitats, communities and infrastructure, in Scotland and around Europe, are under threat.

Despite being under threat itself from the impacts of climate change, saltmarsh habitat actually provides a nature-based solution to these problems. As well as being important for the biodiversity it supports, saltmarsh can store significant amounts of carbon and naturally buffers the coasts against storms and waves. Recreating lost saltmarsh habitat through managed coastal realignment is a nature-based solution being used now and will be needed more in the future.

RSPB Scotland successfully completed Scotland's first managed realignment project in 2003 at Nigg Bay on the Cromarty Firth. Since then it has demonstrated that the technique is viable and good for wildlife

<http://bit.ly/niggbayreport>. England has much greater experience of managed realignment projects with many more examples to be seen. One of the largest, most ambitious and most recent is RSPB's 670ha Wallasea Island Wild Coast Project in Essex.

The RSPB has long experience of managing coastal nature reserves and land, for wildlife and to provide benefits to people. We want to see more, larger, better managed and better connected spaces for nature along our coasts – in line with Sir John Lawton's recommendations (*Making Space for Nature*, for Defra, 2010). RSPB Scotland has highlighted 4135ha of coastal land in 4 main areas of Scotland which have the potential for managed realignment now (*Glorious Mud*, RSPB, 2016). We have a project underway to refine this and widen the analysis to the whole UK.

However, there are few policies in place to make coastal realignment happen now or to plan coastal adaptation at the scale and timescales needed in future. In Scotland, a new national blueprint is needed for our coasts to plan and enable new saltmarsh habitat creation further inland through managed coastal realignment and other sustainable adaptation solutions. We are also working to influence UK and Scottish Government climate adaptation policies to ensure that plans are made to sustainably adapt our soft coasts, with nature-based solutions at a landscape scale seen as a key tool to make this happen.

## 4.5 Social justice in urban adaptation and transformation under climate change: what does this look like in practice?

*Eric Chu, University of Amsterdam and Thomas Thaler, University of Natural Resources and Life Sciences, Vienna*

### Climate justice

1. Inserting rights and justice into urban resilience: a focus on everyday risk (Eric Chu, University of Amsterdam)
  2. Flood risk management: Is it socially just? (Paul Sayers, SPL / WWF-UK)
  3. The undebated issue of justice in Dutch flood risk management (Maria Kaufmann, Radboud University)
  4. Governing Urban Displacement in the Context of Extreme Climate Risks: The case of Tacloban City, Philippines (Roos J. Groen, University of Amsterdam)
  5. Fair allocation of risk and benefits – distributional justices in mountain hazard management (Thomas Thaler, University of Natural Resources and Life Sciences, Vienna)
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**Keywords:** social justice, adaptation, transformation, political economy, distributional impacts, science-policy linkage, interactive discussion

Social justice is fundamental to adaptation and transformation in urban contexts under climate change, although what this might look like in practice – and how it can be achieved – is an open question. Contemporary global research and policy agendas advocate the broad need for effective and equitable climate change adaptation and transformational change in society to achieve more sustainable and resilient futures. The Paris Agreement sets ambitious targets for climate change mitigation which in effect demand transformational change in global systems of production and consumption. The Sustainable Development Goals and the UN-Habitat III agendas also explicitly call for transformational change.

Justice is increasingly recognised as core to achieving transformational change. For example, scholars highlight the importance of social justice issues under climate change such as vulnerability and its political economic determinants (Pelling 2011, O'Brien 2012), and the importance of a justice lens for orienting adaptation efforts in urban contexts (Bulkeley et al. 2013, Hughes 2013, Shi et al. 2016). On the other hand, transformation is a newer agenda that often remains quite conceptual. Questions such as transformation for whom, how, and why immediately begin to raise social justice issues regarding the processes and outcomes of transformation.

Despite these imperatives, translating ideas and aspirations for social justice into practice remains difficult. Social justice is itself a contested concept with different possible interpretations. Even if a particular perspective is agreed upon, it is rarely straightforward how abstract notions should be taken into account in everyday policy and decision-making. Furthermore, there are many practical constraints on individual actors within governance systems such as bounded roles, competing policy objectives, and organisational pressures, which can make it difficult to take account of social justice concerns in practice.

In response, this session aims to connect science and practice of social justice in urban adaptation and transformation under climate change. It will foster dialogue between researchers and practitioners wrestling with the topic of social justice, seeking to link "abstract issues" to "everyday decisions" in order to mobilise knowledge on social justice more effectively. The format will involve a series of presentations, and transition into a facilitated interactive dialogue to explore how theoretical knowledge about social justice can be mobilised in practice.

### Significance to adaptation practice/policy and/or business:

This session is relevant to a diverse range of participants who are concerned with social justice, policy, and decision-making. Through a focus on linking theory and practice, centred on interactive dialogue, this session will

leverage collective insights of the whole group, where diverse experiences and perspectives from practice, policy, business, and civil society will be extremely beneficial. The outcome of this session will be a joint inquiry into the question of what social justice means for practical decision making, and will be written up as a blog post for a relevant forum (e.g. Future Earth) to share findings with a broad audience.

### **1. Inserting rights and justice into urban resilience: a focus on everyday risk**

Eric Chu, University of Amsterdam, The Netherlands.

Resilience building has become a growing policy agenda, particularly for urban risk management. While much of the resilience agenda has been shaped by policies and discourses from the global North, its applicability for cities of the global South, particularly African cities, has not been sufficiently assessed. Focusing on rights of urban citizens as the object to be made resilient, rather than physical and ecological infrastructures, may help to address many of the root causes that characterize the unacceptable risks that urban residents face on a daily basis. Linked to this idea, we discuss four entry points for grounding a rights and justice orientation for urban resilience. First, notions of resilience must move away from narrow, financially-orientated risk analyses. Second, opportunities must be created for “negotiated resilience”, to allow for the integration of diverse interests. Third, achieving resilience in ways that do justice to the local realities of diverse urban contexts necessitates taking into account endogenous, locally situated processes, knowledges and norms. And finally, urban resilience needs to be placed within the context of global systems, which highlights the need to reimagine the role that African cities might play in these global finance, politics and science processes.

### **2. Flood risk management: Is it socially just?**

Paul Sayers<sup>1,a</sup>, Matt Horritt<sup>2</sup>, Edmund Penning-Rowsell<sup>3</sup>, Katharine Knox<sup>4</sup>, Jessie Fieth<sup>5</sup>

<sup>1</sup> Partner, Sayers and Partners, Associate WWF-UK and Fellow, Environmental Change Institute, University of Oxford.

<sup>2</sup> Horritt Consulting

<sup>3</sup> Flood Hazard Research Centre, Middlesex University

<sup>4</sup> Joseph Rowntree Foundation (JRF)

<sup>5</sup> Sayers and Partners LLP

This paper explores issues of social justice within current flood risk management and the challenges presented by climate change. It explores issues of geographic disadvantage across the UK (identifying those communities that are both highly socially vulnerable and exposed to flooding) and systemic disadvantage (the degree to which vulnerable communities are disproportionately at risk when compared to the UK average and the possible policy reasons for this) for both the present day, 2020s, 2050s and 2080s. The analysis builds upon the UK Climate Change Risk Assessment and the Joseph Rowntree Foundation (JRF)’s [Climate Just](#) approaches to present new insights in terms of:

- The characteristics of the neighbourhoods at greatest flood disadvantage now and in the future (under conditions of climate change and population growth) across the UK.
- The degree to which flood risk management can be considered socially just (based on considerations of egalitarian, Rawlsian and utilitarian principles).
- The policy enablers and barriers to improving social justice.

The research presented has been supported by the JRF and will be presented in collaboration with the JRF.

### **3. The undebated issue of justice in Dutch flood risk management**

Maria Kaufmann, Sally Priest, Pieter Leroy, Radboud University, The Netherlands.

Flood risk for all types of flooding is projected to increase based on climate change projections and increases in damage potential. These challenges are likely to aggravate issues of justice in flood risk management (henceforth FRM). Based on a discursive-institutionalist perspective, this paper explores justice in Dutch FRM: how do institutions allocate the responsibilities and costs for FRM for different types of flooding? What are the underlying conceptions of justice? What are the future challenges with regard to climate change? The research revealed that a dichotomy is visible in the Dutch approach to flood risk management: despite an abundance of rules, regulations and resources spent, flood risk or its management, are only marginally discussed in terms of justice. Despite that the current institutional arrangement has material outcomes that treat particular groups of citizens differently, depending on the type of flooding they are prone to, area they live in (unembanked/embanked) or category of user (e.g. household, industry, farmer). The paper argues that the debate on justice will (re)emerge, since the differences in distributional outcomes are likely to become increasingly uneven as a result of increasing flood risk. The Netherlands should be prepared for this debate by generating the relevant facts and figures. An inclusive debate on the distribution of burdens of FRM could contribute to more effective and legitimate FRM.

#### **4. Governing Urban Displacement in the Context of Extreme Climate Risks: The case of Tacloban City, Philippines**

Roos J. Groen, University of Amsterdam, The Netherlands.

A resilient urban governance arrangement is at the core of successful implementation of disaster risk reduction (DRR) policies that address the uncertainties of extreme climate risk, due to the decentralized nature of DRR (IPCC, 2012). One of the most significant uncertainties that cities in the global South face is the risk of community displacement under extreme climate change scenarios. Displacement is not only a key development challenge in itself, due to the wide range of vulnerabilities internally displaced persons (IDPs) face, but it can also potentially result in long-term development challenges. Ineffective and unjust governance decision-making processes can exacerbate displacement outcomes. The literature on urban governance highlight the complexity of multi-level and multi-sector stakeholder interaction, especially when there are conflicting interests (Belloni, 2012; Logan & Molotch, 1987). However, the literature on extreme climate risks has largely ignored the socio-spatial implications of decision-making processes. Therefore this paper will address the following research question: how do urban governance decision-making processes influence extreme-risk socio-spatial displacement outcomes? To increase the resilience of urban governance and to overcome such outcomes, several policy recommendations will be made.

This study takes Tacloban City, the Philippines, a secondary urbanized coastal city in the Eastern Visayas region, as a case study example. Tacloban is highly prone to various types of extreme weather events, and the city experienced a significant amount of displacement in November 2013 attributed to Typhoon Haiyan. This mix-methods study encompasses policy document analysis as well as interviews with a wide range of governance actors operating at national, regional and local levels. In addition, interviews and focus groups were conducted with climate IDPs. The study found that recent neoliberal decentralization mandates in the Philippines have created governance deficits, which in turn create an inability to adequately account for displacement in decision-making processes. Urban governance decision-making processes can exacerbate socio-spatial outcomes of displacement through the exclusion of marginalized groups, conflicting interests amongst actors, the collusion of private and civil society interests in the governance process, the differentiated agency of the actors, and the gaps in human and financial resources. In addition, the multi-level and/or multi-sectoral nature of the urban governance process played an important role in determining the socio-spatial outcomes. By better recognizing environmental justice priorities, such as inclusion, agency, accountability, transparency and advocacy, in urban governance arrangements, we can increase the resilience of cities and overcome scenarios where socio-spatial displacement outcomes are exacerbated.

## **5. Fair allocation of risk and benefits – distributional justices in mountain hazard management**

Thomas Thaler, University of Natural Resources and Life Sciences, Austria.

This presentation examines the questions of distributional justices in mountain hazard risk management of Austria, Europe. As protection against flood risk becomes increasingly challenging, dilemmas of justice emerge: some communities and individuals benefit from natural hazard protection schemes whereas others loose. Decisions on whom to protect differentiate between upstream and downstream communities or different riparian areas, which raises a central but barely discussed conflict: what (or rather who) should be protected against future hazard events? There are multiple and often contradicting concepts of justice, which differ in interpretations of fair resource allocation and distribution. This paper analyses the impact of different philosophical schools of social justice on the Austrian mountain hazard risk management. We use data from a spatially explicit, object-based temporal assessment of elements at risk and compare potential distributional effects of three political jurisdictions. We found that – depending on the respective political direction – various communities gain and others loose within the actual distributional system of mitigation strategies. These findings highlight the distributional consequences of future mountain hazard management and point to the crucial selection of policy direction in navigating the selection of various adaptation strategies.

## 1.3 The challenge of communicating high-end climate change

*Tim Rayner, Tyndall Centre, University of East Anglia*

### Communication, art and culture

1. The challenge of communicating high-end climate change (Tim Rayner, Tyndall Centre, University of East Anglia)
  2. Communicating the need for adaptation to local level decision makers (Tiago Capela Lourenço, University of Lisbon)
  3. The 'resilience trap': exploring the practical utility of resilience for climate change adaptation in UK city-regions (Andrew Kythreotis, Cardiff University)
  4. Facilitated group discussion (Asher Minns, Tyndall Centre, University of East Anglia)
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**Keywords:** Communication, adaptation, resilience, framing, stakeholder engagement

The chances of climate impacts worsening as average global temperature rise exceeds 2°C – or even 4°C - by 2050, are increasing. Faced with the prospect of high-end climate change, climate scientists and communicators risk becoming 'narrators of doom', instilling defeatism and negativity in the various audiences they address. There is a growing need to stimulate engagement and effective responses from policy makers, organisations of various kinds and the public, but how can this be achieved? How can individual citizens and organisations engage seriously with the kind of negative knowledge that few want to hear, including the uncomfortable message that adaptation must often become more 'transformational': requiring the abandonment of currently cherished policy objectives, land uses and practices?

The 1 hour 40 minute session will begin with three presenters taking 10 minutes each to outline what is known from existing research about the dilemmas of communication of unwelcome climate messages, and how they can be most effectively handled. The session will then switch to facilitated group discussion mode, chaired by Asher Minns (Future Earth), in which a range of propositions regarding effective communication, drawn from the research literature and from the experience of presenters working in a local context, are discussed. Mixed tables of practitioners and academics will discuss and then report back in plenary. If we agree that communication efforts based on the linear-rational model have failed sufficiently to motivate, what should take their place? Can we find a way that is truthful to scientific understanding and simultaneously delivers practical messages of agency, hope and urgency?

NOTE: This discussion is convened by the EU FP7 HELIX and IMPRESSIONS high-end climate change projects, based on a working paper on the *Challenge of Communicating Unwelcome Climate Change* (Rayner and Minns 2015) and other on-going work.

#### Target audience

We offer this session as a joint 'science-practice interface' session, intended for a wide audience of anyone whose role involves them in communicating the threat of climate impacts and the need for adaptation, either to policy makers or wider economic and societal stakeholders. It offers the chance for academic researchers and practitioners to exchange experience and insights relating to communication of the need for adaptation, especially of a more transformational kind.

#### 1. The challenge of communicating high-end climate change

Tim Rayner, Research Fellow, Tyndall Centre, University of East Anglia

With the probability that global mean temperature rise can be kept below the internationally recognised 2°C target continuing to diminish, and growing evidence of limits to adaptation, citizens as well as economic and political decision makers need to engage with knowledge about the likelihood and implications of severe future

impacts, and the scale of mitigation required to avoid them, the likes of which few want to hear. The EU-funded HELIX project brought together around 30 individuals from a range of disciplinary and organisational backgrounds for a workshop to discuss how best to do this. Communicators must be more than ‘narrators of doom’, but recognise the need for ‘active hope’, constructed from realistic goals, imaginable paths, doable tasks and a meaningful role within a collective response to problems at hand. New, more dialogical forms of communication, with various audiences in a range of venues are needed, in which new high-end climate messages can be conveyed and processed with citizens and decision makers. Ideally, these processes should be facilitated by highly skilled individuals or teams. These currently less common forms of communication will require additional investment and training.

## **2. Communicating the need for adaptation to local level decision makers**

Tiago Capela Lourenço, Faculty of Sciences - University of Lisbon

Drawing from extensive experience in the Portuguese context, the communication to local-level stakeholders and decision makers of the need for adaptation, particularly to high-end climate change, involves confronting a series of unwelcome messages:

- adaptation is not a (distant) future decision-making need. If current practices are unable to deal with current climate variability, they will most likely not be well prepared for a significantly changed climate;
- adaptation cannot be regarded as a one-time optimization problem, requiring intensive use of resources in a single investment, but requires reflection about how to act and hedge against climate change on a continuous basis;
- adaptation actions cannot be regarded as either purely technical or purely political. Most options will require work in both dimensions;
- most climate-related local problems will require a combination of ‘grey’, ‘green’ and ‘soft’ types of measures in order to lower costs and enhance benefits;
- adaptation decision making should move beyond a framing in terms of incremental vs. transformational actions. In order to consider transformational change, there must be a willingness to change established objectives. Reliance on incremental changes may well mean that current objectives cannot be sustained over the longer term.

These are unwelcome messages at local level, not because they are too controversial or difficult to grasp, but because they introduce a novel way of doing things in a number of aspects. These include planning, allocating resources, methods used, collecting information needs, inter- and intra- departmental cooperation, etc, which are not always easy to accept.

## **3. The ‘resilience trap’: exploring the practical utility of resilience for climate change adaptation in UK city-regions**

Andrew Kythreotis, Lecturer/ Research Fellow, School of Geography and Planning, University of Cardiff

This paper, based on Kythreotis and Bristow (2016), examines how adaptation is interpreted across different UK city-regions by governance and policy actors, finding that the discourse of adaptation is giving way to resilience. This is explained by the value of resilience as a discursive construct in mobilizing and coordinating policy actions. Resilience has greater appeal as a framing device over adaptation to such actors given its potential to enable buy-in from a wider city-regional governance network. However, this paper also highlights the ‘resilience trap’: the dangers of adopting short-term strategies, re-badging existing strategies and widening governance networks that obfuscate sub-national mobilization around adaptation, and may overlook the need for more transformational approaches. It then reflects on how governance actors may act to avoid the resilience trap.



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### Tue PM2, Session 1, Carron 1

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## 1.1 New knowledge and its communication

*Timothy Carter, Finnish Environment Institute (SYKE)*

### Climate services

### Communication, art and culture

1. Assessment Approach and Key Findings from the Fourth Generation of European-wide Climate Change Impact Assessments (Hans-Martin Füssel, European Environment Agency)
  2. Uncertainty assessment of climate impact indicators – presentation of a new methodology (Elke Keup-Thiel, Climate Service Center Germany - Gerics)
  3. Serving the Energy Sector with climate information: the CLIM4ENERGY Copernicus C3S project (Nicolas Fournier, Met Office)
  4. The need for longitudinal surveys to support adaptation and resilience: examples from a three-step survey among flood-affected households in Germany (Philip Bubeck, University of Potsdam)
  5. Potential impact on tourism in Scotland of changing perceptions of landscapes under high-end climate change (Elizabeth Clarke, University Of Edinburgh)
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**Keywords:** communication, impacts, review, survey, perception, uncertainties, tourism, floods

The level of research effort devoted to studies of ongoing and potential future impacts of climate change has increased markedly in recent years. This reflects a growing recognition among decision-makers of the crucial importance and value of such information to support adaptation responses. However, these new findings are often dispersed and difficult to locate, posing challenges for the effective communication and dissemination of vital new knowledge.

This session offers illustrations of some alternative approaches to the communication of new knowledge on climate change impacts and their uncertainties. A first, resource-intensive but comprehensive approach involves compiling, reviewing and synthesising all available new evidence from the available literature, relying on the expert evaluation of authors and reviewers. Another way of generating new knowledge for others to learn from involves surveying actual impacts and responses in the aftermath of damaging climate-related extreme events. Communication through visual or other sensory images can itself be a vital research tool for raising awareness and altering perceptions of future climate change and its impacts. Moreover, if adaptation decisions are to be made on the basis of impacts research, there are likely to be questions raised about the reliability of results, especially when this concerns potential impacts in the future. Thus, an important element of communication concerns confidence in findings and associated uncertainties. Finally, there are numerous web-based outlets designed to provide access to new knowledge. While these usually cater for specific target audiences, there may be general lessons to be learnt from their approach to the communication of climate impacts information.

### Significance to adaptation practice, policy and/or business

The session will offer contrasting examples of how results from climate impacts research can be communicated to decision-makers in a form that may be relevant for supporting adaptation. Some of the information is contextual, providing a basis for understanding the need for adaptation; other information is experiential, describing how adaptation is occurring in practice. Target audiences include public policy-makers, industry planners, public and private utilities as well as the research community. The examples span multiple sectors, are land-based and marine, and focus on scales ranging from city to continent-wide.

## **1. Assessment Approach and Key Findings from the Fourth Generation of European-wide Climate Change Impact Assessments**

Hans-Martin Füssel, European Environment Agency

The European Environment Agency (EEA) has recently published its fourth indicator-based report on climate change, impacts and vulnerability (CCIV), following earlier reports in 2004, 2008 and 2012. This report was coordinated by the EEA with contributions from many other organizations and individuals. In the development of this report, EEA puts an equal focus on the validity of the information, including a discussion of key uncertainties, its comprehensibility, and its relevance for policy-making.

Similar to the earlier EEA reports, the 2016 EEA CCIV report presents around 40 quantitative indicators on climate change and its impacts on climate-sensitive sectors and systems, including the climate system, terrestrial and marine ecosystems, coastal zones, agriculture, human health, energy, transport, and tourism. Past trends and projections for these indicators in Europe are presented in a consistent format including structured key messages, graphs and maps.

One important innovation of the 2016 EEA CCIV Report is the inclusion of a systematic review of multi-sectoral climate change impact, vulnerability and risk assessments with relevance for Europe at different levels, including spillover impacts from outside Europe. This assessment addresses the questions what is known about the risks and opportunities from climate change across European regions, and whether findings from different studies are largely consistent with each other. The report also includes a comprehensive overview of adaptation policies at the global, European, transnational and national level.

The 2016 EEA CCIV report includes a stand-alone Executive Summary, which discusses its main findings in the wider context of climate and environmental policies. The report concludes, among others, that all key findings from the 2012 EEA CCIV report are still valid; some climatic changes have established new record levels in recent years; the rate of change has accelerated for some climate indicators; global climate change has substantially increased the probability of various recent extreme weather and climate events in Europe; the observed changes in climate already have wide-ranging impacts on ecosystems, economic sectors and human health and well-being in Europe; ecosystems and protected areas are under pressure from climate change as well as other stressors; climate change is affecting all regions in Europe, but the impacts are not uniform; climate change adaptation strategies, policies and actions, including mainstreaming into other policies, are progressing at all governance levels; and the knowledge base regarding climate change impact, vulnerability, risk and adaptation assessments in Europe could be enhanced.

## **2. Uncertainty assessment of climate impact indicators – presentation of a new methodology**

Elke Keup-Thiel, Climate Service Center Germany - Gerics

Existing climate data portals mainly treat the uncertainties of climate indicators in two ways: either they provide generic information and/or they express the quantifiable fraction of uncertainty with statistical measures. However, none of the climate data portals provide users with direct guidance on how confident they can be in the displayed data.

A new integrated platform of climate data services has been developed in the FP7 project “Climate Information Portal for Copernicus”, CLIPC. The new data portal of CLIPC provides a single point of access for comprehensive scientific information on climate change and climate change impacts.

In this project, the Climate Service Center Germany (GERICS), developed a methodology on how to assess uncertainties related to climate impact indicators. This approach provides information on the importance of different sources of uncertainties associated with a specific climate impact indicator, and how these different aspects are combined into an overall ‘degree of confidence’, for a given indicator. A key part of our approach was

gathering feedback from users to ensure that the portal was meeting user requirements in terms of uncertainties of climate indicators. In the presentation, we will highlight the new uncertainty assessment approach available at the portal of CLIPC.

#### **Significance to adaptation practice, policy and/or business**

Reliable climate information forms a basis for adaptation planning. CLIPC developed a portal, which provides access to comprehensive scientific information on climate data and climate impacts including an uncertainty assessment in order to depict the confidence of several climate impact indicators. A careful and indicator-specific information on confidence of climate and climate impact data plays a decisive role for adaptation practice.

### **3. Serving the Energy Sector with climate information: the CLIM4ENERGY Copernicus C3S project**

Dr. Nicolas Fournier, Met Office

The Copernicus Climate Change Service (C3S) CLIM4ENERGY project is presented. The project is designed to provide climate information to the energy sector.

Due to ongoing climate change, the energy industry has to cope with major issues. Low-carbon energies have to grow rapidly in the coming decades to avoid exceeding the 2°C threshold (and try to remain below 1.5°C). This rapid transition towards renewables makes the energy production, transmission and distribution increasingly sensitive to weather and climate variability. In this context, energy producers need to anticipate resources, their variability at seasonal timescales and their trends over decades. Grid operators need to identify black-out risks. Electricity traders need to anticipate energy prices depending on the availability of combined resources. Climate change also modulates the weather impact to energy systems. Changing precipitation patterns may affect the management of hydropower resources. Changes in winds, temperature and radiation may affect the variable renewable resources. Investments for infrastructures and networks, refining and distribution must account for unavoidable climate change effects such as future sea level rise. Extreme events have changing occurrence frequencies, inducing a shift in associated risks.

CLIM4ENERGY brings together the complementary expertise of 7 climate research and service centers and 10 energy practitioners, acting as co-designers, to demonstrate, from case studies, the value chain from climate variables to actionable information in the energy sector. As a proof of concept, it will deliver 9 energy-relevant pan-European indicators of climate trends and variability with cross-sectoral consistency, documentation and guidance, estimation of uncertainties, and demonstration of use.

A presentation of the first results from the project will be given. The project investigates 6 cases studies of use of the products (wind power, hydropower, electricity demand-supply balance, freezing rain, bioenergy and oil & gas offshore assets), which will be presented. The emphasis will be on how the project was co-designed and how products can be used by a wide community of users.

#### **Significance to adaptation practice, policy and/or business**

The project is suited to the science/practice interface as it demonstrates the build-up of a climate service with fully co-designed elements. Products will serve policy, industry and research users

### **4. The need for longitudinal surveys to support adaptation and resilience: examples from a three-step survey among flood-affected households in Germany**

Philip Bubeck, University of Potsdam

While anthropogenic climate change is a global phenomenon, its impacts such as rising temperatures or heavy precipitation are being experienced at the regional and local level. Accordingly, adaptation measures are usually implemented at the level of cities, businesses or individual households. Adaptation processes are, therefore, highly context-specific and location-based and their success depends, among others, on the preferences,

perceptions, values and resources of those supposed to undertake or accept these. This makes a good understanding of the local context key to successful adaptation and resilience building. Accordingly, surveys among citizens, businesses or farmers have become an important instrument to gain insights into these aspects. However, the vast majority of these surveys are cross-sectional, i.e. taken at one point in time. This severely hampers our understanding of causal relationships, processes, such as ‘bouncing back’ or ‘learning from disasters’, and feedback mechanisms. To demonstrate the need for and usefulness of longitudinal surveys, we present results from a three-step survey among flood-affected households in Germany. The same households were interviewed by telephone approximately 8, 18 and 30 months after the severe flood of 2013. The longitudinal data are used, amongst others, to better understand the factors influencing the recovery process (bouncing back) of flood-affected households. Results show that individual recovery is largely driven by personality traits rather than event characteristics. To increase societal resilience, aid and recovery efforts need to account for the heterogeneity in individual recovery.

## **5. Potential impact on tourism in Scotland of changing perceptions of landscapes under high-end climate change**

Elizabeth Clarke, University Of Edinburgh

Landscapes are an important element of Scotland’s tourism industry. The unique landscapes and scenery of the Cairngorms region make the National Park an important tourism resource to the local and Scottish economy. Tourism within the Park is primarily focused on landscape- and/or land-based activities. The landscapes of the National Park have been, and will continue to be, influenced and modified by climate and non-climate factors. This includes the future impacts of, and adaptation to, high-end climate change.

The stated preferences of UK tourists for projected Scottish landscapes under high-end climate change were assessed in a photo-based survey. Results indicate the change in visitor preferences to visit and undertake activities in the changing landscapes. These were used to estimate the potential change in visitor trips to the Cairngorms National Park (CNP); a proxy for the potential impact of high-end climate change on summer, tourism-based income. Results suggest a decrease in the number of trips made by visitors arising from a change in their stated landscape preferences, and a resulting impact on tourism income. However, fluctuations are within current inter-annual variations. Although these results are exploratory they begin to illustrate the types of impacts that the landscape-orientated, Scottish tourism sector may face in the future under high-end climate change.

## 5.7 Constituting Local Knowledge of Natural Disasters in Climate Adaptation

*Lisa Van Well, Swedish Geotechnical Institute*

### DRR

#### Participation and co-production

1. The temporality and spatiality of 'local' knowledge and its relevance for climate change adaptation and natural hazard management (Gunhild Setten , Norwegian University of Science and Technology. )
  2. Input from municipalities exposed to debris flows - Optimizing the utilization of warning information for weather events with local knowledge (Charlotte Cederbom, Swedish Geotechnical Institute )
  3. Challenges and opportunities of climate adaptation: highlighting the importance of community networks and social capital through a natural disaster lens (Deanne Bird, University of Iceland)
  4. Using citizens' observations and information sharing in flood risk management (Hans Jørgen Henriksen, Geological Survey of Denmark and Greenland)
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**Keywords:** Local knowledge, natural disasters, risk reduction, community involvement

Climate adaptation strategies and action plans often cite local and community knowledge as one of the main factors for success. This session will problematize and delve deeper into what constitutes this knowledge and discuss innovative ways that local knowledge can be better used as an evidence base relating to risk, natural disasters and climate adaptation. Local/community knowledge here relates to knowledge of geological/geotechnical phenomena, cultural and social capital factors and organizational or institutional capacity knowledge leading to an increased understanding of natural disasters and climate adaptation.

To set the stage for the session the first presentation will look at the question of how exactly might local knowledge work in a crisis within the context of natural hazards and climate change adaptation. The next two presentations consider how local knowledge about natural disasters relates to technical knowledge/solutions and community social capital respectively. Finally the last presentation will provide an example of how local knowledge is co-produced by ordinary citizens' observations. A panel discussion after the presentations will focus on not only good and innovative case studies and practices about how community/local knowledge can be collected, and used in climate adaptation measures, but also how this knowledge can be verified, institutionalized and, employed in monitoring and evaluation schemes. Last but not least, it is also important to find ways to report back to the involved stakeholders and citizens, informing them of the scope and manner in which their knowledge/observations have been utilized.

The presentations highlight different, but interrelated aspects of local knowledge in disaster risk management from the Nordic countries. The panel discussions will also relate to local knowledge use in Australia and South East Asia.

The contributions to this session build upon the NORDRESS (Nordic Centre of Excellence on Resilience and Societal Security) network of researchers. Oral presentations will be 15 minutes each and the final 30-40 minutes of the session will be devoted to a panel discussion with all presenters based on input from the audience. We encourage the participation of local stakeholders in the session and welcome their input into the panel debate.

#### **Significance to adaptation practice, policy and/or business**

The session highlights the importance of using local knowledge about natural disasters in climate adaptation strategies and risk reduction measures. It presents innovative examples of collecting and using local knowledge, but also problematizes what actually constitutes local knowledge and how it can best be utilized. Through the presentations, panel debate and audience participation we hope to raise awareness about the challenges and

opportunities of using such knowledge, spur discussion about various methods and thus provide a concrete input into adaptation practices and eventually the policy debate.

## **1. The temporality and spatiality of 'local' knowledge and its relevance for climate change adaptation and natural hazard management**

Gunhild Setten and Haakon Lein, Norwegian University of Science and Technology

The importance of local knowledges and practices is increasingly acknowledged in relation to natural hazards and climate change adaptation. However, local knowledge has no agreed definition, but can be “considered to be a body of knowledge existing within or acquired by local people over a period of time through accumulation of experiences, society-nature relationships, community practices and institutions, and by passing it down through generations” (Mercer et al. 2010, 217). Local knowledge is often portrayed as distinct from scientific knowledge seen as knowledge which is rational, systematized, placeless and transferable. Agrawal argues that this is a potentially ‘ridiculous distinction’, and suggests that it makes more sense “to discuss multiple domains and types of knowledge with differing logics and epistemologies” (ibid., 218). We concur, and argue that in order to understand more of the nature of local (and scientific) knowledges and its implications for climate change adaptation, we need to pay more attention to the temporality and spatiality of local and scientific knowledges in the event of a hazard.

Empirical material produced with emergency planners and social security officials in central Norway, suggests that during a hazard event, local knowledge as characterized above, is critical in the early stages of the event. Yet, also in interviews, it is held that “In order to release the potential of local knowledge, it needs to be part of a system”, and that “The best way to use local knowledge is to systematize it”. I.e. local knowledge works best when used and understood as part of a larger ‘pool’ of knowledges. This supports Agrawal’s argument, that there is no straight forward distinction between local and scientific knowledges.

In this presentation, we want to problematize when, how and why ‘local knowledge’ throws light (or not) on the nature of knowledge itself, but also how we need to consider its temporality and spatiality within the context of a crisis.

Mercer, J. et al. 2010. Framework for integrating indigenous and scientific knowledge for disaster risk reduction. *Disasters* 34, 1, 214-239.

## **2. Input from municipalities exposed to debris flows - Optimizing the utilization of warning information for weather events with local knowledge**

Charlotte Cederbom, Lisa Van Well and Ramona Kiilsgaard, Swedish Geotechnical Institute

During 2011-2015, a research project was conducted with the aim to investigate if high-resolution precipitation forecasts with a focus on intensive rainfall can be used for improving hydrological forecast resolution. The Swedish Geotechnical Institute (SGI) investigated how warning information provided by the Swedish Meteorological and Hydrological Institute (SMHI) is applied today and what additional functionalities could increase its usefulness for preventing negative consequences of debris flows. In an interview study, we analyzed the state of knowledge and management of the national warning information available for Swedish municipalities with potential or obvious debris flow problems in order to get a picture of improvement needs and the needs of knowledge dissemination in the country. The overall goal was to optimize the benefit of SMHI’s existing warning information for weather events with regard to how municipalities’ handle debris flows.

Conclusions drawn from the interview survey are that all municipalities understand the benefit of SMHI’s warning information. Municipalities that are aware of their problems with debris flows, use the warning information provided by SMHI, especially the meteorological warning information. Many municipalities have experienced that local, intensive precipitation has not always been predicted in advance, and they call for improved resolution in

the forecasting system. Municipalities also see the potential benefit of improved, high-resolution predictions of water flows in vulnerable catchments areas where debris flows are known to occur. Most municipalities have routines for responding to the SMHI warnings. However, they do not have sufficient resources for a follow-up of events that have occurred, or for the evaluation of the actions taken in response to warnings. Thus there appears to be a disconnect between the local and technical knowledge and how it can be fully integrated into institutional procedures in the municipalities.

### **3. Challenges and opportunities of climate adaptation: highlighting the importance of community networks and social capital through a natural disaster lens**

Deanne Bird and Guðrún Gísladóttir, Institute of Life and Environmental Sciences, University of Iceland; Guðrún Jóhannesdóttir, Department for Civil Protection and Emergency Management, Iceland; Guðrún Pétursdóttir, Institute for Sustainability Studies, University of Iceland

While some settlement level impacts of climate change will offer opportunities, most will be challenging for local populations. This paper discusses these challenges and opportunities in relation to the small communities situated along Iceland's south coast where there is a tradition of strong community networks, social capital and livelihoods based on small-scale use of local resources. These traditions, however, are based on local knowledge and experience of the natural hazard events that regularly threatened and reshape the dynamic landscape in which these populations live. External economic forces and patterns of migration are also currently impacting the strength of community networks and social capital. As such, the capacity for settlement level adaptation is highly complex and strongly influenced by factors unrelated to climate change. In some instances, these forces will inhibit the population's ability to adapt. In other instances, they will provide the resources that facilitate adaptation.

### **4. Using citizens' observations and information sharing in flood risk management**

Hans Jørgen Henriksen, Jacob Kidmose and Peter van der Keur, Geological Survey of Denmark and Greenland

Participatory early warning and monitoring systems for disaster management related to flooding from cloud bursts, groundwater, rivers and storm surges is an optional way of expanding monitoring and early warning techniques with network based public participation and citizens' observatories within groundwater and flooding. Hereby more timely and accurate warnings can be issued, and more comprehensive compilations of damage effects can target critical infrastructure and local communities at risk. At the same time public risk perception and hazard awareness can be improved. In the Nordic context this effort aims at collecting synergy from past and ongoing projects within this area, for testing such new citizens' observatories in a Nordic context. The idea is to allow citizens and communities in Nordic countries to take a new role in the information chain, to better monitor water resources including shallow groundwater, and allow citizens to take an active role in data collection, evaluation and communication. Lessons learned regarding such participatory early warning and monitoring systems will be presented, with specific focus on real time monitoring and modelling of groundwater. Furthermore, novel ideas for 2-way-information sharing and communication systems will be presented, and challenges in relation to incorporating citizens observations into public data bases and forecast modelling tools.

## 13.2 Implications for policy and planning of the impacts of climate change on health and wellbeing

*Sari Kovats, LSHTM*

### Health

1. Intra-city variation of mean radiant temperature as a result of urban vegetation – implications to health and well-being (Jorge H. Amorim, Swedish Meteorological and Hydrological Institute - SMHI)
  2. Health impacts of the Urban Heat Island, and the potential benefits of adaptation in a UK city (Helen Macintyre, Public Health England)
  3. Heat wave impacts on Ischemic Heart Disease - present and future impacts in Germany (Hans-Guido Muecke, German Environment Agency)
  4. Quantifying uncertainty in estimating future heat-health burdens in London (Sari Kovats, LSHTM)
  5. Predicting the spill-over risk of tick-borne pathogens at the human-tick interface in an uncertain climate future (Sen Li, University of Oxford)
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### 1. Intra-city variation of mean radiant temperature as a result of urban vegetation – implications to health and well-being

Jorge H. Amorim, Swedish Meteorological and Hydrological Institute - SMH

Mean radiant temperature (T<sub>mrt</sub>) is a robust indicator of human thermal comfort and heat stress in built-up areas, especially due to its ability to capture intra-city spatial gradients, enabling it to account for the effects of urban planning and design, or to quantify the performance of climate change adaptation measures. However, T<sub>mrt</sub> studies are usually limited to small areas, giving a limited understanding of the city-wide variations.

In this work, T<sub>mrt</sub> maps are produced using a downscaling modelling technique that encompasses an average size town in Sweden. Firstly, surface-atmosphere fluxes are calculated at the regional scale using the Numerical Weather Prediction system HARMONIE, in which the Town Energy Balance (TEB) model is applied for downscaling the climate signal down to a 1x1 km<sup>2</sup> spatial resolution. The outputs are then used as atmospheric boundary conditions to the obstacle-resolving urban radiation model Solweig, which allows to simulate spatial variations of 3-D radiation fluxes and T<sub>mrt</sub>, as well as shadow patterns, in complex urban settings. For this purpose, a higher-resolution digital surface model was built based on laser scanning data from the Swedish land survey agency, describing land, buildings and vegetation at 2x2 m<sup>2</sup> resolution. This land-cover database constitutes the set-up for the baseline simulation. Additionally, a planning scenario was created by simply eliminating all forms of vegetation existing in the city. The simulation period includes selected warm episodes in the last 10 years.

The analysis is focused on quantifying and explaining the intra-city spatial gradients of T<sub>mrt</sub>, and its relation with the characteristics of grey/green infrastructure (e.g., dimensions, geometry, orientation and compactness of buildings and trees, and LAI of vegetation) and their interactions. For this purpose, results are plotted over outdoor pedestrian areas. Fine scale architectural details are found to be well represented by the applied computational method. Also, the overall benefit of urban vegetation on human comfort is extracted from the comparison between baseline and scenario. The T<sub>mrt</sub> maps produced allow to identify outdoor spaces that can be critical during a heat wave, and to assess the paths and the proximity to cooler areas in different parts of the city. This methodology can potentially help planners and health experts to improve the resilience of cities to climate change by optimizing the spatial arrangement, design and properties of buildings and plants.

### 2. Health impacts of the Urban Heat Island, and the potential benefits of adaptation in a UK city.

Helen L. Macintyre, Public Health England, Centre for Radiation, Chemical and Environmental Hazards, Chilton, Oxfordshire.



Heatwaves are associated with a range of adverse health effects, which can lead to emergency hospitalisations and mortality. Under climate change scenarios for this century, heatwaves are likely to become more frequent, more intense, and last longer. In towns and cities, the Urban Heat Island (UHI) effect i.e. higher ambient temperatures in the city centre compared with surrounding suburban and rural areas, particularly at night, can exacerbate these health effects. The effects of UHIs are often amplified during anticyclonic summer weather conditions, which can cause or exacerbate heatwaves.

Birmingham (in the West Midlands) is the second most populous city in the United Kingdom. It is a highly-urbanised area, and observations indicate that it has a pronounced UHI. Recent modelling showed that theoretically replacing urban land categories in the West Midlands with rural ones led to a reduction in 2 metre air temperature of around 3°C on average, and up to 7°C during the heatwave of August 2003, compared with the baseline urban simulation. The enhancement of temperature due to the UHI has been associated with excess heat-related mortality in the West Midlands during this heatwave period. Understanding the pattern of risk across a region can help target resources to reduce heat risk in the most vulnerable areas. Adaptation interventions such as cool roofs and urban greening are possible ways to reduce the intensity of the UHI, and thus reduce population exposure to heat.

We use the regional meteorological Weather Research and Forecasting (WRF) model, with an urban canopy scheme, to simulate the UHI in Birmingham and the West Midlands Metropolitan region. Simulations based on variations of the total urban fraction allow us to investigate the role of urban surfaces on enhancing local temperature, and to estimate the resulting heat-related health impacts. The effects of adaptation interventions such as changes to building properties or morphology can also be simulated to determine the potential extent of UHI attenuation.

We present results of spatial analysis of the UHI, and interventions such as cool roofs and urban greening, which may influence exposure to heat risks during a heatwave period.

### **3. Heat Wave Impacts On Ischemic Heart Diseases – The Present And Future Situation In Germany**

Hans-Guido Muecke, German Environment Agency

Heat waves are defined as extended periods of extreme high temperatures, and they exert a stronger influence on health than isolated hot days. Heat-related studies frequently report that the temperature-mortality relationship is stronger than the one for temperature-morbidity. Heat is one of the primary weather-associated threats to life, as dramatically shown by the death toll of the 2003 heat waves in Europe with around 50,000 excess deaths. Elderly, small children and chronically predisposed people are the most vulnerable group to be at high risk, while the heat impact is highest e.g. on the cardiovascular system.

This is the first nation-scale study analyzing the relationship between the impacts of heat on ischemic heart diseases (IHD) in Germany - at present and in the climate changed future. Therefore, heat waves impacts on IHD mortality and morbidity had been analyzed for the decade 2001-2010. Daily excess mortality and morbidity rates were used from a nationwide database. All calculations were performed separately for 19 regions to allow for the investigation of regional differences.

The results show that IHD mortality during heat waves is significantly increased (+15 % more deaths on heat wave days). In stark contrast, no heat wave influence on hospital admissions due to IHD could be observed. Regional differences in heat wave IHD mortality are present, with the strongest impact in the Western part, and weaker than average effects in the Southeastern and Northwestern regions. The increase in mortality during heat waves is generally stronger for females (+19 %) than for males (+11 %), and for chronic ischemic diseases (+18 %) than for myocardial infarctions (+12 %). Longer and more intense heat waves feature stronger effects on IHD mortality, while timing in season seems to be less important.

Furthermore, the influence of future climate change on the occurrence of heat waves in Germany was studied. Simulations of 19 regional climate models with a spatial resolution of 10-25 km are analyzed. All of the models use a moderate greenhouse gas forcing according to the SRES scenario A1B. Three model time slices of 30 years are evaluated, representing present climate (1971-2000), near future climate (2021-2050) and remote future climate (2069-2098).

Based on the model simulations, future heat waves will be significantly more frequent and longer lasting in Germany. By the end of this century, the number of heat waves will be tripled compared to present climate. Additionally, the duration of heat waves will increase by 25 %. Altogether, the number of heat wave days will be four times higher in the period 2069-2098. Regional analyses show that stronger than average climate change effects are observed particularly in the Southern regions.

#### Significance

The results show that in Germany (a) heat waves are associated with increased IHD mortality rates; (b) heat wave characteristics are strongly modulating mortality results; and (c) heat impacts are different concerning regions, gender and diseases. A potential relationship between the heat and IHD morbidity remains unclear. The used methodology does not imply possible adaptations to climate change, but it is most likely that the individual heat burden will increase considerably. The obtained results point to public and individual adaptation strategies to reduce the future heat wave impact on mortality. The study was funded by the German Environment Ministry.

#### **4. Quantifying uncertainty in estimating future heat-health burdens in London**

Sari Kovats, LSHTM

Risks to health from hot weather are a key concern for decision makers with regard to managing climate change in the UK, and in cities like London. The uncertainty in future heat-related number of deaths is a function of the uncertainty in the temperature-mortality relative risks (RR), the uncertainty in future projections of mean daily temperatures and the uncertainty in the future projections of annual number of deaths. In high income cities like London, the impact of high temperatures on mortality is mostly confined to the older age groups. Therefore, future population growth and population ageing are a major determinant of the future burden of heat related mortality.

Probabilistic mortality data were produced using a population model that generates projections with details of future age and gender structure using stochastic error propagation. For daily temperature projections, two sources of data were used: the UKCP09 probabilistic projections (for emissions scenario SRES A1b); and daily outputs from RCM (regional climate model) deterministic projections (for emissions scenarios RCP4.5 and RCP8.5). Age-specific temperature-mortality functions were estimated from epidemiological analyses of observed mortality and temperature data adjusted for seasonal patterns, air pollution and other time-varying confounders. The mean RR and its 95% confidence intervals were estimated. Then, we used a monotonically increasing nonlinear function (3<sup>rd</sup> order polynomial) to extrapolate the RRs beyond the observed temperature range. The final model to quantify the health impact (annual heat-related deaths) contained two time steps: daily and annual. Probabilistic temperature projections are made on a daily basis whereas the probabilistic population-based death calculations are made on an annual basis. We assumed that the deaths remain the same within a year. The uncertainties in the input variables (temperature, RR and all-cause mortality) were propagated through the health model to quantify the uncertainty in future impacts.

Future heat-related deaths were estimated for the following age groups: 0 to 14 years, 15-64 years, 65-74 years, and 75+ years. The PDFs (probability density functions) of the input variables were estimated empirically, and then sampled using Monte Carlo simulations. The findings were used to estimate the distributions of the frequency of and impacts of major heatwave events, and also to understand the major sources of uncertainty and their individual contribution towards the uncertainty in future health burdens from climate change.

## **5. Predicting the spill-over risk of tick-borne pathogens at the human-tick interface in an uncertain climate future**

Sen Li, University of Oxford

The spill-over of pathogens between vectors and humans is one of the most important processes underpinning the emergence of zoonotic diseases. There is an urgent need to understand better where spill-over will occur and public health will be threatened, in order to improve people's well-being in an uncertain climate future. The occurrence of spill-over process represents a complex interaction at the human-wildlife interface, requiring humans to encounter infectious hosts under specific environmental conditions. Such inherent complexity makes this process difficult to model. Agent-based models are important predictive tools with the capability to integrate these heterogeneities in space and time. By using this approach, humans, vectors, and wildlife hosts can be represented as agents, whose behaviors are governed by pre-specified rules, allowing them to interact with each other and environment.

In this study, an agent-based model was developed for the spill-over process of Lyme disease - the most prevalent vector-borne diseases in Europe. It integrated two sub-models that were both modified from our previous modelling studies, namely, (i) a biophysical hazard model for the pathogen transmission between ticks and their wildlife hosts and (ii) a socio-economical exposure model for humans' outdoor leisure activities. The model was applied as a scenario-testing tool to predict the future patterns of pathogen spill-over risk (i.e. the contact possibility between visitors and infectious ticks) for Scotland and Hungary. Scenarios for different trends of climate and social-economic changes were developed by working closely with stakeholder from the case regions. These scenarios were translated into a number of sectoral drivers that can influence the model predictions in different ways, including (i) climatic drivers that impact tick behaviors and pathogen transmission in wildlife populations, (ii) socio-economic drivers that affect the outdoor recreational behaviors of human, and (iii) land use planning drivers that shape the future distribution of residential areas and tick habitats. The joint effect of these drivers on the spill-over risk pattern was predicted under different scenarios and mapped for both case regions.

This study contributes to a unified framework of modelling tick-borne disease risks improved from the previous ones in which the spill-over processes have rarely been included. The predicted risk patterns under different climate and socio-economic scenarios provide useful information to policy makers to stimulate cross-sectoral communications to address potential future adaptation needs, and to the general public to increase their precaution of the disease risks.

## 4.6 Planned relocations from high-risk flood areas: Managing social justice, psychological and spatial challenges

*Sebastian Seebauer, LIFE, Joanneum Research Forschungsgesellschaft MbH and Thomas Thaler, University of Natural Resources and Life Sciences, Vienna*

### Climate justice

#### Flooding

1. Should I stay or should I go? How citizens decide on and cope with planned flood relocation (Sebastian Seebauer, LIFE, Joanneum Research Forschungsgesellschaft MbH)
  2. Influence of the cultural concept of place on the policy of flood risk management (Thomas Thaler, University of Natural Resources and Life Sciences, Vienna)
  3. Resettlement as a strategical planning instrument to adapt for future needs? (Arthur Schindelegger, Technical University Vienna)
  4. Just relocation? Planned relocation from climate change, human rights and justice (Daniel Petz, University of Graz)
  5. Legal Considerations for Implementing Planned Retreat in Developed Coastal Areas - Perspectives from Australia (John Watson, University of South Australia)
  6. Policy Polarities: Migration, Climate Change and Adaptation (Caroline Zickgraf, The Hugo Observatory, University Of Liège)
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**Keywords:** societal transformation; social justice; risk governance; flood risk management, place identity; relocation; policy acceptance; private adaptation

In the field of disaster risk management a large inventory of adaptive responses to climate-induced and socio-economically-driven hazards has been developed. Although this inventory comprises a wide array of structural and non-structural measures, planned relocations of at-risk residents are usually only taken into account if other adaptation strategies are ineffective or unavailable. Despite its obvious effectiveness in permanently reducing vulnerability, relocation is highly contested in the public risk discourse. The session aims to shed light on the social, spatial and equity implications of moving households away from risk areas, and shall illustrate how to navigate common pitfalls in communication and implementation.

The session brings together multiple research perspectives on relocation processes, demonstrating various challenges in the decision-making process. Residents who are affected by relocations are confronted with radical changes of their livelihood: overcoming emotional attachment to the place left behind and adapting to a new residency, as well as coping with financial burden and re-building a neighbourly social network. Relocation zones imply a range of spatial consequences: Resolving land-use conflicts (e.g., agriculture vs. ecological use), redeveloping network infrastructure (e.g., water and energy supply, sewage disposal, roads), or dealing with sites of historical, cultural or religious importance. Heated public discourse may reflect controversial stakeholder negotiations between governance levels, civic protest and focused media attention. Social justice aspects not only address the distribution and fairness of compensation payments to relocating households (distributive justice), but also the process how a certain distribution was achieved (procedural justice). Decisions by policymakers, landowners and residents build on moral and ethical standards, equality of opportunity (e.g., access to information, policy representation/participation, social capital), vested interests, as well as attribution of blame and liability.

The session joins empirical findings from case studies on ongoing or accomplished relocation schemes. The respective presentations shall contribute to a deeper understanding of the transformative potential of planned

relocations in achieving more climate resilient communities, informing the design of relocation schemes in other regions.

## **1. Should I stay or should I go? How citizens decide on and cope with planned flood relocation**

Sebastian Seebauer<sup>1</sup>, Philipp Babczyk<sup>2</sup>, Thomas Thaler<sup>3</sup>

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After a severe flooding in 2013, public authorities initiated an extensive relocation project in the Eferding Basin in Upper Austria. Over 146 at-risk residents, declared un-protectable within the existing technical, economic and legal constraints, had to decide on a relocation offer until the end of 2015. By Autumn 2016, about a third of the households had agreed to relocate; some have already demolished their buildings. While the relocation scheme is voluntary from a legal standpoint, there is a strong political impetus to encourage all residents to leave the risk zone.

We conducted semi-structured qualitative interviews with 78 relocation households prior to the relocation offer deadline in order to identify their decision-making processes, perceived fairness and risk perceptions. Follow-up interviews to capture long-term impacts are foreseen for the end of the year 2016. The interview audio records were transcribed and subjected to qualitative content analysis.

Relocation households consider a wide range of risk judgments, economic consequences and emotional aspects when deciding on the relocation offer. Numerous residents call on their experiences with the most recent flood event to determine future flood risks at their own buildings. Households contrast the offered compensation with the current and future value of their property on the housing market. Personal circumstances, such as recent family foundation, employment, retirement or the prospects of one's children play into their economic assessment. The emotional appraisal is shaped by the personal attachment with the residence or farmyard and by the extent to which the available coping options threaten one's way of living. We find that relocation is usually described as uprooting and undermining people's self-identity. Some households fear stigmatization such as those who remain in the flood plain may receive less social and financial support during future flood events.

In general, households lacked opportunities to express their individual perspectives and considerations with respect to the relocation and regional flood hazards. Future relocation projects should consider engaging an individual or institution to moderate the relocation process between all involved parties in an empathic, neutral and trustworthy way.

Politicians and public authorities should communicate information in a timely, clear and binding manner to avoid raising unreasonable expectations by rash promises; they should disclose decision-making criteria and put them up for discussion. By integrating affected households and their flood risk expertise in a participatory dialogue, small-scale and citizen-oriented concepts may help to manage flood risk and land use in a more effective and consensual way.

## **2. Influence of the cultural concept of place on the policy of flood risk management**

Thomas Thaler<sup>1</sup>, Sebastian Seebauer<sup>2</sup>, Philipp Babczyk<sup>3</sup>

<sup>1</sup> Institute of Mountain Risk Engineering, University of Natural Resources and Life Sciences, Vienna, Austria

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<sup>3</sup> Wegener Center for Climate and Global Change, University of Graz, Austria

In the field of flood risk management a large inventory of adaptive responses to climate-induced and socio-economically-driven hazards has been developed. Although this inventory comprises a wide array of structural and non-structural measures, one of the most effective adaptive responses is planned resettlement of people at

risk. The paper investigates current challenges of relocation programs for communities in flood risk management, and introduces the theoretical concept of place attachment (Heimat) as a central framework to analyse the barriers and challenges of relocation in flood risk management. Two study sites in Austria (Eferdinger Basin and Machland region) are selected to analyse and to assess the use of relocation as an adaptation strategy in flood risk management. The relocation scheme is voluntary with the authorities offering to buy out property at its estimated market value. Although relocation strategy comprises one of the most effective adaptive responses to the flood hazard challenge, this adaptive response is highly contested (legally, socially and economically). People who are affected by relocations are confronted with profound changes in their livelihoods; in particular to overcome emotional attachment to the home left behind and adapting to a new residency as well as re-building a neighbourly network. To investigate the importance of place attachment in the individual decision, we conducted a semi-structure qualitative approach in both study sites. The findings of the study show that place attachment is a central argument against the relocation within the region. Nevertheless, the concept of place attachment is a widely intangible concept, but demonstrates a central argument within the relocation process. We conclude that although a relocation process may be seen as an 'optimal' solution for flood risk management, in practice there are many limitations and barriers in conduct these relocation processes them effective. Rhetoric may not be matched by reality and a 'relocation' agenda may bring more problems than it solves.

### **3. Resettlement as a strategic planning instrument to adapt for future needs?**

Arthur Schindelegger, Department of Spatial Planning, Technical University Vienna, Austria

Resettlement poses a severe state intervention in people's property and way of living. This measure is rarely used in Austria due to its manifold procedural challenges and political dimensions. Nevertheless, relocating people in natural hazard areas, to ensure their safety and reduce the damage potential, represents a feasible adaptation strategy to address shifting hazard frequencies and areas in connection with a changing climate. Resettlement as a strategic and preventive measure itself does not exist as an independent planning instrument. Until now, this lead to a prevalence of large scale projects for flood protection along the Danube river. Responsible state authorities in the field of natural hazard management can offer the possibility for resettling on a voluntary basis within their field of responsibilities.

The study investigates several resettlement projects all over Austria to identify firstly the formal and informal procedures within the administration body and secondly the role of spatial planning itself in making resettlement possible and happen. Starting by analysing the legal framework and capacities, the challenges and constraints in legal issues become apparent. The following investigation of the informal real-life solutions to organise such projects, is based on qualitative interviews with relevant stakeholders in the administrative body and helps to evaluate the actual implementation strategies.

The findings of the research show, that although there is no individual procedure for resettlement, the legal framework is sufficient to carry out such measures on a voluntary basis. The main challenges can be found in the institutional coordination and cooperation in a governance based understanding. Still, there is a crucial lack of strategical and long-term perspectives in identifying possible future resettlement areas. The present study therefore aims to provide a comprehensive analysis of resettlement processes focusing on the side of public authorities and the institutional framework. The research may provide an initial examination of the challenges that occur in organising voluntary resettlement programs, implementing long term planning perspectives and provide experiences based on real-world case studies.

### **4. Just relocation? Planned relocation from climate change, human rights and justice**

Daniel Petz,<sup>1</sup> DK Climate Change, University of Graz

Climate change effects already have impacts on the habitability of human communities in many countries and numerous communities are already considering relocation or are in the process of being relocated. The scope of

planned relocation is likely to rise significantly with increasing climate change effects in the future. While planned relocation has been recognized as part of adaptation challenges under the UNFCCC'S 2010 Cancun Adaptation Framework (§14f), many open questions remain on when, where and how to do planned relocation in a way that guarantees the human rights of those that need to be relocated. This paper focuses on a recent attempt to devise international guidance on planned relocation from climate change, the Guidance on Protecting People from Disasters and Environmental Change through Planned Relocation. It explores advantages of and challenges to a human rights-based approach to planned relocation based on discussing how such a rights-based guidance ascribes responsibilities and deals with contentious questions such as who decides when to move, who is responsible for the planned relocation and which protections exist for those who decide not to relocate. It finds that rights-based guidance documents might be a proactive instrument in terms of preventing human rights violations before they occur, which could be called human rights violations risk reduction. The paper further discusses synergies and conflicts that can arise when additionally conceptualizing planned relocation through a justice lens, looking mainly at how the guidance addresses distributive justice and procedural justice questions. While the Guidance addresses several justice considerations, the paper finds that looking at planned relocation through the justice lens provides an angle that is not fully covered by a rights-based approach as laid out in the Guidance as justice questions can provide both a micro (justice consideration concerning the relocation project) and macro (national, global justice and intergenerational considerations) lens for evaluating planned relocation. Particularly on the macro level, justice can help to connect a specific relocation project to broader societal, global and even intergenerational questions of justice.

## **5. Legal Considerations for Implementing Planned Retreat in Developed Coastal Areas - Perspectives from Australia**

John Watson, University Of South Australia

This presentation explores from an Australian perspective the legality of implementing a 'planned retreat' strategy for adapting existing coastal settlements to the effects of climate change. The ongoing reliance on protection-based strategies for managing coastal hazards is likely to be questioned in coming years given their financial, environmental, and amenity impacts and the onset of climate change.

Planned retreat is a coastal management and climate change adaptation strategy that relocates people and assets from privately owned land deemed vulnerable to erosion or inundation. Vacated land can be sacrificed to the ocean, thereby allowing dynamic coastal environs to naturally accrete and erode, or restored and replenished to acts as a buffer. It provides an alternative policy solution when traditional forms of resilience in urban areas threaten to yield unsustainable outcomes.

Under Australian law governments can compulsorily acquire land for public purposes, provided that those affected are furnished with 'just compensation'. Given that individuals develop a strong affinity with their property and coastal land is expensive, compensation and public discontent are common reasons for governments refusing to embrace retreat strategies. However, scholars have identified alternative techniques such as purchase and leaseback schemes, landswap schemes, entering agreements, acquisition of partial legal rights (such as easements), land-use regulation, innovative use of mortgages, and transferable development rights ('TDR') schemes.

This presentation argues that for these techniques to be successfully applied government authorities must exercise some level of control over vulnerable land. This is a challenge that raises number of legal questions regarding property rights, scope of government power, and environmental management frameworks. It will be contended that the following criteria should be used to evaluate the feasibility of a proposed retreat strategy:

- a) The extent that government authorities can exercise the rights of possession and use over the land in question;

- b) The type and amounts of compensation required;
- c) Whether government authorities have the statutory power or authority to perform activities necessary for retreat; and
- d) Consistency with environmental law and policy that regulates the use of land.

This presentation will conclude that a feasible retreat strategy from a government perspective is one that vests legal title in a government authority, minimise payments of compensation, and ensure consistency with existing legal frameworks without the need to enact legislation. Furthermore, a strategy that satisfies these criteria is more likely to be embraced by governments and relevant stakeholders.

## **6. Policy Polarities: Migration, Climate Change and Adaptation**

Dr. Caroline Zickgraf, The Hugo Observatory, University Of Liège

As the number of concrete international measures remains wanting, the number of migrants forced to move by the impacts of climate change depends largely on the adaptation policies that are implemented at lower levels of governance and in sending and receiving locales. As has become clear, most migration related to climate change remains internal (Newland 2011), and thus it is local and national governments' adaptation initiatives that mold these flows and their outcomes. Primarily, policymakers focus on curbing migration through adaptation strategies in situ in order to reduce the pressure to migrate. In the Mekong Delta, for example, some local governments explicitly discourage migration. Faced with rainfall shortages and variability, they try to attract factories to their primarily agriculture-dependent economies in order to halt rural exodus. At the national level, some countries are grappling with huge shifts in their population distribution and so prioritize adaptation intent on stopping migration to their exploding urban centers. Coastal megacities in West Africa, for example, simply do not possess the infrastructure or socio-economic opportunities necessary to cope with a large influx of migrants (Zickgraf et al. 2016). Without appropriate adaptation measures in destination areas, rural migrants arrive in precarious urban slums and often become the most vulnerable to coastal flooding, associated health risks and other human security concerns.

Such policies tend to consider migration as a failure to adapt. However, an emerging vantage point reflects a shift in discourse: migration as adaptation. Migration can be a positive strategy that diversifies rural livelihoods, reduces pressures on dwindling natural resources, and can lead to rural development. There are indeed countries that seek to harness this potential through skills training, bilateral agreements, and remittance incentives. Kiribati introduced the 'Migration with Dignity' policy as part of their long-term nation-wide relocation strategy. It aims to create opportunities for those who wish to migrate to various receiving countries, such as Australia and New Zealand, so that their expatriates may facilitate chain migration and remit back to their sending communities. It also seeks to improve the levels of educational and vocational qualifications in Kiribati to prepare citizens for a life abroad (McNamara 2015). Resettlement programs are another clear case of initiatives that facilitate population movements (de Sherbinin et al. 2011), which have seen success in the Mekong Delta, but failure elsewhere.

It is these two distinct policy streams – those that seek to deter migration from areas affected by climate change and those that embrace migration as an adaptation strategy in itself – that this paper investigates. We assert that they represent two opposing framings of the relationship between human mobility and climate change whose polarity itself issues challenges and provides beneficial potential.



## 10.2 Understanding adaptation practices in agriculture and fisheries

*Stefan Fronzek, SYKE*

### Agriculture & forestry

1. To adapt or not to adapt to future extreme climate? – Heterogeneity of farmers and their preferences for insurance (Mette Termansen , Aarhus University)
  2. How do agricultural experts perceive climate change impacts and adaptation in Austria? (Hermine Mitter, University of Natural Resources and Life Sciences, Vienna)
  3. An integrated approach for adapting mountain agriculture to climate change (Heidelinde Grüneis, AlpS GmbH)
  4. Climate Change Vulnerability in Agriculture and Adaptation Strategies of Farmers to Climatic Stresses/Extremes (Melike Kus, Nature Conservation Centre)
  5. Techno – Institutional Change and Water Resilience: Climate Variability Responses of Villages of Two Districts of East Nusa Tenggara (Diyane Astriani Sudaryanti, Center for Agricultural and Rural Development Studies, Bogor Agricultural University)
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**Keywords:** Adaptation decisions, insurance, integrated approach, mountain agriculture, perception of climate change and adaptation, stakeholder, survey

Research on how adaptation is put into practice in agriculture is the focus of this session. It consists of papers that attempt to understand how climate change and the need for adaptation are being perceived by different groups of stakeholders and assess how adaptation decisions are being made. A common approach to understand adaptation practices is by means of surveys among stakeholder groups from local and regional to national levels. These can help to explain perceptions and motivations for or possible obstacles to putting adaptation into practice. The social, institutional and economic contexts of those who make adaptation decisions are equally important as the environmental context that determines climate-related risks and opportunities to which adaptation is required. Some of the questions addressed are: What are the key vulnerabilities and adaptation options in the case studies? Do stakeholders have access to the information required to understand and evaluate these? Do the capacities exist to implement adaptations? The case studies presented in this session are from different regions in Europe and India covering a wide range of climatic conditions and socio-economic settings, providing examples of studies focusing on specific types of adaptation options as well as integrated approaches.

### Significance to adaptation practice, policy and/or business

The session is directly reporting adaptation practices in several case studies. These help to understand how and why adaptation decisions are being made (or why not) and allow to give recommendations how to improve the adaptation process within the individual case studies and as lessons learnt that can be applied elsewhere.

#### 1. To adapt or not to adapt to future extreme climate? – Heterogeneity of farmers and their preferences for insurance

Mette Termansen, Aarhus University, Department of Environmental Science

The latest IPCC report has highlighted that the frequency and magnitude of extreme climate events are increasing. Agriculture is one of the key economic sectors expected to experience impacts from this trend. Despite the increasing recognition, in both scientific and policy domains, of the prospective of insurance as part of adaptation strategy, it remains understudied to what extent this appeals to farmers. The overarching aim of the present research is to investigate the scope for farm level adaptation using insurance. This is approached by modelling to what extent different farmers are likely to financially insure their agricultural production from the risks associated with extreme climate events. Data was collected using a choice experiment via an online survey involving a representative sample of farmers across Denmark. 1053 farmers completed the survey, capturing

heterogeneity of farmers and diversity of agricultural land uses. Four attributes of insurance scheme were considered in the design of the choice experiment: 1) self-coverage when the insured qualifying event occurs; 2) farm area to be covered by insurance, 3) price of the insurance, and 4) subsidy towards part of the insurance fee. The data was analyzed using a latent class choice model. The model identified four statistically different groups of farmers, indicating that farmers are heterogeneous in terms of their propensity to consider insurance. Using the model, we can quantify to what extent the design of insurance schemes can have important bearing on the attractiveness to farmers. To this end, we can quantify to what extent the higher price of insurance and larger share of what farmers have to cover in the event of loss are likely to discourage farmers to take up insurance. We can also assess quantitatively to what extent public intervention through provision of subsidy can increase the attractiveness of an insurance scheme. Overall the research demonstrates the potential for insurance scheme in the agricultural sector for adapting to future extreme climate.

## **2. How do agricultural experts perceive climate change impacts and adaptation in Austria?**

Hermine Mitter, University of Natural Resources and Life Sciences, Vienna

In Austria, agricultural experts working for regional agricultural institutions traditionally act as knowledge brokers and multipliers. Despite of their important role in promoting climate change adaptation, their perceptions and future expectations of changes in regional climate conditions, climate change impacts and private adaptation have not been systematically identified and analyzed yet. Therefore, a focus group discussion and qualitative, semi-structured expert interviews have been carried out in two Austrian case study regions (Mostviertel, South-East Styria) which have been selected due to differences in pedo-climatic conditions. The interviews were conducted with agricultural experts representing the bandwidth of regional agricultural institutions including extension services, administration, research institutes, farming engineering schools, regional development agencies, environmental organizations, agricultural cooperatives, producer groups, and machinery co-operations. In total, 21 interviews were conducted, digitally recorded and transcribed word-for-word. Qualitative content analysis has served for analyzing the data. We find that changes in climate are perceived via increasing temperature levels and variability, changes in precipitation distribution, changes in seasons' length, and an increase in intensity of droughts, heat waves and heavy precipitation events. For the future, the agricultural experts expect further increases in mean temperature and temperature fluctuations, changes in timing of precipitation, more severe extreme events and high inter- and intra-annual variabilities. Perceived climate change impacts are focused but not limited to negative effects on plant and livestock yields, expenses for plant production and salaries, natural resources, and physical capital. Expected future impacts refer to inter-annual yield variabilities, harmful effects on natural resources, and damages to physical capital. These expectations determine the perceptions on future adaptation requirements. A broad variety of incremental, systemic and transformational adaptation measures are perceived relevant for the case study regions. The agricultural experts refer to crop, livestock and financial management changes (incremental), farm investments, land use and land cover change (systemic), and to changes in farm specialization, abandonment of farm production, and engaging in non-agricultural secondary activities (transformational). Several incremental and systemic adaptation measures are perceived to gain in importance in the future, including the implementation of new technologies, land use and land cover change, and more sophisticated financial and risk management strategies. Private adaptation is perceived to be stimulated by regional climate change. However, agricultural experts perceive legal, market and policy conditions as equally important at least. This emphasizes the importance of placing climate-related chances and risks in the context of the farm, the region, and the legal, market and policy framework.

## **3. An integrated approach for adapting mountain agriculture to climate change**

Heidelinde Grüneis, AlpS Gmbh

Mountain regions are among the most vulnerable regions to climate change worldwide. Mountain agriculture, which fulfills several important functions, including the conservation of valuable ecosystems and cultural landscapes, is directly dependent on climatic conditions and thus, especially affected by climate change impacts.

There are several ways to cope with climate change. Common approaches include crop management, irrigation or weather information systems. Many of them are technology oriented and aim at particular climate change impacts. However, the cross-sectoral nature of climate change requires a broad integrated approach, which recognizes the unpredictability of certain climate change impacts (e.g. extreme weather events) and which addresses the context in which hazards occur. Although such approaches can hardly be found in national or regional adaptation strategies, regional initiatives seem promising in raising resilience to climate change and enable a flexible response to unanticipated changes. These adaptation relevant actions succeed in linking practical agricultural challenges to the scientific-driven adaptation concept. Such an integrated approach considers regional mountain products, marketing strategies, social networks, organic farming as well as awareness-raising. The study investigates such initiatives in Tyrolean mountain agriculture and identifies and describes adaptation types from practice. These types can contribute to an improved management of climate change adaptation for policy makers since some adaptation types do currently not get any attention, funds or other support for climate change adaptation from the public sector. An integrated approach helps to distribute resources equally and strengthen sustainable development in mountain regions. Data is obtained through qualitative interviews with relevant stakeholders from the agricultural sector and supplemented with literature and desktop research.

#### **4. Climate Change Vulnerability in Agriculture and Adaptation Strategies of Farmers to Climatic Stresses/Extremes**

Melike Kus, Nature Conservation Centre

Climate change has impacts on socio- economic wellbeing of society through losses in the resources used, such as agriculture and other ecosystems services. The effects vary greatly based on the vulnerability level of the society and mitigation measures taken. Loss of agricultural outputs resulting from environmental stressors has substantial impact on local livelihoods, especially on the poor's, and on the food security.

Turkey is located in the Mediterranean Basin which is projected to be severely impacted from climate change. Especially the central and the south-eastern parts of the country are projected to be more prone to the negative impacts. The fact is that the negative impacts such as extended droughts and temperature anomalies have already been experienced in these regions, while they are major agricultural producers. These disasters also set back the socio-economic development of the people in the region.

In order to formulate adaptation policies for agriculture, climatic vulnerabilities of the sector should be well understood. Existing vulnerability studies are mainly built on index studies at national, regional or local level. However, the results of these vulnerability analysis are not validated with data from household level.

The study aimed at enriching district level vulnerability analysis with household level data and understanding the coping strategies of farmers to climatic changes and extremes. Vulnerability of agricultural production in Konya Province in the Central Anatolia, which is the biggest province in Turkey, is determined using climatic, socio-economic and agricultural production data obtained from national and local authorities. Furthermore, a socio-economic field survey is carried out in the study area to understand the vulnerability levels of farmers and their climate adaptation strategies.

The presentation will include the results of the district level vulnerability analysis, outputs of the field survey in terms of the vulnerability levels of the farmer households, their observations regarding climatic changes and coping strategies with these changes.

Climate change as a global phenomenon has changed precipitation rate in many areas especially in Indonesia which located in tropical area. La Nina and El Nino as one of the specific form of climate variability dramatically brings about constrains such as longer period of both precipitation and drought. Drought season causes many problems for those who live in ecologically prone areas such as farm households of arid areas. They build up many

ways to respond climate variability, especially to guarantee availability of water. Water scarcity, uncertainty, water loss, water unavailability, and water quality are major aspects of climate variability related to water availability. Local people builds water conservation action to secure water supply. The water unavailability has been a critical issue in drought prone areas. Recent studies showed insufficient of conceptualization on how people manage water under distress climatic condition.

## **5. Techno – Institutional Change and Water Resilience: Climate Variability Responses of Villages of Two Districts of East Nusa Tenggara**

Diyane Astriani Sudaryanti, Center for Agricultural and Rural Development Studies, Bogor Agricultural University

This paper is written on the basis of empirical studies carried out in two Districts of East Nusa Tenggara Indonesia where drought is obvious. The District of Timor Tengah Utara is a region is representing hilly of upland area. The District of Kupang is representing a relatively plain area. For irrigation and consumption, farm households of District of Kupang is supported by the water supply from a concrete-structured dam that flowing water. A spring water and deep well are also water source for villages of District of Kupang. In the District of Timor Tengah Utara, people are dependent mostly on rainfall. That kind of water resource may be seen as the way of the people to adapt to scarcity of water. Building up small-scale collective water reserve is a kind of water conservation that farm households build to increase their resilience to face climate change. The study used survey method and descriptive qualitative analysis. The study found some interesting findings: (1) exposure of farm household in both areas to drought has stimulated them to build diverse technical adaptation to ensure water availability; (2) Water Institution is built to arrange water availability locally and to become key to manage water resource; (3) water management is part of survival strategies of the farm household; (4) good water management is the precondition to achieve livelihood sustainability.

### **Significance to adaptation practice, policy and/or business**

This research can be used as policy recommendation for managing sustainable water resources in dry region all over in East Nusa Tenggara Province. It is also expected that the result of the study can also replicate and can be applied in other places where the socio-economics and ecological characteristics are similar to this location of the study. In addition, the result of the study can hopefully enrich the study of water resource management and institution.

## 5.2 Novel methodologies & tools for knowledge co-production

*Kirsty Lewis, Met Office*

Communication, art and culture

Participation and co-production

1. Emerging Tools and Methodologies to Support Climate Change Adaptation Decision-Making (Leah Dundon, Vanderbilt University)
  2. Legitimizing story telling as local knowledge in climate adaptation planning (Nicole Klenk, University of Toronto)
  3. Bridging a cultural gulf – making better use of publicly funded research in policy development (Anne Marte Bergseng, Sniffer)
  4. Critical climate stress moments: focussing adaptation by understanding at what moments people are particularly vulnerable to climate and weather-related stresses (Annemarie Groot, Wageningen UR)
  5. Co-designing the future - integrating adaptation knowledge into decision making using a systems approach (Celeste Young, Victoria Institute of Strategic Economic Studies)
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### 1. Emerging Tools and Methodologies to Support Climate Change Adaptation Decision-Making

Leah Dundon, Vanderbilt University

Growing populations in high risk areas coupled with the ramifications of climate change present a problem for which practical tools are needed to inform both public and private decision makers. A predominant practice is to assess expected weather and climate impacts based on past experience or long-term climatology, neither of which provide practical information for planners with shorter time horizons. The scientific community well understands that risk assessments may benefit from integrating seasonal forecast information. Yet, this understanding and data are not accessible to, nor in a relevant format for, most policy makers. Worse, there is often no awareness that such information exists. Recently, researchers have been collaborating with planners to develop tools that bridge this gap and assist planners to identify climate-related risks and to quantify the potential impact of extreme weather events on certain types of infrastructure or activities.

Vanderbilt University and the National Center for Atmospheric Research (NCAR) are developing sophisticated tools and methodologies directly aimed at enhancing adaptation planning with a practical and user friendly approach. This presentation will discuss and demonstrate these developments, including presentation of the results of a comprehensive spatial, climate change infrastructure vulnerability screening assessment that combines climate, weather, and impact data to identify vulnerabilities to a range of weather and climate related risks over a multi-decadal planning period.

NCAR is producing climate datasets in unprecedented detail (on a 4 km grid) across the US for current and future conditions. These datasets contain all relevant variables (temperature, winds, rainfall, snowpack, snowmelt, soil moisture, etc.) and can tell us what historical weather events would look like under future climate conditions, their likelihood of occurrence, and information on events beyond historical experience. The presentation will focus on NCAR's Engineering for Climate Extremes Partnership (ECEP), which provides information and tools to support societal planning for weather and climate extremes. ECEP is developing a suite of web-interfaces known as Climate-i, through which a diversity of users can interact with a continually updated database of climate, exposure and vulnerability data for current and future conditions. Users define their location, time period of interest and other local characteristics, and Climate-i returns credible and relevant climate risk-related information. The presentation will discuss the considerable potential for these types of tools across a range of applications, including agriculture, transportation, construction, and emergency planning.

## **2. Legitimizing story telling as local knowledge in climate adaptation planning**

Nicole Klenk, University Of Toronto

Climate change is affecting the life, livelihoods and survival of individuals and communities in many parts of the world. Moreover, the uncertainties associated with climate change impacts present an unprecedented challenge for adaptation planning. While climate change projections can be developed on the basis of global information and models, adaptation has to be informed by the knowledge of the communities where the consequences are felt. For the maritime province of New Brunswick there is growing necessity for policy-makers to incorporate adaptation considerations into daily decision-making and planning. While the term “local knowledge” originally referred to indigenous ways of knowing (Agrawal, 1995; Ellen et al., 2000), couched in terms such as “traditional ecological knowledge” or “indigenous knowledge”, in this paper we refer to Julie Cruikshank’s (2005, p. 9) definition of local knowledge as “tacit knowledge embodied in life experiences and reproduced in everyday behavior and speech”, including oral history, personal narratives of excrement weather events, and experiential knowledge of environmental change. A recent critical review of local knowledge in global environmental change research suggest that it largely refers to perceptions of environmental change, practices associated with local livelihoods, traditional indigenous knowledge, and the “adaptive” capacity of local communities to respond to environmental change (Klenk et al., unpublished manuscript). Recent reviews (Naess, 2013; Reyes-García et al., 2016) treat local knowledge as an object that can be extracted from its local circumstances of production, circulated and aggregated without questioning its social construction and the knowledge production practices involved in local knowledge mobilization that often remain unquestioned – selection, juxtaposition, deletion, ranking, and framing (Law, 2012). Using a case study of a community-based adaptation planning process in 5 coastal communities of the province of New Brunswick, Canada, we illustrate how and why stories of climate change impacts express, perform and produce local knowledge that is crucial to informing adaptation planning. We situate stories in relation to other types of local knowledges mobilized to inform climate adaptation planning, and determine the “trials of strength” that storytelling faces, and the rhetorical tools its employs to gain legitimacy to inform decision making. Drawing on the field of science and technology studies (STS), which has documented the ways in which knowledge production is a social and rhetorical process (Latour, 1987; Callon et al., 2009; Law, 1987), we show how the affective and material aspects of stories of recent flooding events in New Brunswick are challenging dominant regimes of evidence in climate adaptation governance.

## **3. Bridging a cultural gulf – making better use of publicly funded research in policy development**

Anne Marte Bergseng, Sniffer

Aligning science and policy is a well-known challenge. Scientists and policy-makers often have different goals, priorities and measures of success. Decision makers in public and private sector are requiring evidence support for adaptation action and take the necessary actions to increase resilience across society, economy and environment.

Models of knowledge exchange for connecting science with policy and practice are key to achieving this. ClimateXChange (CXC) - Scotland’s center of expertise on climate change – has since its inception in 2011 developed highly effective relationships between a network of researchers and the central government decision makers who require data and analysis.

The Centre grew from the Scottish Government’s clearly specified need to make better use of publicly funded research in policy development, and from a frustration at the silos within which policy development and research operated. Researchers and policy teams were too often talking at cross-purposes. Researchers appeared more interested in their own research focus, rather than answering questions posed by policy teams in a timely manner. Conversely, policy teams often posed questions that were not amenable to a bounded piece of analysis by researchers.

The session will look at how the Centre now actively “brokers” knowledge between the respective communities, involving synthesis, translation, packaging and communicating research insights to help government policy making. The model is built around delivering timely and high quality advice to the Scottish Government; coordinating research, analysis and interpretation across the subject area; stimulating innovative thinking; and developing a programme of knowledge exchange.

We will discuss the importance of relationships and the context in which each project sits; the balance between science push and policy ‘demand’ pull; how to incentivise researchers to participate; and how research needs are prioritized and developed into short and longer term programmes.

#### **4. Critical climate stress moments: focussing adaptation by understanding at what moments people are particularly vulnerable to climate and weather-related stresses**

Annemarie Groot, Wageningen University & Research

With climate change affecting livelihoods, the need for adaptation has become increasingly recognised. Although the amount of information available on climate impacts, vulnerability and adaptation options is growing, challenges have emerged for the uptake and practical use of this information. In our work, we review these challenges and recent advances to overcome them. One element found common in the recent advances is that these look at *when* specific climate stresses occur and what are the drivers. This offers an additional perspective to asking who and what is exposed or impacted by climate change, and where are vulnerable people and their livelihoods located; - these being questions typically emphasized in vulnerability analysis and impact assessment.

Based on this insight, we introduce the concept of ‘critical climate stress moments’ in the context of weather variability and climate change. ‘Critical climate stress moments’ (in short: critical moments) are defined as those moments when a household or community and the livelihood systems it depends on is particularly vulnerable to climate and weather-related risks and hazards. In other words, critical moments are a combination of specific present and past conditions (context-specific), in which climate stresses are particularly likely to be risky and adverse for a specific household or community and the system they depend on. A ‘moment’ refers to a time period shorter than a year. A ‘moment’ can be days, weeks or even months depending on the driver and intra or inter annual variability and change.

Our research discusses the conceptualization of critical moments and introduces the research methods and tools we developed to assess them. Next it offers case examples of critical moments in the Hindu Kush Himalayan (HKH) region. The HKH region is a vulnerable region with a warming trend higher than the global average, which is a cause for grave concern. With the assessment of critical moments our research answers “When are people (socially stratified) in the HKH region particularly vulnerable to climate hazards and weather variability with respect to achieving their livelihood goals and what are the root-causes of their time- and context-specific vulnerability? Preliminary result for the Soan River Basin in Pakistan show, for example, how April has become a critical month over the last ten years. In April, many crops germinate and are particularly sensitive to water stress. Here, supplement irrigation would be particularly effective. Furthermore, male and female farmers experience different critical moments over the year.

#### **5. Co-designing the future – a systems approach to integrating knowledge into decision making**

Celeste Young, Victoria Institute of Strategic Economic Studies, Australia

As adaption knowledge matures and the focus moves toward implementation of adaptation actions, new approaches are emerging. Implementation in this area is complex because it is a systemic issue and requires a highly collaborative model; one where ‘uneasy alliances’ work together to achieve goals. This can be an uncomfortable space particularly for researchers because co-designing starts in a fundamentally different space. It requires researchers to develop understanding from inside end user contexts rather than develop knowledge

from outside it. It is a process of matching the knowledge to the need and tailoring information so end users can use it. Communication is a key part of this and active listening and negotiation are crucial.

This presentation will show a methodology which has been used to develop frameworks that integrate research into decision making systems through co-designing solutions that evaluate end users context and the systems that are part of this. It will show where the starting point is for research and outline key steps. It will illustrate the different applications of this methodology using case studies and discuss outcomes to date. It will also explore some of the challenges that practitioners and researchers face undertaking this work and what the benefits of co-designing the future are and why they matter.



## 6.13 Monitoring and evaluating adaptation in practice: learning from (sub) national examples from Europe and beyond

*Timo Leiter, German International Development Agency (GIZ GmbH) and Mike Harley, Climate Resilience Ltd*

### Monitoring and evaluation

1. South Africa: using Desired Adaptation Outcomes to monitor and evaluate the transition towards climate resilience (Mike Harley, Climate Resilience Ltd)
2. Morocco: Lessons from the pilot phase of a climate adaptation and vulnerability monitoring system for priority sectors (tbd)
3. The Netherlands: a reflexive monitoring and evaluation system for the Delta Programme (Jelle van Minnen, PBL Netherlands Environmental Assessment Agency)
4. Monitoring and evaluation of adaptation policy and practice: approach, lessons learned and future developments at various scales across the UK (Anna Moss, Manuela Di Mauro and Ruth Monfries, ClimateXChange)

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**Keywords:** Monitoring, evaluation, adaptation outcomes, tracking adaptation, climate resilience

**Lead session organiser:** Timo Leiter, Advisor, Climate Policy Team, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Germany

**Session co-organiser:** Mike Harley, Director, Climate Resilience Ltd., Stamford, UK

Many governments have committed to taking steps towards climate resilient development and have put in place strategies, policies and initiatives to address the impacts of climate change. Tracking their implementation and understanding their outcomes is important to guide policy-making and to assess whether progress towards climate resilience is actually being made. The Paris Agreement underscores the role of monitoring and evaluation (M&E) and requires that Parties report on progress in implementing commitments made through Nationally Determined Contributions.

Whilst many countries are currently developing national adaptation M&E systems, a small number of pioneers have already started operationalising them and reporting on adaptation progress. Practice to date shows that national adaptation M&E systems differ in regard to scope, content, methods used and responsibilities of actors (Leiter, 2013; Hammil *et al.*, 2014; Price-Kelly *et al.*, 2015). So far, the ability of existing adaptation M&E systems to assess the actual effectiveness of adaptation responses has been limited, with few links being made between national and sub-national approaches (Leiter, 2015).

This practice session will explore the experiences and insights gained from four adaptation M&E systems. These case studies, from South Africa, Morocco, the Netherlands and the UK, will highlight different M&E approaches at national and sub-national levels of government. They will provide a rich basis for reflection and peer-to-peer learning. Specifically, the presentations will share insights from the development process and, where available, lessons learned from their first years of operation. Interactive discussions with the audience will explore the main take-away messages for the development adaptation M&E systems in other countries.

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## **1. South Africa: using Desired Adaptation Outcomes to monitor and evaluate the transition towards climate resilience**

Mike Harley, Director, Climate Resilience Ltd, UK

South Africa's *National Climate Change Response White Paper* (NCCRWP) advocates a risk-based approach to adaptation. This seeks to address the immediate and observed threats of climate change to South Africa's society, economy and environment, and to identify and prioritise short-to-medium term risk management policies and adaptation interventions to reduce vulnerability and build resilience to climate change.

Adaptation to climate change in South Africa will largely be delivered through sector plans stimulated by the National Adaptation Strategy and also through the adaptation goals set out in its Intended Nationally Determined Contribution under the UNFCCC. The sectors at particular risk from climate change have been identified and stakeholders are required to prepare, implement, monitor and report on adaptation plans. These plans should clearly articulate how roles, responsibilities, policies, interventions and actions will contribute to the National Climate Change Response Objective.

The concept of Desired Adaptation Outcomes (DAOs) was devised to facilitate, inform and focus monitoring and evaluation of South Africa's progress towards climate resilience. Eight generic DAOs have been developed, each of which is of cross-cutting, cross-sectoral relevance and describes a desired state that will enhance South Africa's resilience to climate change in the short-to-medium term (i.e. over the next five to 20 years).

In addition to the eight generic DAOs, 75 DAOs have also been developed for five 'at risk' sectors identified in the NCCRWP (water, agriculture and forestry, health, biodiversity, human settlements), for three 'at risk' sectors not considered in the NCCRWP (food security, energy security, buildings and transport infrastructure), and for disaster risk reduction and management. The climate change-related issues for each of these sectors were summarised and the associated adaptation priorities to enhance their resilience translated into sector-specific DAOs.

This case study presentation will provide insights into the DAO concept, which was introduced in *South Africa's 1st [2015] Annual Climate Change Report*. The generic and sector-specific DAOs are now being finalised through consultations with stakeholders. Progress with the development and achievement of DAOs will be reported in successive *Annual Climate Change Reports*.

## **2. Morocco: Lessons from the pilot phase of a climate adaptation and vulnerability monitoring system for priority sectors**

Representative of the Government of Morocco (invited via GIZ Morocco)

In 2013, Morocco began using its adaptation M&E system in two regions: Marrakech Tensif Al Haouz and Souss Massa Drâa. The system aims to assess changes in vulnerability in key sectors and help monitor adaptation interventions. Conceptually, the system is based on climate change impact and vulnerability chains, which map vulnerability components and highlight entry points for adaptation measures (details are provided in a study by

Hammil *et al.*, 2014). Following a successful pilot phase covering the most vulnerable sectors (water, agriculture and biodiversity/forests), the M&E system is now being extended to additional regions in Morocco. One of its reporting outputs is an annual overview in regional 'state of the environment' reports. This case study presentation will reflect on the experiences gained during the testing of the adaptation M&E system and outline how these have informed its roll-out. It will also highlight lessons learned for other countries and regions that are currently developing adaptation M&E systems.

### **3. The Netherlands: a reflexive monitoring and evaluation system for the Delta Programme**

Jelle van Minnen, PBL Netherlands Environmental Assessment Agency

The Delta Programme aims to protect the Netherlands from flooding and ensure a sufficient supply of fresh water. It is a nationwide initiative, led by a Government Commissioner, with a complex network structure involving many parties, which together form the 'delta community'. The Programme comprises three main themes (flood risk management, fresh water supply, and spatial adaptation) and operates at the frontline of developments in participatory, adaptive and integrated planning and policy implementation in delta areas.

In 2016, the Delta Programme entered its first year of implementation. Given the uncertainties that lie ahead, implementation is based on the principles of adaptive management, through which it seeks to ensure the participation of numerous parties and the adoption of a broad and integrated approach that captures the ambitions and efforts of a range of stakeholders.

This case study presentation will outline recommendations for a reflexive approach to M&E for the Delta Programme. The approach not only recognises and captures the challenges of adaptive management, but also:

- Increases the capacity for systemic learning
- Creates a basis for shared accountability
- Creates a basis for trust and transparency.

The characteristics of the reflexive approach to M&E are that: (a) joint efforts are made by all stakeholders to achieve adequate M&E during the implementation of a programme; and (b) there is a focus on shared learning paired with shared accountability. This provides an environment for ongoing policy improvement during programme implementation, while also harnessing the energy and innovation of all stakeholders. In dealing with uncertainties, it is important that M&E procedures are aware of both implementation practice within adaptation programmes (internal dynamics) and the scientific and societal environment outside a programme (external dynamics). This form of M&E furthers adaptive management, allowing a programme to revise its strategies and actions in a timely manner.

### **4. Monitoring and evaluation of adaptation policy and practice: approach, lessons learned and future developments at various scales across the UK**

Anna Moss, ClimateXChange & University of Dundee; Ruth Monfries, ClimateXChange & Royal Botanic Garden Edinburgh; & Manuela Di Mauro, UK Committee on Climate Change

The UK Climate Change Act (2008) established a policy framework to promote adaptation action in England, Scotland, Wales and Northern Ireland. The National Adaptation Programme (NAP) sets out adaptation actions for England and for non-devolved matters (e.g. defence) in the other three countries. In Scotland, the Scottish Climate Change Adaptation Programme (SCCAP) sets out adaptation policies and proposals. Both programmes require M&E every two years.

The Adaptation Sub-Committee (ASC) of the UK Committee on Climate Change is responsible for reporting to UK Parliament on progress being made in implementing the NAP. It also has a duty to report to the Scottish Parliament on progress with the SCCAP. To fulfil this statutory role, the ASC has developed a methodology for

M&E adaptation at national level. The first part of this presentation will discuss the lessons learnt in applying this methodology, including the resulting recommendations made to both the UK and Scottish Governments.

Working with the Scottish Government, its agencies and other experts, ClimateXChange has developed over 100 indicators to monitor climate change adaptation in Scotland. The indicators and supporting contextual narratives are intended to help policy-makers and others understand progress being made with adapting to climate change, highlighting where successful adaptation is occurring and where policies may be needed to encourage and strengthen adaptation. The second part of this presentation will outline the Scottish approach; it will also provide an overview of ongoing work to improve M&E of adaptation policy and practice in Scotland and to inform the development of the second SCCAP.

At regional level, local authorities engage in complex decision-making processes to determine planning outcomes and the shape of major developments. Such processes often involve competing priorities and stakeholders, as well as legislative requirements, across policy areas. Adapting to climate change is just one of many considerations. The third part of this presentation will examine the decision-making process in one Scottish local authority (Stirling Council); it will identify key decision points, drivers and barriers, and discuss how effectively national adaptation policy is being incorporated into the planning process and how knowledge gained through M&E can help improve decision-making.

## 2.1 Adaptation options for coastal areas

*Mário Pulquério, University Of Lisbon*

### Coastal

1. A Global Analysis of Retreat under BCA-optimal Protection Decisions (Daniel Lincke, Global Climate Forum)
  2. Risk-based adaptive planning for urban coastal flooding in South Florida (Laurens Bouwer, Deltares)
  3. Port vulnerability to extreme events, and adaptation potential, in a climate change future: A UK perspective (Esme Flegg, University Of Southampton)
  4. Learning the lessons from engaging with a community whose long term sustainability is threatened by sea level rise (Philip Bennett-Lloyd, JBA Consulting)
  5. Analysis of proposed managed realignment in England and Wales (Sally Brown, University of Southampton)
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**Keywords:** Coastal areas, floods, sea-level rise, adaptation options

Coastal areas are one of the most exposed and vulnerable areas to climate change. The increasing frequency and intensity of heavy precipitation, storm surges and tropical cyclones are major threats to coastal livelihoods and infrastructure. This extreme events affect every year a large number of populations and have large economic costs. Another major threat is sea level rise. Combined with the fact that a large percentage of European and worldwide population live in coastal areas it is urgent to assess future impacts in these areas and understand what the adaptation options are and how they can be implement to minimize the impacts and protect coastal populations. In this session a number of case studies will be presented with the objective of:

- discussing socio-economic impacts on coastal livelihoods and infrastructure
- discussing adaptation options for coastal areas and understand the diversity of such options and their implications
- reflecting on the importance of engaging with local populations on the discussion of such adaptation options

### Significance to adaptation practice, policy and/or business

This session will present a variety of case studies that will lead to a discussion between researchers, policymakers and practitioners on the impacts of climate change in coastal areas and what are some of the adaptation options for protection coastal livelihoods and infrastructures. The discussion will provide an overview of the complexities of dealing with increasing coastal floods and erosion in highly populated areas.

#### 1. A Global Analysis of Retreat under BCA-optimal Protection Decisions

Daniel Lincke, Global Climate Forum

Coastal flooding due to extreme sea-level events (*i.e.* storm surges, tropical cyclones) is currently one of the major threats to coastal livelihoods and infrastructure and, due to sea-level rise, flood risk is expected to increase significantly over the 21st century. Despite this, coastal floodplains throughout the world are characterized by rapidly increasing exposure due to socio-economic development, coast-ward migration of people and urbanization. This raises the question whether coastal flood risks can be kept at acceptable levels if these socio-economic trends continue under sea-level rise or whether human settlements need to retreat from the coastline.

This paper explores this question and presents results from, to our knowledge, the first global assessment of economically robust retreat and protection strategies. Using the DIVA framework and a global database of 12.148 coastal segments, we apply a robust decision making approach to identify, for each segment, robust strategies, defined here as strategies that have a benefit-cost ratio bigger than 1 under the full range of sea-level rise, socio-economic development and discount rate uncertainty over the 21st century. We thereby consider sea-level rise

scenarios from 30cm to 190cm global mean sea-level rise until 2100, all five Shared Socio-economic Pathways (SSPs), and five discount rates from 0.0% to 6.0%. The paper presents how results differ at local, national and global scales in terms of as adaptation and damage cost, as well as the percentage of scenarios under which the economically optimal strategy is protection.

We find that without considering retreat options, it is, from a pure monetary perspective, economically robust to protect 12% of the global coastline and *not* to protect 69% of the world's coastline. We show that introducing retreat as a further option in our analysis shifts the economically optimal global adaptation response significantly towards less protection. From a social perspective, this shift implies that a large number of people living in rural and less densely populated coastal areas would be forced to migrate with likely adverse social consequences. These results suggest that we are likely to see increasing coastal inequality with urban and densely populated areas being protected and rural less densely populated areas suffering from flood damages and eventually having to retreat from the coast.

## **2. Risk-based adaptation strategies for urban coastal flooding in South Florida**

Laurens M. Bouwer<sup>1</sup>(Deltares), Marjolijn Haasnoot (Deltares),<sup>2</sup> Micheline Hounjet (Deltares), <sup>2</sup>Jennifer Jurado (Broward County), <sup>3</sup>Jayantha Obeysekera <sup>3</sup>(South Florida Water Management District), and <sup>4</sup>Edwin Welles (Deltares USA)

Coastal and low-land flooding is causing increasing nuisance and damages in many communities across South Florida. Increased heavy rainfall events and sea-level rise are projected to increase the likelihood of such flood events in the future. In this presentation we present recent work done by a consortium of researchers and local policymakers and planners, aimed at understanding which adaptation actions in the water system and local communities can deliver more resilience.

We focus on the performance of the current water system of South Florida, by analysing current and future flood risk in several hydrological basins, and possible measures to reduce flood occurrence. Performance is expressed as the level of current and future expected direct flood damages. Hydraulic simulation of the water management system is done with the xpSWMM model, and flood damage estimation is done using the HAZUS-MH approach within the Delft-FIAT model. Measures to improve the water management system include the installation and upgrading of municipal pumps and booster pumps, operational modifications, hardening of structures, nature-based solutions, as well as the raising of roads, adapted building construction, and land-use planning. We show in an adaptive planning approach, how the costs and timing of the strategies with different sets of measures can best be approached.

In addition, the impact of flooding on critical infrastructure is assessed, using the Circle tool. With this interactive tool, dynamic flood scenarios as well as failure of critical infrastructure during flooding are being visualized. Information on coastal flood hazard is provided by the Climate and Stormwater Model developed by Broward County and the USGS. The Circle tool is built on information provided by stakeholders, and supports discussing causes of indirect impacts, and potentials for risk reduction. The tool is set-up for analysis in the particularly flood-prone county of Broward, and is being further developed to include costs related to enhancing flood resilience.

## **3. Port vulnerability to extreme events, and adaptation potential, in a climate change future: A UK perspective** Esmé Flegg, University Of Southampton

Ports are vital components of global trade, providing strong international trade networks. 95% of trade by weight enters the UK by sea supplying a diverse range of goods from foods to electricals. Despite the importance of UK ports only limited steps have been taken to address their vulnerability to both extreme weather events and climate change. This is concerning as ports are susceptible to a diverse range of extreme weather pressures; a challenge anticipated to become more severe in future decades. Legislative and policy is particularly lacking in terms of adaptation guidance. UK ports are managed by Port Authorities rather than the Government; therefore

this industry is free to independently tackle issues, such as extreme weather events, that impact its operation and competitiveness within the global trade market. However little empirical data on port vulnerability to extreme events is publically available. To address this issue a database of extreme weather events (e.g. storm surges) that negatively impacted UK ports was developed, spanning 1950-2014. These results highlight disparities in vulnerability to extreme weather events across UK ports, highlighting a range of different pressures and weaknesses. Disruption impacts ranged from temporary port closure and damage to vessels, equipment or cargo to injury or even death. The benefits and effectiveness of a number of applied adaptive responses were also identified. This historical study was built upon to determine the current pressures experienced by four UK ports: Dover, Felixstowe, Southampton and Tilbury. A database was constructed of commercial vessel activity and port responses to periods of disruption. Dover and Felixstowe ports were found to have been impacted most frequently within both databases, with wind storms and rough seas being the primary disruption cause. These disruptive events tended to occur between October and February. In comparison, Southampton and Tilbury were rarely, if at all, subject to disruption over the past few years. However, future risks of disruption are anticipated to change with climate change. Extreme events are expected to be exacerbated by climate change; for example rising sea-level will increase storm surge heights. Improved understanding of UK ports' vulnerability to extreme events is vital to identify points of potential increased weakness under climate change. Sea-level rise and potential changes in storminess could have significant effects for the UK port industry. The databases developed during this study will justify the need for, and guide the implementation of, effective adaptation measures within ports.

#### **4. Learning the lessons from engaging with a community whose long term sustainability is threatened by sea level rise**

Philip Bennett-Lloyd, JBA Consulting

Fairbourne is a small coastal community (570 homes) in Gwynedd, north west Wales. It was built on reclaimed land, largely in the late 19th Century and then the 1920s and 1930s. The village has tidal embankments on two sides offering varying degrees of flood protection from the sea and estuary, and is also at risk from fluvial and ground water flooding.

The West of Wales Shoreline Management Plan (SMP2) policy for Fairbourne is 'Hold the Line' moving to 'Managed Realignment' in 20-50 years' time. Managed Realignment would require relocation of the village. This policy decision resulted from concerns that projected sea and ground water level rise could lead to more frequent and severe flooding potentially risking lives, damaging buildings and infrastructure. The SMP policy states that building higher flood defences and providing ongoing pumping would be unviable. Opportunities for the community to relocate are limited due to the surrounding Snowdonia National Park.

The SMP2 policy was based on a robust evidence-base, but inevitably raised concern and unrest among the Fairbourne community. This concern was exacerbated by inflammatory media reports in February 2014 that negatively affected house prices and insurance.

Since the media coverage and heightened concern amongst the community, Gwynedd Council has established the Fairbourne Moving Forward (FMF) Project to develop a plan and support the community through the process of change over the next 40 years. This presentation sets out the lessons from the Fairbourne Learning Project that JBA Consulting and Icarus are undertaking for the Welsh Government, working with Gwynedd Council and FMF stakeholders.

The Fairbourne Learning Project aims to:

- Undertake an independent reflection and review of the impact on the Fairbourne community of the SMP2 and related engagement activities. Findings will inform wider SMP delivery across Wales.
- Provide a "critical friend" role to stakeholders associated with SMP delivery at Fairbourne.

Key learning points to date have focused on the importance of building relationships and trust, recognising that taking time to build relationships is often overlooked in multi-stakeholder planning and decision processes. When things go wrong or unexpected pressures impact on the project, it is the strength of working relationships, mutual trust and respect that give the initiative resilience. Clarity around governance and decision-making processes is also essential and will be useful to discuss on a European platform due to the varying decision-making architecture, powers and lines of accountability in different countries.

## **5. Analysis of proposed managed realignment in England and Wales**

Sally Brown, University of Southampton, Sally Smith, Environment Agency, Robert J Nicholls, University of Southampton

With sea-level rise, artificial coasts will become harder and more costly to protect as shorelines steepen and flood risk increases. To manage coastal policies in England and Wales, non-statutory Shoreline Management Plans indicate where to protect (hold the line), retreat (managed realignment), no nothing (no active intervention) or advance the line over the next 100 years by dividing the coast into 1,998 segments called policy units, representing lengths of tens to hundreds of metres. The plans consider regional sediment conditions, climate change, sea-level rise, population density, geomorphology, financial restrictions, legislation, designations and stakeholder opinions.

The second generation of Shoreline Management Plans (2007-2012) indicated a shift away from a policy of hold the line of presently defended coasts, to one of managed realignment or no active intervention. This follows the increasing popularity of more natural solutions in the way we manage our coast. This presentation takes a national overview and determines the extent of policy changes over three epochs, at national and regional levels, and analyses potential factors affecting management options.

In Epoch 1 (the next 20 years), 55% of the 7,300km length of coast is subject to hold the line, 11% subject to managed realignment and 33%, no active intervention and 1% other or mixed policies. In Epoch 2 (the following 30 years), 87% of policies remain the same, but many of those that change move the managed realignment. Thus, there is a 54% increase in the number of policy unit under MR, which represents 17% of the total coastline. This level is maintained in Epoch 3, representing the second half of the 21<sup>st</sup> century / early 22<sup>nd</sup> century. These policies are dominantly reported in south-west England and Wales, and in moderately or sparsely developed areas, with no clear relation to geology or population density.

Shifting to a lesser protected coast brings engineering, financial and social challenges that need further address in the near future, simultaneous to rising sea-levels and increased flooding. Whilst many areas are rural, some residential areas will be affected. One challenge is understanding how to cope with those that would be forced to move due to sea-level rise or are at increased erosion risk. This presentation considers those challenges and presents an example of living with a dynamic coast.

### **Significance to adaptation practice, policy and/or business**

Managed realignment, reduced protection and natural solutions of protection on coasts are common and growing policies. Initially unpopular, acceptance of coastal change is emerging, but a national picture is yet to emerge. These results are useful for policy makers and national governments in England and Wales, and other countries to determine why change happens, when it could occur and whom it may affect, so that complementary policies and solutions to future problems can be planned for. This could affect home owners and businesses alike. It also reviews softer approaches to shoreline management.



## 4.11 Collaboration for transformation: inspiring stories of successful adaptation approaches in UK cities

*Kit England, Sniffer and Sophie Turner, Adaptation Scotland*

### Participation and co-production

#### Urban, energy & infrastructure

1. Delivering a 'Climate Ready' Clyde – The relationship between adaptation and Glasgow City Region partnership working (Kit England, Sniffer)
  2. Aberdeen City's adaptation journey - From the Adaptation Learning Exchange to the beginnings of a city-wide adaptation strategy. (Alison Leslie, Aberdeen City Council )
  3. 'Edinburgh Adapts' – Drivers and successes of Edinburgh's partnership approach to developing its first climate change adaptation action plan. (Fiona Macleod , The City of Edinburgh Council )
  4. Overcoming the language barrier: Effective communication of adaptation (Kristen Guida/Shona Paterson)
  5. Roundtable discussion (All)
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#### Lead session organisers:

- Sophie Turner, Climate Resilience Project Coordinator, Adaptation Scotland
- Kit England, Climate Ready Clyde Project Manager, Sniffer

#### Presenters:

- Kit England, Climate Ready Clyde Project Manager, Sniffer
- Alison Leslie, Sustainable Development Officer, Aberdeen City Council
- Fiona Macleod, Senior Strategy and Planning Officer, The City of Edinburgh Council
- Kristen Guida, London Climate Change Partnership, and Shona Paterson, UCC/ Future Earth Coasts

Urban adaptation is crucial given ongoing trends in urbanisation, climate change and globalisation taking place all across Europe. However, it can't be set apart from wider socio-economic development; each City's actions are framed by the ebb and flow of politics, economics, society and technology. For the last 10 years, the UK has experienced significant socio-economic change, with the recession, public sector spending reductions, and rising demands for services. There has also been devolution to Scotland and City Regions, as well as votes on Scottish Independence, and the planned exit of the UK from the European Union. This has driven a fundamental reimagining of how local places function, how services are designed and delivered, and the role of commissioning and the private sector.

Amongst this, England and Scotland's national adaptation approaches have provided markedly different contexts for local action. Whilst both have requirements for a climate change risk assessment and national plan, they have supported local areas differently. England adopted a centrally-driven support programme, which provided guidance and tools and placed the onus on whether to it onto individual organisations. In contrast, the Scottish Government requires most public organisations to report progress, and is funding Adaptation Scotland, a strong programme which promotes adaptation and supports places and organisations to take action.

Despite the wider context, UK cities have continued to show significant leadership on urban climate adaptation, shaping, influencing and delivering action from local to European levels, and working to reduce exposure and vulnerability to climate hazards both incrementally and transformationally.

The session will showcase the progress of UK cities in these contexts, with a particular focus on how they have sought to integrate and mainstream urban adaptation into wider economic and social activities. Senior officers from the various cities across the UK will tell their stories of how their adaptation programmes were born, and

showcase the range of approaches being taken to urban adaptation across the UK at the City or City Region level. In each session, they will offer insights into how they developed and delivered their adaptation approaches, including the catalyst for starting, and the range of drivers, enablers and barriers. They will also discuss their most significant successes, where actions or initiatives failed and the factors that contributed to both.

### **Significance to adaptation practice, policy and/or business**

Adaptation cannot be separated from the wider economic, social and environmental activities in Cities. Alongside preparing for climate change, cities have other structural challenges such as economic prosperity, inequality, and mitigation. However the urgency of implementing cost-effective adaptation is not matched by the speed in which they are being delivered.

To survive and thrive in the face of unprecedented levels of warming, cities need to improve the process of developing and delivering adaptation, from securing initial political support, to finance and programme management. Hearing from the experiences of others will offer insights and practical hints and tips to allow practitioners to improve their own approaches, as well as insights for academics on how to better leverage or disrupt the existing systemic governance of Cities to increase the scale and pace of transformation.

### **1. Delivering a 'Climate Ready' Clyde – The relationship between adaptation and Glasgow City Region partnership working**

Kit England, Sniffer (Climate Ready Clyde)

This presentation will focus on the Glasgow and Clyde Valley City Region, looking at the work of establishing a 'Climate Ready Clyde', a regional cross-sector partnership which seeks to build resilience to climate change impacts across the Glasgow City Region.

Climate Ready Clyde was conceived at a time of significant change in the region, including Glasgow City's participation in the Rockefeller 100 Resilient Cities network, as well as a regional 'City Deal' of £1.13bn of investment. However, rather than being driven in response to particular extreme weather events, the City Region (supported by others), has been working to make the case for a number of years.

The partnership, once formally established, will comprise three objectives:

- To develop and deliver a world-leading climate change risk assessment, strategy and action plan
- To provide and promote climate leadership, making the case for adaptation across the City Region and beyond
- To add value by providing co-ordination, expert advice and support, training, knowledge exchange and capacity building.

Kit will present his experiences of climate adaptation partnership development, including how adaptation relates to traditional approaches of partnership formation. In particular, he will focus on the challenges it presented and how they were overcome to launch a successful initiative in the City region which supported the wider socio-economic renewal from an area which experienced post-industrial decline. He will also compare and contrast his recent work with his previous experience as Chair of Core Cities - UK's Climate Resilience and Adaptation group, and as lead on climate adaptation in Newcastle upon Tyne, to draw lessons for other practitioners.

### **2. Aberdeen City's adaptation journey - From the Adaptation Learning Exchange to the beginnings of a city-wide adaptation strategy.**

Alison Leslie, Aberdeen City Council

In the last decade, Aberdeen City Council have been affected by weather related incidents, ranging from flooding on the roads, to fallen trees during stormy weather, and school closures caused by snow and ice. Although the Council may be able to cope with occasional extreme weather, it needs to adapt to continue to provide the

services and infrastructure that enable the city to keep open and running on a day-to-day basis. This presentation explains the approach the Council has taken to increase its resilience to climate change, highlighting work completed as part of Adaptation Scotland's Adaptation Learning Exchange (ALE), and the development of a new city-wide adaptation strategy.

In 2014, Aberdeen City Council joined the ALE to push climate change adaptation up the agenda internally, and to reach out to regional and sectoral partners to build collective capacity. Through a combination of workshops and one-to-one support the Council were able to fully incorporate climate risks into the corporate risk register and make significant progress with their adaptation work.

Recognising the benefits from this collaborative approach, the Council went on to participate in the ALE's Risk Assessment Task Group to enhance officer knowledge and skills in undertaking a climate change risk assessment. The Task Group involved six practitioner-led discussions to work through the risk assessment, in addition to meetings with managers at the Council to assign risk ratings to priority climate threats. This process led to an assessment of current and future climate risks for the Council, with regular reporting to senior management.

Since then, the Council, together with the University of Aberdeen, has successfully obtained funding from Adaptation Scotland for an ambitious new 'Aberdeen Adapts' project. The stakeholder led project aims to produce a citywide adaptation strategy and build the foundation of a lasting holistic partnership to direct adaptation action across the city. The influence of the Council goes beyond protecting corporate assets and service delivery. The Council can play a key role in working with city partners to address climate risks and opportunities, protecting people, property, infrastructure, as well as future growth potential. The strategy will reflect the views of people, businesses and organisations from across Aberdeen, and increase the understanding of the adaptation challenges and opportunities facing the city.

### **3. 'Edinburgh Adapts' – Drivers and successes of Edinburgh's partnership approach to developing its first climate change adaptation action plan.**

Fiona Macleod, The City of Edinburgh Council

The Climate Change (Scotland) Act 2009 provided the catalyst for the development of Edinburgh's adaptation framework and action plan, with the Act placing a legal duty on Public Bodies to adapt to the impacts of climate change and report on progress. In 2014, the Edinburgh Sustainable Development Partnership (ESDP) published the Resilient Edinburgh Climate Change Adaptation Framework which set out the climate change risks and opportunities faced by the city. Following the publication, the City of Edinburgh Council and Adaptation Scotland worked together to support the ESDP to co-develop a city-wide Action Plan and Vision to drive forward Edinburgh's adaptation work.

'Edinburgh Adapts' is a joint initiative between the ESDP and Adaptation Scotland. The project focused on identifying actions that organisations can't implement on their own and that need a joined up response from two or more partners. The ESDP formed a dedicated Task Group, which included representatives from across the City, to help plan and run a programme of engagement activities. Through a series of five stakeholder workshops and additional one-to-one meetings, over fifty organisations from businesses, public agencies and community organisations helped lay the foundations for the city's first adaptation action plan and vision. This included working with the Edinburgh Biodiversity Partnership to develop an Action Plan for 2016-18 that, for the first time, includes adaptation actions.

In December 2016, the first Edinburgh Adapts Action Plan and Vision were published. The Action Plan runs from 2016-2020 and contains over 100 committed adaptation actions. The Vision looks even further; setting out the project partners' adaptation aims for two key landmark dates, 2025 and 2050, and illustrates the benefits of becoming a climate ready city.

This presentation will outline how the drivers, the character of the city, and the partnerships developed, help shape Edinburgh's first adaptation action plan. It will also examine how building partnerships is crucial to embedding adaptation across a range of strategies, plans and sectors. Lastly, how different forms of engagement can contribute to generating a number of project successes and innovative adaptive measures.

#### **4. Overcoming the language barrier: Effective communication of adaptation**

Kristen Guida/Shona Paterson, London Climate Change Partnership/UCC, Future Earth Coasts

Adaptation is, at least in part, a function of the horizontal and vertical flow of knowledge between institutions, organisations, communities, and individuals. This dictates that, in order to achieve successful adaptation, the gap between policy, scientific evidence, and practitioner communities across sectors must be bridged. Working in partnership allows this facilitation of knowledge exchange across and within sectors, governments and communities, connecting technical expertise from a variety of disciplines and backgrounds to co-design effective solutions.

Effective communication of the impacts and problems associated with climate change, and on the translation of climate change information into the language of health professionals, property developers, community groups, politicians, planners, and a myriad of other actors who can support adaptation relies on partnership working.

This presentation will cover some of the challenges and lessons learned about communicating effectively about adaptation to a range of different audiences involved in the London Climate Change Partnership. Providing examples primarily from London, on ways to breakdown climate terminology through impactful audience engagement, a series of tools and approaches that have worked well to overcome technical language barriers in order to achieve effective communication will be explored.

## 5.4 Capturing and sharing knowledge on adaptation across Europe: how to support decision makers in the EU

*André Jol, European Environment Agency and Kati Mattern, European Environment Agency*

### Participation and co-production

#### Climate services

1. State of play: EU adaptation policy and knowledge needs (Jelena Miloš, Directorate-General for Climate Action)
2. Assessing adaptation knowledge in Europe: national adaptation plans, resilient infrastructure and ecosystem based adaptation (Sarah Hendel-Blackford, Ecofys)
3. Success factors and limitations in the development of user-oriented climate information portals: Lessons from CLIPC, Euporias, Climate4Impact and SWICCA (Annemarie Groot, Wageningen UR)
4. Sharing adaptation information across Europe - evaluation of the European Climate Adaptation Platform (Climate-ADAPT) (Kati Mattern, European Environment Agency )
5. Lessons learned from the development and implementation of the Spanish adaptation platform and upcoming improvements through the LIFE SHARA project (Anna Pons, LIFE-SHARA Project coordinator, Spanish Ministry of Agriculture and Fisheries, Food and Environment)
6. Effectivity, quality, credibility and user's enjoyment: how the German Environment Agency takes up success factors of user-centred adaptation portals (Petra Mahrenholz, German Federal Environment Agency)

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**Keywords:** Knowledge exchange, adaptation policy, adaptation planning, adaptation platforms, informed decision making, co-production of knowledge, knowledge gaps, governmental reporting of adaptation, awareness raising  
The purpose of the session is to:

- Showcase how European knowledge on adaptation has expanded since the creation of the EU Adaptation Strategy in 2013
- Showcase a range of mechanisms that have been used to capture and share this knowledge (research project web platforms, national and European knowledge Platforms (Climate-ADAPT – webinars, conferences, newsletters)
- Learn from participants how they have developed, captured and shared knowledge in the most effective ways to enable decision-making (3- breakout groups in a workshop)
- Use the findings to feed into the Evaluations of both Climate-ADAPT and the EU Adaptation Strategy

One of the objectives of the 2013 EU Adaptation Strategy is to promote better informed decision making to contribute to a climate-resilient Europe. This has been actioned by identifying gaps in adaptation knowledge and addressing them through various avenues. The development of the knowledge base has been promoted through use of substantial amounts of EU funding, such as structural funds, research and other funds (FP7, H2020, and Copernicus). Improved sharing of knowledge and experiences has been promoted through the development of the European Climate Adaptation Platform (Climate-ADAPT) that has collated scattered adaptation information into one location, and shared this knowledge across Europe.

This session will communicate what has happened since 2013 to develop, gather and share knowledge. The session will also be a forum to exchange opinions in a workshop about the future needs for sharing adaptation knowledge in Europe and how to address these. This session would be of interest to policy-makers interested in contributing to the priority setting of the next phase of EU adaptation policy development. It will also be of interest to experts or researchers producing adaptation knowledge and experiences and wishing to share this.

This session will be split into two parts - a presentation part and a workshop part.

**Part 1 - Presentations** - The presentations will reflect on what has been done and some lessons learnt since 2013 from a variety of EU, project-based and national perspectives.

**Part 2 - Audience participation workshop** - The workshop will capture opinions about the future needs for sharing adaptation knowledge and how to address these. The participants will be split into 3 groups to discuss:

- Group 1. (Facilitator: Clare Downing) *Embedding the online platforms into processes* - What **added activities/services** could be used to reach out, beyond the platforms to make the knowledge sharing more effective, particularly for supporting the development of NAS/NAPs (including sector plans) in EU countries (e.g. linking with sector-specific activities, online webinars and face-to-face training)?
- Group 2. (Facilitator Kati Mattern) *Focusing the future knowledge needs* - What are the **new knowledge needs** from different governance levels (e.g. city, national, transnational) and how can they be addressed in a complementary way?
- Group 3. (Facilitator: Emiliano Ramieri) *New approaches for developing knowledge* - What **new/innovative approaches** are available to capture and share knowledge to support action?

**Wrap-up** The session chair will summarise the key recommendations from the groups to further enhance knowledge sharing on adaptation that have emerged during the session.

A session report will be produced to feed into the conference proceedings and future EEA and European Commission (DG Clima) work, such as the Evaluation of the Climate-ADAPT and the EU Adaptation Strategy 2017/18.

**Organisers:** European Environment Agency; Directorate-General for Climate Action, European Commission; Ecofys; European Topic Centre on Climate Change Impacts, Vulnerability and Adaptation (ETC/CCA); National Environment Agencies of Spain and Germany.

**Presenters:**

1. **State of play: EU adaptation policy and knowledge needs** (Jelena Miloš, Directorate-General for Climate Action, European Commission)

This presentation will start with a strategic overview of policy on adaptation in the EU and this will be followed with an update on how gaps in adaptation knowledge have been identified and addressed. This will cover the whole spectrum – from climate information (via Copernicus Climate Change Service), to climate impacts (covered by e.g. JRC studies) and adaptation options. As such, specific knowledge assessments have been funded by the European Commission on cross-cutting topics like ecosystem-based adaptation, selected vulnerable sectors e.g. infrastructure, and for important methodologies like vulnerability assessments. DG CLIMA has also promoted the linking of science, policy and practitioners through various forums and communities of practice. The results of these assessments and other efforts will be presented to exemplify the state of the art and suggested ways forward to advance the knowledge and how EU adaptation policy can capitalize on these findings.

2. **Assessing adaptation knowledge in Europe: national adaptation plans, resilient infrastructure and ecosystem based adaptation** (Sarah Hendel-Blackford, Ecofys)

This presentation will provide an example of an EC project that was focused on filling gaps in knowledge on 'assessments'. The European Commission funded this assessment to compile and summarize the state-of-the-art knowledge relevant for adaptation assessments. This project evaluated the available knowledge on ecosystem-based adaptation options; infrastructure resilience and adaptation to climate change; and vulnerability

assessments. These areas were considered to be of interest to European policymakers and adaptation actors to support their decision making on adaptation. This knowledge assessment collected information from Climate-Adapt, research projects supported by Commission programmes (e.g., FP6, FP7 and Horizon 2020 projects, JRC projects and the LIFE programme) and supplement this by exploring practice across Europe. The data and analysis provide the evidence to identify the knowledge gaps in each of the specific areas. The results of this assessment, including the recommendations, will be added to the resources available on Climate-ADAPT. This will contribute to the knowledge transfer requirement and support the objectives of the EU Adaptation Strategy.

**3. Success factors and limitations in the development of user –oriented climate information portals: Lessons from CLIPC, Euporias, Climate4Impact and SWICCA** (Annemarie Groot, Wageningen UR)

This presentation will show an example of a number of research projects (FP7 and Copernicus) that have developed user-oriented climate information portals. The lessons, success factors and limitations will be described from the research projects: CLIPC, Euporias, Climate4Impact and SWICCA.

**4. Sharing adaptation information across Europe - evaluation of the European Climate Adaptation Platform (Climate-ADAPT)** (Kati Mattern, European Environment Agency)

The European Climate Adaptation Platform (Climate-ADAPT) is one of the core elements of the EU Adaptation Strategy and aims to facilitate a better informed decision making on adaptation at all levels in Europe. An EEA “Climate-ADAPT evaluation” report that will be published at the beginning of 2018, will be presented. EEA has collaborated with experts from a range of organisations in the preparation of this report, including the European Topic Centre on climate change impacts, vulnerability and adaptation as well as the National Reference Centres on adaptation, and various EU research projects. It gives an overview of how the platform has provided verified sources of information complemented by a package of awareness raising measures e.g. workshops, conferences, webinars, EEA technical reports and a newsletter. The presentation will in particular show that knowledge from across Europe was captured in a way that is complementary to the information that is available at national level. In addition, the presentation will show how the information has been used in decision making processes at different governance levels. First thoughts of new and upcoming user’s needs and ideas of implementing them will also be explained.

**5. Lessons learned from the development and implementation of the Spanish adaptation platform and upcoming improvements through the LIFE SHARA project** (Anna Pons, LIFE-SHARA Project coordinator, Spanish Ministry of Agriculture and Fisheries, Food and Environment)

The Spanish Climate Change Office (OECC) is providing the knowledge base on adaptation in Spain via the web-based adaptation platform **AdapteCCa**. It was launched in 2014 after a very wide participatory process that included experts and stakeholders from the research community, administrations and institutions at different levels, NGOs and private sector.

It was developed as a tool to facilitate information and knowledge exchange and also to reinforce coordination among Spanish stakeholders. The presentation will demonstrate in particular how the **AdapteCCa** platform will gain a central role in the governance of climate change adaptation in Spain through the LIFE SHARA 2016-2021 project, linking the information available at national level and EU level via **Climate-ADAPT** and reaching out further to involve all adaptation stakeholders.

**6. Effectivity, quality, credibility and user’s enjoyment: how the German Environment Agency takes up success factors of user-centred adaptation portals** (Petra Mahrenholz, German Federal Environment Agency)

The German Environment Agency will demonstrate its approach to analyse the gaps in adaptation knowledge at the national level and the strategies to close these gaps. The presentation will trace experiences and lessons-

learned in the implementation and evaluation of the national adaptation platform “anpassung.net”. It will reflect on the process of identifying and updating strategic objectives, overarching goals, target groups and key messages of the platform. Selected key features are discussed, including a database on best-practice adaptation projects (“Tatenbank”), a tool for the development of local adaptation strategies (“Klimalotse”) as well as participatory approaches for communicating adaptation practice (national competition “Blauer Kompass”).

The presentation will highlight how national funding is applied to systematically integrated results and outputs of adaptation research in the national platform to keep knowledge and tools up to date. It will reflect on experiences in evaluating user needs through web analytics and on current efforts to increase usability through a customized interface, design and layout.



## **Business Day 5: Opportunities for climate readiness: market demand & finance**

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*Marc Gramberger, Prospex*

### **Economics and business**

1. Kirsten Dunlop, CEO, Climate-KIC
  2. Wolfgang Teubner, Regional Director Europe, ICLEI – Local Governments for Sustainability
  3. Mr Claus Kondrup, Acting Head of Adaptation Unit, DG CLIMA, European Commission
  4. Craig Davies, Head, Climate Resilience Investments, Energy Efficiency & Climate Change Team, European Bank for Reconstruction and Development
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What opportunities are there for businesses to prepare for a world facing climate change? In this interactive session, we will explore market demand and financing for demand and supply.

## 6.5 How climate services can enable successful urban adaptation

*Kit England, Sniffer*

### Climate services

#### Urban, energy & infrastructure

1. Climate proof retrofitting of urban areas: easy and affordable (Jeroen Kluck, Amsterdam University of Applied Sciences)
  2. Harmonizing the effectiveness of heat related adaptation options (Maddalen Mendizabal, Tecnalia R&I)
  3. Combining academic and practitioner expertise to develop a climate change-related web-based GIS tool (Angela Connelly, University of Manchester)
  4. Lessons learned from Adaptation Support Tool based workshops for urban climate resilience around the world (Reinder Brolsma, Deltares)
  5. Multifunctional climate change adaptation in municipalities – Concept, approach and empirical testing (Sebastian Bartel, Leibniz Institute of Ecological Urban and Regional Development (IOER))
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**Keywords:** adaptation, common challenges, replicability, science-policy interface, barriers, cost, solutions

It is often said that whilst mitigation is global, adaptation is local. This is partially true. Whilst mitigation approaches are broadly more easily replicable across the globe, Cities all over the world collectively face the need to adapt to climate change, alongside addressing other global challenges. These include globalisation, urbanisation, demographic change and the digital economy, all of which are rapidly reshaping the infrastructure and services cities need to provide.

Many cities are adopting similar adaptation actions, and this knowledge and experience of common solutions has been enhanced by platforms which share solutions, such as Mayors Adapt, and the Climate-ADAPT portal. However, whilst the broad set of climate hazards and adaptation solutions is similar, the final solution in a place can vary considerably, based on the scale and likelihood of risk, geographical location, the stakeholders involved, the time horizons, economics, political acceptability and skills and capacities of places to take action. These variations make replicability and transfer of solutions from one place to another more challenging, frustrating the process of cities adapting.

This session outlines important lessons needed to overcome such frustrations, by showcasing successful approaches which are globally replicable, but locally relevant. Each presenter has used innovative approaches such as prototyping, standardisation and benchmarking, or novel climate services to enable adaptation action. It also offers broader lessons about what makes successful co-creation of knowledge and data between academics and policy makers work to enabling such approaches.

### Significance to adaptation practice, policy and/or business

Adaptation practitioners cite common barriers when implementing solutions to adapt cities to climate change. These include evidence, complexity of stakeholder relationships, the business case, and understanding the effectiveness of solutions.

This session shows that affordable solutions for inclusive adaptation planning which are globally applicable, but locally tailored, are within reach. Many places still conduct bespoke assessments. But building universal solutions and platforms is vital to adapt at the scale and pace at which our climate is changing. Such approaches can

increase cities' engagement in adaptation by lowering the costs and effort associated with understanding risk and vulnerabilities and potential solutions.

## **1. Climate proof retrofitting of urban areas: easy and affordable**

Jeroen Kluck, Amsterdam University of Applied Sciences

Due to climate change the frequency and damage in urban areas caused by cloudbursts will increase. Dutch municipalities claim to need proofs of the possibilities of climate proof urban street designs. For Dutch characteristic typologies of urban residential areas we have investigated how to climate proof the urban areas during projects of redevelopment of those areas. For each case we designed several alternatives of street lay-outs and determined the life cycle costs and benefits. This showed that most flat Dutch typologies of urban living areas can easily be transferred in a climate proof way without additional costs (when compared to the standard designs).

This project is initiated and carried out together with several municipalities who expressed the need of common case examples showing that climate proofing is not hard, but feasible. The use of characteristic urban typologies was chosen in order to make a link between water engineers and urban planners. For the latter group those typologies appear a strong way of communication.

In the presentation, we will start with a short explanation of the flood risk and consequences, and the problems of municipalities to adapt to those risks. This is followed by the spatial implication for climate resilience, which is calculated and graphically presented. The costs and benefits of nine cases within six neighbourhood typologies are designed and calculated.

## **2. Harmonizing the effectiveness of heat related adaptation options**

Maddalen Mendizabal, Tecnalia R&I

Having universal processes and metrics for climate change adaptation, as is found in mitigation, is challenging. The lack of well-structured operational and standardized methodologies which evaluates the performance of adaptation has created the interest and somehow the need for researchers and practitioners to address this issue. Some of the reasons that contribute to the difficulty of the harmonization of the effectiveness are related to the dependence on local conditions, the timescales associated with climate change studies and the multi-dimension nature of adaptation options. It is not only a question of the metrics, but also the processes used for developing these effectiveness metrics and the influence of other variables can lead to different results for the same adaptation option.

Therefore, the aim of the present study is to propose a set of analysis which will help identifying the key issues that condition the evaluation of the effectiveness and give advices for the harmonization.

Heat related adaptation option effectiveness is analysed in detail in this work. For this, an extensive literature review has been carried out and a database collecting the information has been developed. The analysis has been carried out with the options compiled from 88 scientific papers that involve a total of 1324 entries into the database. For each adaptation option, several variables (some categorical and others numerical) are considered for the effectiveness evaluation, which are key parameters for harmonizing the process and metrics.

Related to the process, the specific set of variables, which are conditioning the effectiveness evaluation process, are identified and the effect of different variables into the effectiveness value has been studied. The variables that have the most influence on the effectiveness are then used to harmonise the effectiveness and increase the comparability of options. For this, a categorical linear regression has been undertaken.

Even the models has a lower adjusted  $R^2(0.4-0.5)$ , some variables are detected which affect the variability of the effectiveness: time, study location (city) and season. Considering that the data analysed are provisional and the final database will be more extensive, we expect an increase of the correlation in the final model.

What we realize with this analysis is that the time in which the effectiveness result is given affects its value and therefore, it is a key element for the harmonization process. We therefore harmonized all the effectiveness data analysed according to the time and study location.

### **3. Combining academic and practitioner expertise to develop a climate change-related web-based GIS tool**

Angela Connelly, The University of Manchester

Understanding how different people and groups may be affected by extreme weather events and climate change may help to formulate more socially just responses (Lindley et al. 2011). Academic research that is shaped alongside practitioners can assist in the undertaking of detailed vulnerability/risk assessments, as well as raising awareness on the need to take a social justice perspective when addressing flood risk assessments and the interaction between a changing climate and socio-economic and demographic change. However, there are a wide variety of climate change-related tools that may not be appropriate for end-users and often have a short serviceable life.

The *Mapping Flood Disadvantage in Scotland, 2015* project, funded by the Scottish Government, explored the differentiated combination of multi-dimensional social vulnerability to flooding and flood hazard (referred to as flood disadvantage) at neighbourhood level. The data was mapped to produce a web-based GIS tool for use amongst local authorities in Scotland (Kazmierczak et al. 2015). Expert practitioners commented on the development of the indicators and, during data processing, workshops were held with three case study local authorities in order to shape the outputs. Further workshops, engaging the majority of local authorities in Scotland, and subsequent interviews with tool users, helped to understand the co-creation process and the application of findings and data.

This presentation analyses the research process by focussing on how the assessment of flood disadvantage and social vulnerability to climate change was enhanced through the close involvement of practitioners in academic research. We describe the findings that may hold interest for those working to translate scientific research into practice. These include:

- differences in technical expertise, available resources and capacity mean that outputs cannot be ‘one size fits all’;
- recognising the added value of climate change-related web-based GIS tools which may guide the actions of other municipal service areas and third sector organisations, as well as supporting cross-departmental collaboration on climate change risk (e.g. housing and social care); and,
- climate change-related research can be transferred to a wide range of practitioners through close collaboration from the initial research design stage through to dissemination.

### **4. Lessons learned from Adaptation Support Tool based workshops for urban climate resilience around the world**

Reinder Brolsma, Deltares

Past years we performed workshops in different cities around the world to plan and design for urban resilience using primarily green and blue infrastructure. We present the lessons learned from these workshops in which we applied the touchtable-based Adaptation Support Tool (AST) in interactive sessions with local stakeholders to create sets of different climate adaptation measures that are effective in creating a more climate resilient, and attractive city.

Urban planning for climate resilience involves many stakeholders, especially when aiming at green infrastructural solutions. We developed the Adaptation Support Tool (AST) to support this planning process.

The AST is a touchtable-based planning support system that has been developed, tested and applied to create sets of adaptation measures that meet predefined resilience targets. The AST includes a selection assistant for 72 potential climate adaptation measures. By selecting a measure and drawing the measure on the map of the project area its effectiveness is estimated for water storage, peak flow reduction, groundwater recharge, heat stress reduction, water quality effects, social benefits and costs. These estimates are made for each planned adaptation measure and for the total package of measures.

We applied the Adaptation Support Tool during conceptual and preliminary design sessions for reconstructing or developing urban areas in Beira (MZ), Berlin (DE), New Orleans (US), Oaxaca (MX), London (UK) and Utrecht (NL). The aim of the sessions was to create different packages of adaptation measures to meet predefined adaptation targets with all relevant stakeholders including untrained citizens.

The interactive sessions were always effective to inform stakeholders on all the different potential measures that are available to create a climate resilient design. In most cases different sets of sustainable adaptation measures were sufficient to reach predefined adaptation targets and in the other cases the tool showed the physical constraints and need for traditional grey measures. Key to the success of the sessions is that stakeholders can immediately see the effect of the proposed measures, which contributes to a more clear discussion.

Next to that the positions of the different stakeholders become clear. Based on stakeholder interviews and dialogues during the sessions we found out what kind of information is relevant to them and which information gaps hampered the discussion. Resulting conceptual designs for interventions were compared and used as starting point for more detailed designs of an adaptation plan.

## **5. Multifunctional climate change adaptation in municipalities – Concept, approach and empirical testing**

**Sebastian Bartel, Leibniz Institute of Ecological Urban and Regional Development (IOER)**

Municipalities and in particular small and/or financially weak municipalities often cannot afford the generation of required information on climate change risks and evidence-based derivation of suitable adaptation activities. This leads to a lack of preparation for the future that may even worsen their challenges especially regarding the quality of life and the disposable budget.

Therefore, tailored concepts and approaches are needed that facilitate the access to information on climate change risks affecting the statutory duties of municipalities as well as the suitability of alternative instruments and measures. Against this background, research has been carried out to develop an appropriate scientific concept with its operationalisation as decision support tool for small and/or financially weak municipalities.

The proposed concept and the resulting approach consist of five steps: First, they cover the identification of predominantly mandatory tasks of municipalities ensuring services for the public according to legal regulations (e.g. water supply). Second, the scientific evidence on climate change risks relevant for each task is collated. Third, alternative instruments and measures for adaptation in a wider sense encompassing adaptation in a narrow sense and resilience are systematically derived and described. Fourth, these instruments and measures are evaluated referring to their effectiveness and efficiency. Fifth, instruments and measures are prioritised particularly considering their multi-functionality as ability to reduce more than one climate change risk and additional challenges evolving from societal change such as demographic change. The operationalisation of the concept is based on a sequence of algorithms with standardised text phrases. It originates generic information for all municipalities, but also allows for site-specific concretion of outcomes.

This two-level approach is supposed to enable municipalities using available information without further efforts or to go in further details in case of local in-depth knowledge for instance from regional climate change impact assessment and adaptation studies. The approach has been tested as climate service in small and/or financially weak municipalities in Germany. Key empirical findings are shown together with recommendations for future research and practice.

## 8.1 Adaptation, Mitigation and Transformation: The high-end context, synergies and trade-offs

*Diogo de Gusmão-Sørensen, European Commission, Directorate-General for Research and Innovation*

### Pathways and transformation

1. Scenario-guided pathways: Using SSPs to contextualise adaptation strategies in Europe (Simona Pedde, Wageningen UR)
  2. Cross-sectoral climate change impacts and vulnerability: Assessment of low (1.5 degree) vs high-end RCP x SSP scenarios for Europe (Robert Dunford, University of Oxford/ Centre for Ecology & Hydrology)
  3. Co-creating adaptation, mitigation and transformation pathways: a transition management application to extreme climate change scenarios (Katharina Hölscher, Drift)
  4. Synergies and trade-offs between climate change adaptation and mitigation: a review (Alison Smith, ECI, University of Oxford)
  5. Borderless climate risks: Implications for the European Union (Richard Taylor, Stockholm Environment Institute)
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**Keywords:** impacts, vulnerabilities, adaptation, synergies, trade-offs, scenarios, pathways, high-end

The session starts by describing a multiscale extension of the global Shared Socio-economic Pathways (SSPs) in which a series of European SSPs are developed for geographically and socio-economically different case studies that range from municipal, river basin, national to European scales. These scenarios provide the socio-economic context for adaptation and mitigation strategies and solutions until 2100. The next presentation uses an integrated assessment model to quantify the differences between low- (1.5°C) and high-end (>6°C) climate change scenarios with respect to impacts and vulnerability. The aim is to show the full extent of climate change vulnerability, rather than viewing single sectors in isolation. Using both scenarios and modelling of impacts and vulnerability, the next paper then presents a transdisciplinary process methodology that supports decision-making processes to build resilience against climate change impacts and other social, economic and environmental pressures, deal with uncertainty and surprise, and facilitate sustainability transitions. In particular, the focus here is on developing adaptation, mitigation and transformation pathways that foster resilience and sustainability in the context of extreme scenarios. This is followed by a presentation on the main synergies and trade-offs between adaptation and mitigation, identifying 'win-win' options, and providing case study examples to illustrate how synergies can be exploited in practice and how trade-offs can be reduced. This review will also discuss the practical barriers that have impeded integration of adaptation and mitigation to date and identify how to overcome these barriers. The final paper in the session addresses cross-border climate risks resulting from climate change impacts in other regions. The paper will also give an overview of some of the key impacts that could affect the EU in future, drawing on a new indicator-based assessment of exposure to transnational climate impacts

### Significance to adaptation practice, policy and/or business

Decision-makers and practitioners will benefit from the clear presentation of climate change response options within the context of a range of possible futures. Presentations show the implications of socio-economic factors in determining impacts of and vulnerability to climate change and provide insights about how to deal with different and non-linear conditions and impacts over time to move towards a desired future vision. With a focus on cross-scale and cross-sectoral interactions the session addresses both the benefits of climate change adaptation and mitigation but also the potential for adverse side-effects.

## **1. Scenario-guided pathways: Using SSPs to contextualise adaptation strategies in Europe**

Simona Pedde, Wageningen University and Research

The climate change scientific community has developed global Shared Socio Economic Pathways (SSPs) to provide a framework that addresses socioeconomic challenges to mitigation and adaptation independently from a specific emission scenario. The SSPs are designed for (multi)sectoral extension and application by climate change impacts, adaptation and vulnerabilities (CCIAV) communities.

Since the completion of global SSPs, new methods have been developed to extend SSPs, and to integrate them with emission scenarios and climate projections, in CCIAV studies in different world regions. Methods so far focus on downscaling quantifications and nesting narratives from global SSPs. Though useful in understanding cross-sectoral interactions, these methods do not yield explicit information on how the scenarios unfold over time and what are enabling and disabling factors for climate adaptation strategies and solutions. We present, therefore, a multiscale extension of the global SSPs in which a series of European SSPs are developed for geographically and socio-economically different case studies that range from municipal, river basin, national to European scales.

The European SSPs describe four extreme socio-economic futures for each case study including also non-linear developments as the context for building robust adaptation and mitigation strategies.

The methods used are highly participatory involving a broad range of stakeholders within a set of scenario development workshops. The European SSPs, as well as including narratives (and other quantitative products including population and GDP), indicate trends of social, human, and manufactured capitals in three time steps until 2100. Within the scenarios, capitals are used to analyse the socio-economic enabling/disabling conditions in the scenarios for achieving a sustainability vision. These enabling/disabling conditions describe the opportunities and barriers for action by indicating what capitals can be mobilised in a given scenario. This facilitates the development of scenario-dependent pathways of adaptation, mitigation and transformative actions.

We demonstrate the importance of extended SSPs and the role of non-linearity and capitals therein in influencing the building of robust strategies. Unlike previous exploratory scenario exercises, the European SSPs provide the feasibility and socioeconomic context for adaptation and mitigation strategies and solutions until 2100.

Acknowledgement: this study is carried out within the IMPRESSIONS project (Impacts and Risks from High-end Scenarios: Strategies for Innovative Solutions), EU-FP7 603416, [www.impressions-project.eu](http://www.impressions-project.eu)

## **2. Cross-sectoral climate change impacts and vulnerability: Assessment of low (1.5 degree) vs high-end RCP x SSP scenarios for Europe**

Robert Dunford, University Of Oxford

The Paris agreement aims to limit global average temperature change to 1.5oC. However, any climate change will lead to amplified interdependencies between different land use and environmental sectors. As such, to better understand the implications of the Paris agreement it is important to consider these cross-sectoral interactions. This presentation uses an integrated assessment model to quantify the differences between low- (1.5o) and high-end (>6oC) climatic scenarios with respect to climate change impacts and vulnerability. This is important in developing appropriate adaptation strategies to climate change, since such insight builds the capacity of decision-makers to understand the full extent of climate change vulnerability, rather than viewing single sectors in isolation. Furthermore, with society changing as dramatically as climate, both low- and high-end climatic scenarios may unfold in very different ways depending on the socio-economic conditions within those scenarios.

To address these challenges a regional integrated assessment model has been used to explore combined climatic and socio-economic scenarios. The model captures interactions between six environmental/ land use sectors: agriculture, forests, biodiversity, water, flooding and urban. Combinations of the IPCC Representative



Concentration Pathways (RCPs) and Shared Socioeconomic Pathways (SSPs) were analyzed to assess the relative importance of climate vs. socio-economic change. In doing so this presentation will i) quantify climate impacts and vulnerabilities in worlds where the 1.5o target is met; ii) compare these with high-end scenarios (>6oC) where climatic change is left unchecked and iii) assess the implications of socio-economic change in addition to climatic change in both high and low- end scenarios. In doing so it presents the first cross-sectoral picture of the implications of the Paris agreement for Europe's future and highlights the complex interactions between sectors and between climate and society.

### **3. Co-creating adaptation, mitigation and transformation pathways: a transition management application to extreme climate change scenarios**

Katharina Hölscher, Drift

Extreme climate and socio-economic scenarios involve a considerable likelihood of risks, surprises, threshold effects and fast and radical system changes. Addressing climate change under such scenarios requires long-term strategies and innovative solutions that can deal with non-linearity and deep uncertainty, link climate resilience to broader notions of sustainability and societal desirability, and foster fundamental changes to overcome underlying path dependencies and lock-ins. Responses to extreme scenarios require an integrated systems perspective that reveals the interactions and possible synergies between different types of (social, ecological etc.) system dynamics across scales and sectors.

In this paper, we present a transdisciplinary process methodology that supports decision-making processes to build resilience against climate change impacts and other social, economic and environmental pressures, deal with uncertainty and surprise, and facilitate sustainability transitions. Our aim was to co-create with stakeholder's time-dependent adaptation, mitigation and transformation pathways that foster resilience and sustainability in the context of extreme scenarios. In recent years, the development of pathways has been used to focus on cross-sectoral progressive courses of action that connect short-term to long-term actions towards achieving specific goals. It enables us to consider how long-term, transformative change can contribute to a sustainable and resilient future.

Our methodology builds on an advanced transition management framework to guide the development of transformative visions and pathways in the context of extreme climate and socio-economic scenarios. Transition management has been introduced as a theoretical and methodological framework to offer operational guidance on how to set up strategic co-creation processes for change-oriented interventions in complex adaptive societal systems. We advanced transition management by linking it to concepts from social-ecological systems, resilience and climate change literatures to integrate radical changes, thresholds and deep uncertainty into the framework. The development of pathways was positioned in extreme socio-economic and climate scenarios that describe change over time until 2100. Different scenarios provide through their distinct contexts different enabling and disabling conditions for building resilience and promoting sustainability transitions. They hence mark the starting points for thinking about what are feasible and desired responses for achieving a shared sustainability vision. The vision guides the development of pathways towards a desirable – sustainable and resilient – future.

### **4. Synergies and trade-offs between climate change adaptation and mitigation: a review**

Alison Smith, Environmental Change Institute, University Of Oxford

Climate change mitigation and adaptation are still often treated as separate issues, dealt with by different departments of national and local government. This can lead to over-reliance on adaptation actions that increase greenhouse gas emissions, such as construction of large concrete sea defences or increased use of air-conditioning. Ironically, these actions will lead to the need for ever-more expensive adaptation actions in the future. Similarly, some climate change mitigation actions can have trade-offs for adaptation, such as increased cultivation of bio-energy crops that may worsen food and water security.

However, a range of options are available that have benefits for both mitigation and adaptation. For example, urban green infrastructure can provide local cooling and stormwater management, as well as increasing carbon sequestration and reducing building energy needs. Designing buildings to use passive cooling and natural ventilation can adapt to increased temperatures while cutting energy use. Increasing the organic matter content in soil can increase crop resilience to drought as well as sequestering carbon. This presentation will give a comprehensive overview of the main synergies and trade-offs, identify 'win-win' options, and provide case study examples to illustrate how synergies can be exploited in practice. There may be cases where options with trade-offs, such as hard sea defences or use of bio-energy, are still required. The review will therefore also identify ways in which trade-offs can be reduced, e.g. through the use of lower-carbon materials for hard adaptation infrastructure, through development of bio-energy options that use less water and land, and through forest carbon protection options that implement strict social and environmental safeguards.

Finally, the review will discuss the practical barriers that have impeded integration of adaptation and mitigation to date, identify how to overcome these barriers, and discuss recent progress that is opening up the pathways to better integration in international, national and local policies.

## **5. Borderless climate risks: Implications for the European Union**

Richard Taylor, Stockholm Environment Institute

The European Union is highly dependent on other parts of the world for its stability and prosperity. To appreciate this, consider the effects of a "refugee crisis" caused by destabilisation and conflict in Europe's neighbourhood, which is still shaking the foundations of the EU project. The EU also seeks to play a major role in global governance, international diplomacy and development cooperation worldwide, and is the biggest trade actor in the world, accounting for 16% of global imports and exports. It therefore seems obvious that climate change impacts beyond Europe's borders – particularly under "higher end scenarios" – are likely to create risks and require adaptation "at home". But so far, the external dimension of climate risks has been largely ignored by adaptation planning at the EU level. Additionally, given high levels of integration achieved by the European project since its foundation, climate change within Europe is likely to create spillover effects from one member state into others. And yet the EU Adaptation Strategy does little to consider this transnational dimension of climate risk. So how can the EU adapt to borderless climate risks, both internally and externally?

This paper will present results from a targeted survey of national adaptation focal points in Europe to assess the current state of play in addressing these borderless climate risks and the possible role of the EU. The survey covered terminology, national level initiatives, national and European Union responsibilities for adaptation planning, and finally barriers to addressing and taking into account transnational impacts in this area of adaptation work.

The paper will also give an overview of some of the key impacts that could affect the EU in future, drawing on a new indicator-based assessment of exposure to transnational climate impacts – The TCI Index (Benzie et al, 2016). It will end by considering the implications for the governance of adaptation at EU levels, including the role of specific DGs and external functions in managing transnational climate risks within and beyond the EU's borders.

### 3.1 The economics of climate change

*Andrea Roventini, Scuola Superiore Sant'anna and Shouro Dasgupta, Fondazione Eni Enrico Mattei*

#### Economics and business

1. Faraway, so close: an agent-based model for climate, energy and macroeconomic policy (Andrea Roventini, Scuola Superiore Sant'anna)
  2. Assessing the impact of fossil fuels and renewable energy subsidies on green growth: the EIRIN flow-funds behavioural model (Irene Monasterolo, Boston University)
  3. An agent-based stock-flow consistent model of the sustainable transition in the energy sector (Marco Raberto, University of Genoa)
  4. Technology transfers in the context of climate policy: A network-based approach and insights on wind energy diffusion (Antoine Mandel, Université Paris)
  5. Development, Climate Change Adaptation, and Maladaptation: Some Econometric Evidence (Shouro Dasgupta, Fondazione Eni Enrico Mattei)
  6. Agricultural impact and adaptation through irrigation: a focus on Sub-Saharan African countries (Lorenza Campagnolo, Fondazione Eni Enrico Mattei)
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**Keywords:** Climate change, complexity science, stranded assets, climate policy risk, agent-based models, network models, energy transition policy

Recently, the relation between climate change risk, macro-economic dynamics and financial stability emerged as prominent concern on the climate policy agenda. Moreover, it is likely to gain further importance with the emphasis on the 1.5°C target brought forth by the recent COP21, as well as with the recently launched Task Force on Climate-Related Financial Disclosure by the Financial Stability Board. Still, there remains a lot of uncertainty on the role of alternative combinations of green fiscal, monetary and innovation policies and their systemic implications on financial markets and the amplification and cascading effects on the real economy. The sector based and Integrated Assessment Models, being based on the equilibrium modelling approach, are not able, by construction, to model the dynamics of a complex system, such as the green economy, which is characterized by non-linearity, multiple feedbacks, time delays, non-rational and short term thinking agents. Instead, complexity science approaches based on system dynamics, agent-based models and network analysis, could fill this modelling gap and contribute to understanding and action. Therefore, the aim of the session is to gather different contributions grounded on the complexity approach which could help the understanding the risk and challenges of climate change for macro-economic and financial system stability and possibly improving sustainability models to timely inform the climate policy process and increasing the transparency towards the development of an international governance for sustainability.

#### Significance to adaptation practice, policy and/or business

This session will shed light both on the methodological and policy implications that characterise the challenge of financing the transition to a low carbon economy under COP21's 1.5 degrees target. In particular, the papers presented in the session will contribute to understand the implications of the introduction of alternative climate policy measures on the complex system represented by the interaction of heterogeneous agents of the real economy and the financial sector with climate change, in terms of winners and losers and sources of systemic risk. In so doing, the session will contribute to inform the feasibility of climate policies.

#### 1. Faraway, so close: an agent-based model for climate, energy and macroeconomic policy

Andrea Roventini, Scuola Superiore Sant'Anna, Italy

This paper presents an agent based model for the study of coupled economic and climate dynamics that endogenously co-evolve across a range of different scenarios. The model offers a flexible laboratory to test various combinations of macroeconomic, industrial and climate policies both in the context of long run economic growth and medium run transition towards a greener economy. Furthermore, we propose a stochastic description of the feedbacks stemming from a warming and more volatile climate and study how such negative shocks propagate through the economy. For this reason, the model is particularly well suited for the study of extreme climate events, which are usually forgotten by standard integrated assessment models.

## **2. Modeling the impact of fossil fuels and renewable energy subsidies on macro-economic and financial stability: the $\epsilon$ IRIN System Dynamics model with heterogeneous agents**

Irene Monasterolo, Frederick S. Pardee Center for the Study of the Longer Range Future, Boston University

The recent Paris Climate agreements in December 2015 highlighted the need for a new financial architecture to limit global temperature increases to as close to 1.5 degrees C above preindustrial levels. In order to reach this goal, international organizations and development banks pointed out the role of fiscal instruments such as a carbon tax. Subsidies to fossil fuels and government incentives to renewable energy even complicate the picture. There is great uncertainty about the effects of phasing out of fossil fuels subsidies and the increase in renewable energy incentives on macro-economic and financial stability and the distributive effects on growth, jobs and inequality. In this paper, we propose the  $\epsilon$ IRIN System Dynamics model with heterogeneous agents as a tool to simulate the phasing out of fossil fuels subsidies (tax rebate to energy companies) and the introduction of renewable energy incentives either through green fiscal incentives to green investments and production or through green sovereign bonds. We then display their effects on firms' investments, unemployment, wages and skills, credit market and economic growth. Rooted in a balance sheet approach, the stock-flow consistent model is characterized by heterogeneous classes of agents that interact through a set of markets and import a share of Raw Materials and energy with the Rest of the World. The production function is based on a Leontief technology with no substitution of the four production factors (Labour, Capital, Raw Materials and Energy) to explicit GDP energy and resource intensity. A full energy sector characterized by different mining companies, brown and green utility companies and capital goods products is introduced. Simulations show that maintaining full subsidies to fossil fuels energy has negative effects in terms of higher unemployment, lower capital accumulation and reinvestment in the economy and higher tax levels. Instead, increasing subsidies to renewable energy through green monetary policies (green bonds), rather than green fiscal policies, would benefit the real economy and contribute to financial stability with lower unemployment, higher capital accumulation and internal aggregate demand.

## **3. An agent-based stock-flow consistent model of the sustainable transition in the energy sector**

Marco Raberto, University of Genoa (Italy)

Major structural changes to the current fossil-fuel based economic system are needed in order to address the climate change challenge. To this purpose, effective Renewable Energy Sources (RES) support policies, along with concrete efforts towards the improvement of energy efficiency, have been adopted in many countries. One of these policies is the feed-in-tariff (FiT) mechanism, according to which electricity produced by RES is sold at guaranteed prices (feed-in tariffs), which are higher than market ones, for fixed periods of time. In this paper, we investigate how to foster a sustainability transition of the energy system towards an economically and ecologically sustainable growth path by using an enriched version of the Eurace model. Eurace has been enriched by including an energy sector where electricity is demanded by domestic producers and is supplied by a fossil-fuel based power producer as well as a renewable-energy based one. Both power producers undertake pricing and capacity investment decisions based on the price of imported fossil fuel and feed-in tariff government policy. In particular, we investigate how the economy is affected by the fiscal costs of financing the feed-in tariff mechanism and by the benefits of lower fossil fuels imports, in order to devise the policy with the best cost-benefit trade-off for the macroeconomy as a whole. Results show that the feed-in-tariff policy is effective in

fostering the sustainability transition of the energy sector and that it increases the level of investments in the economy with a slightly positive impact on the unemployment rates. Moreover, we observe that its financing costs do not impact government finances in a relevant way. On the other hand, the higher level of investments occurs at the expense of the production of consumption goods, therefore with a negative impact for the living standards, at least according to the perspective of a consumerist society. However, if factors like better employment rates and the reduced GHG emissions are also taken into account, along with consumption, by an appropriate preference function, the final outcome on well-being should be probably deemed as favourable.

#### **4. Technology transfers in the context of climate policy: A network-based approach and insights on wind energy diffusion**

Antoine Mandel, Université Paris 1 Panthéon-Sorbonne (France)

In light of the urgency of climate change, there is a substantial and growing literature on the role of technology transfers and how policy can promote diffusion of climate-mitigation technologies. A key issue is that the diffusion network is generally not observed. To address this issue, this paper proposes a systemic method building on the network inference literature. We apply this approach using detailed data on the adoption of wind turbines at the global scale since the 1980s to infer the network of diffusion of wind energy technologies. The substantial growth of wind power makes it an interesting case to investigate structural properties of the diffusion process at the global, regional, and country-level. Moreover, the inferred network can be used to gain further insights on strategies to achieve efficient technology diffusion.

#### **5. Development, Climate Change Adaptation, and Maladaptation: Some Econometric Evidence**

Shouro Dasgupta, Fondazione Eni Enrico Mattei and Università Ca' Foscari

This paper examines the determinants of climate related disasters and attempts to estimate the presence of adaptive capacity in terms of per capita income and population density elasticities. Using robust econometric analysis, we find evidence of adaptive capacity in a weak form both in terms of income and population density elasticities for our entire sample. That is, damages are in fact increasing with income and population but less than proportionally. There is also evidence of countries improving their adaptive capacity over the long-run but some maladaptation occurs in the short-run. Furthermore, we find that higher income countries show adaptive capacity in a strong form, i.e. damages decrease with GDP but lower income countries highlight the opposite behavior. Finally, using Granger causality tests for panel data, we find evidence of increase in GDP per capita Granger causing climate related damages for lower income countries but not in higher income countries.

#### **6. Agricultural impact and adaptation through irrigation: a focus on Sub-Saharan African countries**

Lorenza Campagnolo, Fondazione Eni Enrico Mattei

This paper provides a macroeconomic assessment of climate change impact on Sub-Saharan African agriculture using a General Equilibrium framework considering land heterogeneity, rain-fed and irrigated land, and a dedicated capital endowment for irrigation. This specification offers a more detailed description of climate change impacts under two climate scenarios proposed (RCP8.5 with different assumptions on CO<sub>2</sub> fertilization effect). Agriculture results are highly vulnerable to climate change and are largely based on rain-fed and traditional crop growth techniques; therefore, an adaptation plan boosting irrigation practices represents a key strategy to cope with climate change and at the same time to favor development.

## 5.1 Co-production as a means of climate change governance

*Tim Rayner, Tyndall Centre, University of East Anglia*

### Participation and co-production

#### Governance

1. Characterising the demand for climate information across a nation (Suraje Dessai, University of Leeds)
  2. The role of the Intergovernmental Panel on Climate Change in informing local decision-making in the UK (Candice Howarth, University of Surrey)
  3. AdaptaClima: 'knowledge users' and 'knowledge producers' engage with diverse stakeholders to co-create the first Brazilian knowledge hub on adaptation (Laura Silici, Independent (IIED/GVces Consultant))
  4. Exploring interdisciplinary science-stakeholder collaboration to support climate change adaptation (Sandra Tenggren, Stockholm Environment Institute)
  5. Actionable Climate Science: stakeholders and scientists working together towards climate adaptation in the United States (Renee McPherson, University Of Oklahoma )
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**Keywords:** supply, demand, co-production, science-stakeholder dialogues, climate information.

A mismatch between the knowledge demanded by decision makers and stakeholders, and what is supplied through scientific research, has been identified as a potential problem for decision making on climate change adaptation. This session investigates how climate research and knowledge of various kinds could be better utilized to produce 'actionable' scientific advice to inform decision-making on climate change across levels of governance and different sectors. Making science and knowledge more practice- and decision relevant requires a better understanding of the demand for and supply of climate information across all stages of the adaptation process. The session features research that has sought that improved understanding, and that has explored some of the key variables affecting the demand for information in public, private and third sector contexts. Several papers explore new, innovative institutional arrangements through which interaction is occurring – or could in future occur - between knowledge users and knowledge producers, and steps being made towards improved 'co-production' of 'actionable' science. Experience from a range of country settings (including the UK, Brazil, Sweden, US) and policy sectors will be brought to bear, and consideration given to common challenges and the transferability of lessons drawn from particular contexts.

#### Significance to adaptation practice, policy and/or business

A mismatch between the knowledge demanded by decision makers and stakeholders, and what is supplied through scientific research has been identified as a potential problem for decision making on climate change adaptation. This session investigates how climate research and knowledge of various kinds could be better utilized to produce 'actionable' scientific advice to inform decision-making on climate change across levels of governance and different sectors. Experience from a range of country settings (including the UK, Brazil, Sweden, US) and policy sectors will be brought to bear, and consideration given to common challenges and the transferability of lessons drawn from particular cases.

#### 1. Characterising the demand for climate information across a nation

Suraje Dessai, Sustainability Research Institute, School of Earth and Environment, University of Leeds

Action on adaptation has become an inevitable reality and practice-relevant science for adaptation is called for. Such practice- and decision relevant science and knowledge are more readily facilitated with a better understanding of the demand for and supply of climate information across all stages of the adaptation process. Building on previous research into the use and usability of climate information, we present a conceptual model of the demand function for climate information. Based on past research, the key variables affecting the demand have been identified as perceived knowledge and concern, actual experiences as well as perceived risks and

vulnerabilities, trust and perceived reliability of the information, and the decision and organisational context. We test the validity of these different variables using a comprehensive review of the adaptation process in the UK with insights from the public, private and third sector. To do so, we draw on three different sets of quantitative data from surveys conducted in the UK (Survey 1 with businesses and local authorities, n = 2517; Survey 2 with private and public sector organisations, n = 89; Survey 3 with businesses, n = 604); qualitative data from 47 follow on interviews from Survey 2 and data from the Adaptation Reporting Power documents for those organisations with whom interviews were conducted. The UK was chosen as a case study, as it was the first country to make adaptation to climate change legally binding through its Climate Change Act in 2008 and because it has put in place a comprehensive procedural framework for adaptation. We find that many of the variables discussed are more salient to the public and third sector, leading to an increase in demand compared to the private sector. In addition, our exploratory application of the demand function to two specific organisations from the energy and water sector further highlights that the demand function is flexible and context specific, allowing for differing combinations and weightings of variables instead of a rigid formula to predict demand. Our findings demonstrate the clear need to take a much more in-depth look at how the demand function needs to be broken down into its individual parts to gain a better understanding of how the individual variables in it interact with each other and to gain an appreciation of how the sum of these parts creates different levels of demand for climate information.

## **2. The role of the Intergovernmental Panel on Climate Change in informing local decision-making in the UK**

Dr Candice Howarth, University of Surrey, Candice.howarth@surrey.ac.uk

Responses to climate change often occur at the local level with a growing range of climate mitigation and adaptation measures taken at the local authority level. In addition local decision makers have a deep understanding of the impacts of climate change locally, how local stakeholders, communities and structures respond and their role in driving solutions for effective low-carbon transformations. Yet these audiences are not being fully acknowledged in the definition of its end users by the IPCC, which does not capture their needs and values in informing their decision-making processes.

This presentation will explore the extent to which the Intergovernmental Panel on Climate Change's (IPCC) review of how to make its Assessment Reports (ARs) are a useful tool through which scientific advice informs local decision-making on climate change in the

United Kingdom. Results from interviews with local policy representatives and workshops with UK academics, practitioners and local decision makers are presented. Drawing on these data, we outline three key recommendations made by participants on how the IPCC ARs can be better utilized as a form of scientific advice to inform local decision-making on climate change:

1. To provide more succinct summaries of the reports paying close attention to the language, content, clarity, context and length of these summaries;
2. To better target and frame the reports from a local perspective to maximize engagement with local stakeholders;
3. To work with local decision makers to better understand how scientific advice on climate change is being incorporated in local decision-making.

### **3. AdaptaClima: ‘knowledge users’ and ‘knowledge producers’ engage with diverse stakeholders to co-create the first Brazilian knowledge hub on adaptation**

Laura Silici, Independent, IIED/GVces Consultant

Adaptation measures need multiple stakeholders to be effective. More than 80 Brazilian organisations have joined forces to set up AdaptaClima, a knowledge hub on climate change adaptation to be launched by December 2017.

The project comes at a critical time for Brazil. At COP21, adaptation was included in the Nationally Determined Contribution. Also, the first objective of the National Adaptation Plan, ratified in May 2016, foresees an “online platform to manage adaptation knowledge created and available to society”. Despite the progresses of the agenda, the use of climate change knowledge to support decision making is still limited. The efforts of several players involved are not aligned, whereas planning is concentrated amongst few, resulting in low commitment to adaptation measures. Another major constraint is the lack of relevant, reliable and timely data for decision making, which is what AdaptaClima intends to address.

Three circumstances make AdaptaClima innovative: it is the first adaptation web platform in Brazil; it is being co-created by different stakeholders – academia, public sector, business sector and no-profit; and it aims to facilitate access to systematized information on adaptation and to promote interaction between ‘knowledge users’ and ‘knowledge producers’. Once connected, these stakeholders will be able to share and co-produce knowledge, thereby reducing gaps and disconnections between research, policy and practice.

The Brazilian Ministry of Environment, IIED, GVces and British Council (through Newton Fund) initiated the project in February 2016 and constitute the management committee. A mapping involving more than 130 Brazilian organisations was done and according to their respective relevance and influence, 35 organisations were invited to join the project as ‘key actors’, while 28 were invited as ‘collaborators’. The former attend workshops and take a more direct role in shaping up the platform, whereas the latter participate through webinars and online consultations. A third group of ‘reference actors’, made of 17 British and international organisations, provide feedback based on their experience as developers and/or users of adaptation platforms. This participatory process is critical to promote recognition amongst stakeholders and consolidate a network.

Some lessons can be drawn so far. The eager participation of key actors in the workshop, despite an unstable political situation, and the expectations articulated during the webinars corroborate the need to conduct the adaptation agenda in a connected and collaborative manner. Amongst the challenges, keeping the stakeholders engaged during the long project life may prove difficult, especially until an interactive platform is working.

### **4. Exploring interdisciplinary science-stakeholder collaboration to support climate change adaptation**

Sandra Tenggren, Stockholm Environment Institute

Science-stakeholder collaboration is becoming an increasingly common approach to counter existing mismatch between the knowledge demanded by stakeholders and the research actually carried out by natural and social scientists. There are repeated claims that collaboration between science and societal actors could lead to more user-driven and decision-oriented research on climate change adaptation. Considering the increasing popularity of integrative research initiatives, a better understanding of the conditions under which science-stakeholder collaboration can support decision-making processes is needed. Hence, to better understand why projects may succeed or fail in reaching their objectives this paper analysis the organisation and dynamics of a science-stakeholder collaboration component within a research programme on climate change adaptation in the Swedish forestry sector. The specific aim is to identify critical factors that influence the interdisciplinary science-stakeholder dialogues to achieve decision-oriented and user-driven climate change adaptation practices. The method builds on researchers’ observations and 22 qualitative interviews with practitioners and researchers directly or indirectly involved in the dialogues. The interviews centred on stakeholder perceptions regarding the



structure and organisation of the collaborative work, the participatory process and the final outcomes. The results show that the science-stakeholder dialogues have fostered cooperation, not only between researchers and stakeholders, but between researchers from different disciplines as well, as well as awareness raising and knowledge sharing. Several of the respondents also expressed that their participation have lead to new valuable contacts, new insights and increased understanding of the impacts of a changing climate on the forest, but also insights on thoughts and heuristics of forest owners. At the same time, many of the issues that are known to be problematic in projects that aim for collaboration between researchers and stakeholders are applicable also in this study, including communication problems between representatives of different scientific disciplines and disparate views of the value of different forms of project deliverables. Other obstacles are the epistemological and ontological differences that need bridging. To overcome these challenges the conclusions are summarized into six aspects that are crucial for long-term successful science-stakeholder collaboration: i) ensure careful selection of participants, ii) establish clear objectives for the process from the very outset, iii) create a collaborative group environment through e.g. social activities, iv) incentivize researchers to participate actively, v) include a broad set of activities and vi) locate meetings outside academic environments.

## **5. Actionable Climate Science: stakeholders and scientists working together towards climate adaptation in the United States**

Renee McPherson, University Of Oklahoma

Established in 2012, the South Central Climate Science Center (SC-CSC) is one of eight Climate Science Centers that expands the scope and geographic reach of the climate-science efforts of the United States Department of the Interior and provides decision makers with the science, tools, and information they need to address the impacts of climate variability and change on their areas of responsibility. The centers provide scientific information, tools, and techniques that land, water, wildlife and cultural resource managers, and others can apply to anticipate, monitor, and adapt to climate and ecologically driven responses at regional-to-local scales in the United States. Each center delivers basic climate-change-impact science to those within their respective regions, including physical and biological research, ecological forecasting, and multi-scale modeling.

The SC-CSC is transforming how climate science is conducted and applied in our region of the United States by supporting multi-institutional and stakeholder-driven approaches to climate variability, change, impacts, mitigation, and adaptation research. In addition, the SC-CSC is developing training and outreach materials to help resource managers incorporate cutting-edge science, tools, and information into their decision-making process.

The term “actionable science” is increasingly used to describe science that not only informs decisions and management strategies, but also facilitates actions on climate change. Given the scope, magnitude, and the scientific and social complexity of managing the effects of climate change, actionable climate science can play an increasingly important role in developing climate adaptation planning and actions. There are many forms of actionable science across a spectrum from deep co-design and co-production of science and its outcomes to less-intensive client-based climate services. In this talk, I will give concrete examples of these various kinds of actionable science from our work in the south-central United States and how they led to climate adaptation planning and actions. As a result, I will (1) advance the dialogue on actionable science strategies and practices, and (2) provide case studies that improve the understanding of the many forms of actionable science.

## 2.7 Food security and supply chain resilience under a changing climate

*Katy Richardson, Met Office*

### Agriculture & forestry

### Economics and business

1. Food system resilience from the perspective of food prices and the agricultural economy (Richard Tiffin, University of Reading/Agrimetrics)
  2. Using climate model output to understand present-day and projected future risk to food systems and supply chains (Kirsty Lewis, Met Office)
  3. Adaptation to changing future risk of agricultural irrigation constraints during drought (Ian Holman, Cranfield University)
  4. Climate change impacts on international supply chains and markets – project insights from Switzerland and Germany (Madeleine Guyer, INFRAS AG)
  5. Panel discussion (All)
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**Keywords:** Food security, supply chains, climate change, climate variability, resilience

Understanding how the global food system will respond to a changing climate is complex due to the interconnectedness of the system (through food trade) and the interdisciplinary nature of the impacts (e.g. production, yield, trade, stability of supply). This session aims to address some of the interdisciplinary challenges of evaluating the impacts of climate change on food systems for the purpose of business and government planning. There will be three presentations covering the topic of food security and supply chain resilience from different perspectives, followed by an open panel discussion with all speakers.

The first presentation outlines food system resilience from the perspective of food prices and the agricultural economy. This will be followed by an introduction to interpretation of climate model output to understand the probability of present-day and projected future crop production shocks in the context of the global food system. The next presentation will look at more detailed, local level to discuss agricultural irrigation constraints during drought in the UK and adaptation to changing risk. The final talk will return to a global view, looking at indirect impacts of climate change on international supply chains and markets and the importance of evaluating these impacts for national policy making and businesses.

The open panel discussion will focus on the challenges of interpreting information about climate change impacts on the food system at different scales and for different decision makers, given the complex nature of the system and the interdisciplinary nature of the problem. The range of perspectives from the presenters on the panel will provide interesting discussion and direct pull through of the climate science into adaptation practice and planning from a business perspective.

### Significance to adaptation practice, policy and/or business

This session will consider how to build resilience in supply chains to ensure food security under a changing climate. The focus will be on the interdisciplinary nature of the problem, and methods for understanding and interpreting the available information to inform planners and risk managers. The speakers will present a range of perspectives on this topic, from both science and business, with a focus on how the science is pulled through to inform adaptation policy and business practices.

## **1. Food system resilience from the perspective of food prices and the agricultural economy**

Prof. Richard Tiffin, University of Reading/Agrimetrics

The food price spikes of 2008 and 2011 were significant factors in raising the profile of global food insecurity. The twin pressures of rapid population (and demographic) change and climate change mean that our food system is likely to be under more pressure than ever before over the next 20 years. This presentation will discuss ways in which the food system can adapt to increased temperature and changes in the patterns of rainfall. It will also discuss the capacity within the system to respond to increasing common extreme weather conditions.

The changes in climate and population are taking place in a system which is increasingly complex and integrated. In some respects, this provides resilience as a consequence of the buffering capacity that is provided across regions. However, our limited understanding of the potential non-linearities in this complex system mean that there is a risk of there being presently unforeseen tipping points.

## **2. Using climate model output to understand present-day and projected future risk to food systems and supply chains**

Kirsty Lewis, Met Office

Assessments of the impacts of climate change on the food system often concentrate on how changes in climate will affect long term crop yields. However, climate variability and change also has consequences for the resilience of our food systems.

Production of a number of key agricultural commodities is highly concentrated in areas of high yield around the globe. As such crop failures in a few key locations in the same year could have a significant impact on availability and access to food. Estimating the risk of this kind of multi-breadbasket failure from weather events is not possible given the limited observational record, but understanding this risk - and how it could change as the climate changes - is critical.

This presentation will discuss the ways that we can explore the current plausible range of adverse climate impacts on global food production and supply chains, using multiple modelled realisations of the present-day and future climates. We discuss the way an approach that focuses on system risk, can inform climate science questions and the value that can be extracted from climate models to manage that risk.

## **3. Adaptation to changing future risk of agricultural irrigation constraints during drought**

Prof. Ian Holman, Cranfield University

Agricultural irrigation is important in humid regions to supplement precipitation so as to assure crop quality and yield. In the UK, agricultural irrigation generates annual on-farm net benefits in a 'design' dry year of more than £650 million, with further benefits through the food supply chain. However, significant economic impacts arise if farmers are unable to follow their irrigation plan due to abstraction restrictions during droughts. These can arise due to insufficient volume allocation in their abstraction licence (or permit) and/or mandatory abstraction restrictions imposed to protect the aquatic environment. This presentation describes research to understand the relative risk of these two constraints across England during drought under baseline (1961-90) and future (2071-98) climate. The research uses climate and simulated daily river flow from the Future Flows project, which developed and used an ensemble of gridded climate transient projections based on 11 variants of the Hadley Centre Regional Climate Model HadRM3-PPE to drive hydrological models for more than 180 catchments.

In this presentation, the risk of licence constraints are identified by applying observed relationships between annual abstraction and an agroclimatic index (annual maximum Potential Soil Moisture Deficit) in each water resource management unit across the country to the current and future climate scenarios. Abstraction restrictions are identified through application of the environmental regulator's drought management plan rules to

the simulated streamflow. Results show that the annual risk of having insufficient licenced water is currently highest in some parts of the east of England (at up to 70% annual probability) but expands to much of eastern and southern England by the end of the century. In contrast, the currently low annual risk of mandatory abstraction restriction of less than 5% across the country increases most in western England to up to 30%. The implications of these changing risk patterns and sources will be discussed in the context of regulatory and business adaptation.

#### **4. Climate change impacts on international supply chains and markets – project insights from Switzerland and Germany**

Madeleine Guyer, Dr Jürg Fussler and Martin Peter, INFRAS AG, Switzerland

During the last years, there has been a significant increase on studies regarding the economic impacts of climate change and adaptation (Agrawala et al., 2011; Aaheim et al., 2012; Ciscar et al., 2011, 2012, 2014). Existing studies normally assess the costs of climate change on national, regional and global level. However, international impacts from climate change, such as on trade, migration, health or security, are usually being excluded. Due to increasing international and economic interdependencies it is however crucial, to not only incorporate national climate effects but also international impacts such as e.g. on trade and supply chains. A Swiss study from 2007 estimates, that indirect international climate change impacts on Switzerland are equal or even higher than national impacts of climate change<sup>1</sup>. This thematic is facing increasing relevance. Some European countries such as Germany, the UK, the Netherlands and Switzerland having started analyses on how they're affected by indirect international climate change impacts. Generally, the topic is still very new and requires further applied science.

The presentation focuses on preliminary results and learnings from two policy focused research projects from Switzerland and Germany. Many countries have developed in-depth national adaptation strategies including vulnerability assessments from national climate change impacts. Case studies on risks and opportunities of direct climate change impacts have been conducted and adaptation measures developed. However, climate change impacts via international impact chains such as e.g. trade have not been sufficiently targeted by many countries. The presentation hence fosters the discussion on the relevance of the inclusion of international climate change impacts on national adaptation planning. Furthermore, the presentation will build an important bridge between the research community and the practice as the findings are from two governmental supported policy research projects.

#### **5. Panel discussion**

All presenters.

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<sup>1</sup> INFRAS/Ecologic/Rütter + Partner 2007: Auswirkungen der Klimaänderung auf die Schweizer Volkswirtschaft (Internationale Einflüsse), Schlussbericht, im Auftrag des BAFU, S. 115

## 6.7 Adaptation cultures: knowledge, values and practices

*Melanie Boeckmann, Heinrich Heine University Düsseldorf and Thorsten Heimann, Leibniz Institute for Research on Society and Space*

### Communication, art and culture

1. “Climate Cultures” of Adaptation: Differences and Similarities in Handling Floods and Climate Change in European Coastal Areas (Thorsten Heimann, Leibniz Institute for Research on Society and Space )
  2. Reflexive research on heat adaptation in Japan (Melanie Boeckmann, Heinrich Heine University Düsseldorf)
  3. Culturally adapted to floods? - Settlement, relocation and re-settlement practices in flood-prone areas in Monterrey, Mexico (Libertad Chavez-Rodriguez, CIESAS Northeast, Monterrey)
  4. Discussion
- 

Climate change adaptation as a cross-sectional issue is relevant to various disciplines and touches many different aspects of human lives and societies. Adaptation research is interested in contextual determinants across countries, regions, and cultures, but is also subject to a “climate culture” itself which often stresses technocratic adaptation solutions and tends to view social aspects as an add-on. Linking culture to risks and climate change adaptation studies and practices is important as culture has a hidden power that can offer explanations for dealings and doings within a risk reduction context. Differences in cultures, societal values, and norms, while not always openly acknowledged, play a significant role in adaptation decision-making: they shape the types of adaptation actions proposed and evaluated, which in turn affect the lived experiences of adaptation practitioners and participants. However, culture cannot be interpreted as a given set of social factors, but as a constantly changing and shifting configuration of social practices, or as an outcome of experiences that are inscribed into society. If culture is left out of the analysis of climate change paradigm, we risk that disaster risk reduction and related issues of adaptation, such as coping, knowledge and power relations, cannot be fully grasped. Drawing attention to differences and similarities in knowledge, values, norms and practices of adaptation-cultures is necessary to deepen our understanding of how adaptation is perceived and shaped in different communities and in different regions of the world.

In this session, we will discuss adaptation cultures situated within processes by which people shape their diverse beliefs, institutions and surroundings around climate change and extreme events. We also address issues such as equity and justice terms and their role in adaptation research, ask how local and socio-cultural contexts shape adaptation decision-making, discuss potential problems of the dominant adaptation discourse as well as investigate effects on projects and people. The session will therefore address the following research questions:

- How are climate change adaptation cultures constructed?
- How are perceptions of and attitudes towards disaster risks and climate change embedded into cultural contexts?
- How are culture-related discourses shaped and communicated?
- How are these discourses in turn represented in adaptation decision-making?
- And how might culturally embedded perceptions and ideas determine the potential creation or elimination of livelihood risks?

### Significance to adaptation practice, policy and/or business

This session and its topic raise awareness on potential pitfalls of one-size-fits all adaptation policy solutions. We suggest that adaptation is strongly linked to its social and cultural environment both as practice and policy, and propose critical analysis of the determinants that may influence policy effectiveness.

## **1. “Climate Cultures” of Adaptation: Differences and Similarities in Handling Floods and Climate Change in European Coastal Areas**

Dr. Thorsten Heimann, Leibniz Institute for Research on Society and Space (IRS), Erkner/Berlin, Germany

Ways of dealing with climate change risks differ depending on socio-spatial and cultural backgrounds. Actors who want to implement solutions have to consider differences in the knowledge of agents involved. Even similar climate scenarios from the natural sciences are treated differently. Thus to identify suitable coping strategies, cultural characteristics need to be taken into account. Consequently we have to ask: Which role do differences in knowledge and culture play in handling climate change risks?

To answer these questions I explore the shared knowledge of agents from spatial planning and coast protection from European coastal areas. In a quantitative survey, agents assess possible threats and opportunities as well as adequate measures to cope with them. I investigate how their approvals are interconnected with shared values, worldviews and socio-spatial identities. Furthermore, I ask how national and regional backgrounds discriminate climate change related knowledge and practices. More than 800 agents from European coastal municipalities in Germany, Denmark, the Netherlands and Poland gave their opinion.

The empirical results give evidence to support theories both of homogenization and differentiation across Europe. On the one hand, we find similar forms of shared knowledge related to climate change across all coastal areas; on the other hand, variables like national affiliation also contribute to its discrimination. For example, Polish respondents believe to a significantly lesser extent in climate change and anthropogenic cause compared to respondents from Germany, Denmark and the Netherlands. Nevertheless, cultural constellations change, if we focus on coast-protection strategies, where Polish and German agents show similar patterns of preference and differences to the other countries.

## **2. Reflexive research on heat adaptation in Japan**

Dr. Melanie Boeckmann, Institute of General Practice, Centre for Addiction Research and Clinical Epidemiology, Medical Faculty of the Heinrich-Heine-University Düsseldorf, Germany

Extreme weather events and disaster risk reduction play an important role in Japanese environmental and health policy, and climate change-related weather impacts such as heat waves are being targeted by heat prevention strategies, among others. Can European climate change adaptation research and practitioners learn from Japanese examples in the field of heat prevention? Can there be universal examples of “what works” in adaptation even across culturally different contexts? Seeking answers to these questions, I conducted a pilot interview study in environmental and public health agencies in three Japanese prefectures in 2013.

This presentation will give a brief overview over findings on the state of heat adaptation in these Japanese prefectures, specifically creative approaches to strategy design, and discuss the researcher’s role in adaptation assessment across borders.

The second point is of high interest since during my research I encountered language, gender and institutional logic differences that may influence interpretation of results. How do investigators’ backgrounds and knowledge, the discourses they were trained in, shape what they discover abroad? And how should we incorporate reflexive practices into research result presentations to allow policymakers and practitioners to judge what examples might work for them? This presentation hopes to encourage a discussion on pitfalls and opportunities in intercultural assessments on global issues to strengthen the role of reflexivity on adaptation cultures.

### **3. Culturally adapted to floods? - Settlement, relocation and re-settlement practices in flood-prone areas in Monterrey, Mexico**

Dr. Libertad Chavez-Rodriguez, CONACYT-CIESAS Center for Research and Advanced Studies in Social Anthropology, CIESAS Northeast, Monterrey, Mexico

Poverty reduction and disaster risk reduction policies are connected to relocation measures of households from flood-prone areas in the recent history of the Metropolitan Area of Monterrey, located at the Northeast of Mexico. Nevertheless, evidence of local practices of settlement and even re-settlement in (the same) flood-prone areas questions the effectiveness of such policy measures.

Through ethnographic work in socio-spatial segregated neighborhoods of the Metropolitan Area of Monterrey, I examine the points of view of directly impacted or damaged households around decisions of settlement, relocation in non-flood-prone areas and re-settlement in flood-prone areas, as well as changes in their social vulnerability to floods over time. I carry this out by focusing on household member's subjective risk perception, meanings and own framing of their everyday exposure to risks, and recurrent landslide, waterlogging and flood experiences as a consequences of heavy rainfalls, tropical storms and hurricanes.

I study these motivations beyond common dichotomizations of people as victims or as agents of change, drawing upon debates about victimization and/or agency conducted by feminist scholars regarding the framing of women at disasters and in the context of the climate change consequences; to take in consideration that it is not necessary to deny social inequalities and differences in the social vulnerability to natural hazards to recognize people's agency to face every day risks and survival practices at recurrent extreme weather events.

Empirical evidence underscore the importance of aspects of subjective risk perception, place attachment and community cohesion related to decisions of settlement. I argue that sociocultural aspects play a determinant role in household and individual decision-making processes that may influence responses and behavior during emergencies, the implementation of precautionary measures at household level, and the acceptance of public infrastructure measures, which in turn influence the effectiveness of disaster risk reduction policies.

The acknowledgment of sociocultural aspects in Disaster Risk Management policies are undoubtedly of greater importance bearing in mind the expected regional impacts of climate change, which include – according to some climate change scenarios – changes in regional runoff of -25% to -50% by 2080 and an increase in cyclone frequency and intensity.

## 6.8 Adaptation in action: case studies from the water and sewerage sectors

*Mike Keil, Consumer Council for Water*

### Flooding

#### Ecosystem services and NBS

1. Future Proofing New York City's Wastewater Infrastructure (Adam Hosking, CH2M )
  2. Securing climate ready water supplies - the Birmingham Resilience Project (Jane Simpson, Severn Trent Water)
  3. Embedding adaptation into investment decision making (David Quincey, Anglian Water)
  4. Adaptation & Resilience Framework for the Bristol Avon Catchment: The integration of adaptation actions across sectors into spatial planning (Silole Menezes, Wessex Water)
  5. Building with Nature: Adapting to Climate Change through innovative catchment management in the Tweed UNESCO HELP Basin, Scotland (Christopher Spray, University of Dundee)
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**Keywords:** Adaptation, Delivery, Collaboration, Good practice, Water, Waste Water

The water sector is arguably the most vulnerable sector to the impacts of climate change; this is because almost all the activities involved in providing water and sewerage services are sensitive to the weather.

Ensuring that there are enough water resources available to maintain reliable supplies into the future is a key issue for the water sector. However, the challenges go beyond balancing water supply and demand. In this session we consider the wider adaptation challenges. We look across all water and sewerage infrastructure and examine what adaptation means in practice.

Key areas of focus include:

- How to go beyond the initial risk assessment phase, to build business cases and ultimately deliver projects on the ground?
- How can multiple benefits, beyond adaptation, be delivered from projects to build climate resilience?
- How can partnership working be harnessed to deliver successful projects?

### Significance to adaptation practice, policy and/or business

This session will be valuable to scientists, practitioners, businesses and policy makers as we aim to show how real action is being delivered on the ground. The session also aims to demonstrate how effective solutions tend to involve partnership working across a variety of disciplines.

#### 1. Future Proofing New York City's Wastewater Infrastructure

Adam Hosking, CH2M

The devastation caused across New York City in 2012 by Hurricane Sandy demonstrated the risk to lives and property that coastal communities face as our climate becomes more volatile. As many of NYC's wastewater treatment plants and pumping stations reside along the waterfront, they were among the hardest hit infrastructure during Sandy, with a reported flood damage exceeding \$95 million. Damage to the facilities also resulted in environmental impacts: over 560 million gallons of dilute, untreated sewage was released into local waterways. Flood risk is likely to increase as more frequent and severe storm surges, heavy rains, and sea level rise are projected in the coming decades.

Building on the 'Climate Risk Assessment and Adaptation' study that was ongoing before Sandy hit, the New York City Department of Environmental Protection (DEP) developed 'Disaster - Proofing Vital Infrastructure' that



proposes strategic, forward-looking resiliency initiatives, design standards, and protective measures to harden the City's wastewater infrastructure against future climate risks. The results represent the culmination of an innovative risk management assessment, encompassing future climate, risk, and adaptation analyses. In all, the study successfully identified critical facility and infrastructure vulnerabilities and proactive measures to minimize prolonged service interruption during major floods.

NYC's wastewater treatment system is one of the largest in the world, with 96 pumping stations and 14 wastewater treatment plants collecting and treating 1.3 billion gallons of sewage daily. The benefit cost analysis undertaken to inform resilience option selection, demonstrated that by investing USD\$315 million in a strategic mix of robust protection measures, including elevating or flood-proofing equipment, installing static barriers, sealing buildings, sandbagging and installing backup power capabilities, over USD\$1 billion in wastewater infrastructure can be cost-effectively protected. This could potentially save the City USD\$2.5 billion in infrastructure repair costs over the next 50 years and would safeguard the public health of eight million residents and the environment from sewage released to waterways.

The study's findings detailing facility vulnerabilities and cost-effective protective strategies have integrated into the City's Capital and Operations programs, with many of the suggested strategies already implemented. The presentation will showcase some of these resilience improvements. The study also serves as a model for other coastal cities around the globe that can use the adaptable risk management framework to perform their own assessments, building stronger, more resilient communities against future climate risks.

## **2. Securing climate ready water supplies - the Birmingham Resilience Project**

Jane Simpson, Head of Asset Creation at Severn Trent

England's second biggest city, Birmingham, is heavily reliant on water from the Elan Valley Aqueduct (EVA). Weather and climate change risks present major challenges to the EVA which is one of Severn Trent's strategically important assets. The EVA is a 118km aqueduct which transports water from mid-Wales to Birmingham. It carries nearly 20% of Severn Trent's raw water and has delivered reliable service for over 100 years. It plays a key part in providing strategic resilience to Severn Trent's water network.

The EVA is also a low carbon asset as it requires no pumping to bring water 118km to Birmingham and it also delivers good quality water which means the energy requirements for treatment are relatively low. This is another key driver for ensuring the EVA is a reliable asset into the future.

The EVA passes through some rugged terrain – straddling mountains and rivers on its route. Both landslides and flood related river scour can cause significant damage to the structure of the EVA. Research from the Met Office and British Geological Survey shows that these risks are increasing over time due to climate change. Severn Trent's structural analysis of the EVA indicates that now is the right time to invest to protect this asset for the future.

Severn Trent are investing around £300m to develop an alternative source of supply for Birmingham by 2020 and is their ever biggest engineering project to date. This will allow Severn Trent to provide an uninterrupted service in the event of an EVA failure and provide the capability to shut-down the EVA for planned maintenance periods. This ensures a resilient supply of water to Birmingham and surrounding communities for generations to come, securing an economical and low carbon source of water, which itself is robust to the impacts of climate change.

Constructing a robust business case for one of the biggest adaptation projects ever proposed in the UK presents significant challenges. In this presentation we highlight the key elements of the business case and give an overview of the progress that's been made in the delivery phase of this ambitious project.

### 3. Embedding adaptation into investment decision making

David Quincey, Anglian Water

Climate change is one of the greatest risks Anglian Water faces. It has the potential to impact upon the service we provide to our customers and the wider sustainability of our region. The significance of this risk has been recognised by embedding it into one of our 12 corporate goals, committing us to, “lead and champion the effective management of growth and climate change”.

Key to managing climate change is adapting our assets to be able to deal with the arising challenges. Adaptation is therefore now embedded into our corporate governance ensuring that climate change impacts are considered and acted upon as part of business as usual. All projects being taken forward to construction must demonstrate that they have assessed climate change risks, costed appropriate adaptation options and adjusted their designs accordingly.

The following examples illustrate how we are investing in adaptation which goes beyond our conventional approach and makes a real difference on the ground<sup>2</sup>.

- *Costessey sewer flooding mitigation*: The standard solution was to provide storage protecting from a 1:30 year design storm. A 20% uplift was applied to the storm severity to account for climate change resulting in a significant increase in the storage volume provided;
- *Repps With Bastwick new sewerage*: The conventional solution suggested a new pumping station location with a flood risk greater than 1:100. A climate change adapted solution was identified, costed and implemented which moved the pumping station to an area with a less than 1:1000 risk;
- *Bridgham new sewerage*: The pumped main was re-routed minimising the length in the current and future flood plain and the section in the flood plain was continuously welded and manufactured with no fittings. This reduced its flood vulnerability and the need for maintenance work in the flood plain. In addition the design of a pumping station was adjusted to reflect its current and future flood risk. Construction heights were increased and kiosks flood proofed.
- *Great Dunmow Water Recycling Centre refurbishment*: As most of the landholding is within flood zone 3 a full independent flood risk assessment was completed and a combination of approaches taken to address the risk. This comprises sheet piling protection, raising of critical assets above the 1:100 year future flood event and increasing flood compensation within the site boundary.

To date adaptation delivery has focussed on water supply, power supply and flood resilience. However significant risks are associated with raw water quality and temperature change. We are improving our understanding of these so that they can be incorporated. It is anticipated that climate change adaptation will feature heavily in our next investment plan from 2020.

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<sup>2</sup> Larger non-infrastructure examples are not given as they are still in design and have not yet delivered their adaptations.

#### **4. Adaptation & Resilience Framework for the Bristol Avon Catchment. The integration of adaptation actions across sectors into spatial planning**

Silole Menezes, Wessex Water

The Adaptation & Resilience Framework for the Bristol Avon Catchment is a collaborative initiative to address climate change adaptation and increasing economic pressures by integrating cross-sectoral adaptation actions into spatial planning at a catchment scale.

A multi-sector working group was formed to look at risks, and opportunities across political boundaries to enable a better understanding of the interdependent impacts of upstream land use changes on downstream assets. The group includes governmental organisations; five Unitary Authorities, the Environment Agency, Natural England, two Local Enterprise Partnerships and Highways England. It also includes non-governmental organisations; two Nature Partnerships, the Bristol Avon Catchment Partnership and two private companies: Bristol Water and Wessex Water, and is in the process of engaging with other key stakeholders.

The Framework takes a systems approach to understand and plan for complexity so that development decisions can be made on wider identified risks, wider costed solutions and routes to delivery. It raises awareness across sectors of the risks and opportunities of the top six areas of interrelated climate change risks for the UK as outlined in the latest UK Climate Change Risk Assessment (July 2017). It focuses on systems and relationships rather than specific risks thereby allowing an adaptive management approach.

The West of England, which includes the 'Core City' of Bristol is facing increasing pressures for housing and development and has recently become a devolved administration with a newly elected Mayor. It is currently in the process of preparing a Joint Spatial Plan (JSP) and a Joint transport Plan (JTP) for housing and transport for the next twenty years as well as updating Local Plans. This offers opportunities to integrate adaptation measures into these plans as well as providing a vehicle for multiple organisations to plan for better-integrated solutions to shared risks. .

An Integrated Catchment Management approach allows all parties to have sight of the competing demands for the provision of roads, cycle ways, footpaths, on street parking and green infrastructure. This project does not require significant overhaul of organisational responsibilities but rather facilitates improvements between organisational communication and planning and more efficient expenditure of resources. It enables issues to be addressed at source rather than by end of life costly solutions with the potential to pool budgets to deliver collaborative investment in multi-functional solutions.

#### **5. Building with Nature: Adapting to Climate Change through innovative catchment management in the Tweed UNESCO HELP Basin, Scotland**

Christopher Spray, University Of Dundee

Nature based solutions, which look to work at the landscape scale as part of a suite of potential adaptation measures are an increasingly important policy response to challenges posed by climate change. Targeting the most effective intervention measures at the right location, right scale and through the right means is key to this adaptive management approach. Whilst policies that look to deliver multiple benefits for flood risk, habitats, biodiversity and other ecosystem services are emerging, an urgent need exists to establish the science-evidence base for these potential adaptations to climate change, and to bridge the gap between science, policy and practice on the ground.

We report on work within the Tweed UNESCO HELP basin by a partnership led by the participative catchment NGO, Tweed Forum and, in particular the restoration of the Eddleston Water. This looks to provide the evidence-base for 'building with nature' as an adaptive response to climate change, covering both bio-physical and socio-

economic aspects. We link this to the EU INTERREG North Sea Region Building with Nature programme of which this is part.

The Eddleston Water is a 70 kms<sup>2</sup> catchment of Tweed that suffers both from flooding and historical habitat degradation. Our research shows the landscape, landuse, habitats and ecosystem services derived from it, have changed dramatically over time, largely in response to policy and market-driven pressures.

Begun in 2009 as a scoping study, the Eddleston project is a national pilot financed by Scottish Government to provide the science evidence base to support policy requirements for utilisation of 'natural characteristics' of a catchment within a wider sustainable flood risk management and river basin management framework (Flood Risk Management (Scotland) Act 2009). Its aims are to restore the catchment to reduce flood risk to local communities and improve habitats, taking a scientifically driven, holistic approach. We report on results from detailed hydrological, ecological and social science studies to show the effectiveness of key measures. These include re-meandering old straightened river channels, creating temporary storage ponds, holding back flood flows with leaky wood barriers and tree planting that together increase resilience to climate change induced changes in hydrology. We report on responses to introduction of such new measures from farmers within Tweed and the economic implications for introducing these measures.

Through working with local stakeholders and policy-makers, we aim to bridge the science-policy gap, providing the evidence for building with nature to deliver greater resilience to climate change.

## 11.1 Adapting to floods in coastal areas

*Agustin Sánchez-Arcilla, Universitat Politècnica de Catalunya*

### Coastal

### Flooding

1. To what extent can societies adapt to sea-level rise? (Daniel Lincke, Global Climate Forum)
  2. How to combine sea-level rise impact and population activities in the Mediterranean. The Catalan coast case. (Agustin Sánchez-Arcilla, Universitat Politècnica de Catalunya)
  3. Comparing hazard and impacts from storm surge flooding along a complex coastline: An example from the UK North Norfolk coast (Elizabeth Christie, University Of Cambridge)
  4. Deltaic adaptation with natural nourishment plus biologic stabilization. The Ebro Delta case in the Western Mediterranean (Vicente Gracia, Universitat Politècnica de Catalunya)
  5. Climate adaptation to coastal flooding - decision support in the Hazard Support project (Helen Andersson, Swedish Meteorological And Hydrological Institute)
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**Keywords:** Floods; coasts; relative sea level rise; storm surges; storminess; coastal typologies; hazards; decision making

Coastal areas are limited in horizontal extent but subject to frequent flooding from the river and the sea. Adapting to floods has been essential for coastal societies to survive and to reach, in some areas of the planet, high standards of living. Under future climates the pressure on coastal societies and infrastructures will increase due to sea level rise primarily but also due to changes in wave and surge climates and the expected increase in the variance of some climatic variables.

The resulting enhanced risks will require additional adaptation with respect to present adaptation levels, relevant for global to local scales. In the session we expect to start the discussion with the global implications of sea level rise for coastal societies. This will be followed by a number of regional studies from the Mediterranean and the North Sea coasts. The session will also include a deltaic case since deltas are already experiencing some of the expected acceleration in sea level rise due to the combination of sea level rise plus subsidence.

Finally, the session will consider how to adapt and take decisions in the face of present and future climate uncertainties and the implications this has for managing coastal systems. Discussion on such implications, from short to long time scales, is welcome to enhance the application of our results to coastal adaptation to excesses (flooding) and limitations (droughts) in water availability.

### 1. To what extent can societies adapt to sea-level rise?

Daniel Lincke, Global Climate Forum

Sea-levels will rise substantially due to climate change. According to the current literature, a global mean sea-level rise of up to 2 meters is possible during the 21st century, albeit being unlikely. Against this background, an important research and policy question is, to what extent humans are able to adapt to substantial rises of sea-levels. This paper addresses this question in the light of a set of diverse cases including Bangladesh, Catalonia, Jakarta, the Maldives, New York and the Netherlands. The question of whether societies can adapt to sea-level rise is made operational through the concepts of limits and barriers to adaptation. The focus lies on the following four limits and barriers that have found to be most important for coastal adaptation in previous comparative case study research: i) technological limits, which arise when there are no technological measures available to effectively mitigate the impacts of sea-level rise; ii) economic barriers, which arise if the implementation and maintenance of adaptation options is more costly than the impacts avoided through the options; iii) financing

barriers, which arise if it is difficult or impossible to access financial resources for adaptation; and iv) institutional barriers, which arise whenever stakeholders' conflicting interests impede or exacerbate adaptation.

Across the cases it is found that the ability of societies to adapt to 21st century sea-level rise is not constrained by technological limits. In some cases, such as the ones of Miami and Bangladesh, adaptation involves engineering challenges, but these do not constitute limits, but will make adaptation costlier. Regarding economic barriers, we see a divided world. On the one hand, there are densely populated urban areas, for which it is highly profitable to protect against rising sea-levels. On the other hand, protecting rural areas and agricultural land is generally not profitable. But even when profitability is high, coastal adaptation is frequently constrained by inaccessible finance. One reason for this is that coastal protection projects involve high up-front investments, while the benefits (i.e. the avoided cost of extreme sea-level events) are stochastic and occur over a long-time horizon. Social conflicts are present in almost all cases. The reason for this is that both sea-level rise and coastal adaptation projects massively redistribute risks and benefits amongst stakeholders, which means that there will be winners favouring adaptation and losers objecting.

## **2. How to combine sea-level rise impact and population activities in the Mediterranean. The Catalan coast case.** Agustin Sánchez-Arcilla, Laboratori D'Enginyeria Marítima (LIM/UPC), Universitat Politècnica De Catalunya

Most developed coasts in the Mediterranean show a high level of pressures and conflicts under present climate and socio-economic conditions. This results in a high exposure and low adaptive capacity leading to high risk levels that will get aggravated under future sea-level rise projections.

In this work we shall assess the impact of sea-level rise on available beach area and combine these analyses with socio-economic indicators (population density, GDP and number of tourist places available). We shall consider three main scenarios for SLR, ranging from 0.53m to 1.75m by 2100 in accordance with projections from RCP categories (4.5 to 8.5 plus a high-end scenario). We shall carry out a regional analysis in terms of two of the main functions provided by beaches, i.e. recreation (linked to tourism) and protection (linked to hinterland activities and safety). This will be supplemented by a pilot case in a local sector at the North of the Catalan coast where the recovery of old wetland may help to prove the increased resilience associated to a buffer zone in the back beach.

The results obtained illustrate the severe decrease of protection and recreation functions which will increase coastal risk levels unless an adaptation plan is put into practice. The impact of sea-level rise with and without accommodation space and the role played by wetland areas will serve to discuss how adaptation may increase resilience and how it can become a competitive alternative to traditional engineering interventions.

## **3. Comparing hazard and impacts from storm surge flooding along a complex coastline: An example from the UK North Norfolk coast**

Elisabeth Christie, University of Cambridge

On bathymetrically and topographically complex barrier island coastlines, records of storm surge impacts often show considerable local variability in maximum water levels at the populated coast. It is important to identify the locations at greatest risk so that scarce resources for coastal management can be most effectively deployed. To improve upon existing flood forecasting systems - which show little alongshore differentiation in flood levels at the sub-regional scale - we report new methods for both hazard assessment and patterns of socio-economic vulnerability. These identify coastal 'hotspots' on the 45-km long barrier coastline of North Norfolk, eastern England. This is a case study site of the EU FP7 RISC-KIT (Resilience-Increasing Strategies for Coasts – toolKIT) project.

Applying complex high-resolution modelling approaches along a regional coast is not resource efficient, necessitating an initial assessment process. Local coastal 'hotspots' are selected using a coastal index approach

combining hazard and exposure components. These hotspots are then compared using a chain of coastal inundation and impact assessment models.

Spatial variability in storm surge runup and flood inundation on the North Norfolk coast results from the passage of storm tides and waves over and through a wide variety of 'ecogeomorphic' units, including gravel barriers, sand dunes, tidal channels, mudflats, saltmarshes, and reclaimed (freshwater) marshes. Here we report on the application of XBeach and LISFLOOD models which aim to capture these complexities in improved local hazard assessments.

In addition to direct impacts, storm surges can generate indirect impacts extending far beyond the exposed areas and temporally beyond the immediate aftermath of an event. These larger scale and longer term impacts may include the disruptive effects of population displacement, transport and utilities disruption, changes in natural ecosystems, business interruption and the delayed financial recovery of businesses and households. Here we assess these potential disruptions following a severe coastal event using the open-source INDRA model (INtegrated DisRUption Assessment model). The INDRA model identifies the at-risk natural and man-made assets which attract visitors to the North Norfolk coast and calculates how direct impacts to these assets negatively affect local tourism activity. The coastal hotspots are then able to be compared using a Multi-Criteria Analysis.

#### **4. Deltaic adaptation with natural nourishment plus biologic stabilization. The Ebro Delta case in the Western Mediterranean**

Dr. Vicente Gracia, Laboratori d'Enginyeria Marítima LIM/UPC, Barcelonatech (UPC)

Deltas in developed countries are suffering vertical (loss of level) and horizontal (loss of emerged area) erosion due to sediment misbalances. This situation has been aggravated by river flow regulation due to the presence of numerous dam barriers. The inherent problems will get more acute under future climates. From now until 2100 deltas will be experiencing an acceleration of relative sea-level rise (RSLR, subsidence plus global warming) that for a case like the Ebro Delta in the North-Western Mediterranean may result in RSLR rates that go from 0.8m (RCP 4.5) to 1.2m (RCP 8.5). Hard protection is not suitable due to high costs, downstream impacts and limited long term sustainability. The combination of "Nature Based Solutions" (NBS) with conventional works (such as beach nourishment) appears as an alternative that may result in higher resilience, lower costs and impacts. The combination of "Nature Based Solutions" (NBS) with conventional works (such as beach nourishment) appears as an alternative that may result in higher resilience, lower costs and impacts.

The main objective of the study is to analyse the suitability of classic engineering plus NBS for maintaining coastal resilience with affordable economic and energy costs. The proposed management strategy consists in the maintenance of a sandy belt through artificial nourishment plus a sediment reshaping and fixation based on natural beach plan/profile geometries and vegetation. These flexible interventions will enhance natural dissipative capacity under wave storms. The plan also considers the use of emerged sediment at stable/accretive beaches to increase resilience of highly eroding sectors. The feasibility of the proposed measures will be assessed through numerical modelling of the associated hydrodynamic and morphodynamic processes under RCP 4.5, RCP 8.5 and a High-End scenario. Wave attenuation, changes in nearshore circulation and sedimentation rates will be used as indicators with respect to a non-intervention policy. The source areas will be also clustered in terms of sediment trap efficiency to determine the sustainability of the solution. A cost transfer function incorporating the land loss will be used to determine the potential benefits that NBS offer.

The paper will end with some conclusions on how the proposed combination of NBS plus a structured adaptation plan can provide a feasible option for maintaining coastal resilience with affordable economic and energetic costs.

#### **5. Climate adaptation to coastal flooding - decision support in the Hazard Support project**

Helen Andersson, Swedish Meteorological and Hydrological Institute

This project approaches different stakeholders' need of climate impact information in order to produce best scientific practice guidelines and to handle changing climate-projection information in their adaptation plans. When it comes to climate adaptation to changes in flooding risks, there is the underlying need to adapt to global mean sea -level rise. This, in combination with other climate-change impacts can at the regional level increase the intensity and frequency of coastal flooding. The combination of factors such as mean sea level rise, land uplift, tides, local winds, air pressure, and topography will give different future flood risks at different locations along the Swedish coast, which calls for different adaptation actions, and the climate-change information and impact data needs to be tailored in order to meet different end-users' needs.

To produce the information we use available sea level data as well as different models.

A thorough analysis of historic sea level data provides information on return periods in present climate. However, due to the relatively short observation periods the information on longer return periods is limited. The numerical models complement the observations and increase the statistical information base. They also enable investigation into different linear and nonlinear interactions between mean sea levels, wind speed and extreme levels. We use different IPCC climate scenarios (RCP 2.6, 4.5 and 8.5) and an ensemble of global climate models to assess uncertainty ranges. To understand the impact on both regional mean sea-level change and changes in the extremes, we use regional downscaling methods and a coupled atmosphere-ocean model for the Baltic and North Seas.



## 2.6 Are you sure you want to do this? An interactive participatory experiment on extremes and uncertainty

*Karianne De Bruin, Wageningen UR & CICERO and Thordis Thorarinsdottir, Norwegian Computing Center*

### Participation and co-production

### Communication, art and culture

1. Adaptation decision-making under climate extremes (Karianne de Bruin, Wageningen UR & CICERO)
  2. The role of uncertainty in evidence based climate change adaptation: The case of sea level rise (Thordis Thorarinsdottir, Norwegian Computing Center)
  3. Adaptation decision-making in Zanzibar's clove plantations: a cost benefit analysis extended to light-touch uncertainty treatment (Alina Tepes, Basque Centre for Climate Change)
  4. Urban SIS: Demonstration and impact assessment of using spatially and temporally distributed extreme rainfall inputs to urban flooding modeling (Lena Strömbäck)
  5. Interactive session (Karianne de Bruin, Wageningen UR & CICERO and and Thordis Thorarinsdottir, Norwegian Computing Center)
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**Keywords:** Decision-making under high uncertainty, extremes, statistical modelling for climate services, regional modeling, climate change adaptation

Long-term planning and decision-making regarding fundamental societal infrastructure such as transportation, energy supply and water and drainage systems must account for a changing climate and extreme events. Considerable challenges however continue to exist in understanding of climate extremes, the associated impacts and the identification of potential adaptation options. As a result, severe inherent uncertainties persist along all parts of the processing chain from climate projections to adaptation assessments, and it is critical that decision-making appropriately account for this.

This session will explore the current state-of-the-art and highlight the advantages of using fully probabilistic approaches that account for uncertainty both in climate projections and benefit assessments i.e. to turn information on uncertainty into a driver of change rather than a barrier. In this context, the participants will discuss the linkages between the current scientific knowledge and evidence base of future climate extremes and the practical application of adaptation planning and decision-making to deal with the impacts of these extremes as well as with the associated high uncertainties.

The format of the session is highly interactive and will employ game-based tools to stimulate active discussions and knowledge sharing amongst the participants. Based on three short scoping presentations, the participants will be part of an interactive experiment towards resilient and robust adaptation decision-making in the face of climate uncertainties e.g. by the means of statistical and risk-based approaches. Participants are encouraged to share questions to be discussed in the context of this session. A subset of these questions will be used to prepare the session. Contact: [karianne.debruin@cicero.oslo.no](mailto:karianne.debruin@cicero.oslo.no)

### Significance to adaptation practice, policy and/or business

This session provides a real-life experience on what it means to turn information on uncertainty into a driver of change rather than a barrier, whether you are active in adaptation practice, policy and/or business. It builds up a common understanding on the role of uncertainty in adapting to extremes and provides interaction between the different actors dealing with adaptation to climate change.

### **1. Adaptation decision-making under climate extremes**

Karianne de Bruin, CICERO & Wageningen Environmental Research (Alterra)

To ensure that improved understanding of climate extremes and their representation in climate models contributes to a reduction of severe impacts of climate extremes to society, improved knowledge on climate extremes needs to be incorporated in adaptation decision-making. This presentation will highlight how and why the incorporation of uncertainty in adaptation decision-making tools is crucial for a better assessment of adaptation options.

### **2. The role of uncertainty in evidence based climate change adaptation: The case of sea level rise.**

Thordis Thorarinsdottir, Norwegian Computing Center

Decision making for climate change adaptation involves the assessment of climate, impacts and cost/benefits of adaptation options. All of these components are inherently uncertain in nature and decision making tools should be able to account for each of the uncertainties in a coherent fashion. We discuss a light touch approach to the propagation of uncertainty from climate projections to assessment of cost/benefits in a case study on the impact of sea level rise in Bergen, Norway.

### **3. Adaptation decision-making in Zanzibar's clove plantations: a cost benefit analysis extended to light-touch uncertainty treatment**

Alina Tepes, Basque Centre for Climate Change (bc3)

Flexibility and robustness have been repeatedly mentioned to be important characteristics for sound decision making in the realm of climate change adaptation. This is because traditional methodologies for project appraisal do not match well with uncertain circumstances in the real world. These include uncertainties about climate change projection and modelling as well as classical socio-economic uncertainties that usually make investments risky. Real option analysis (ROA) derived from financial markets as well as robust decision making (RDM) have attracted much interest to adaptation economists for their potential to generate additional information into project evaluation processes where the most widespread cost benefit analysis is usually performed. Generally, however, these methodologies require high computational expertise and most ROA and RDM practice to date are found in sectors with high infrastructural components or sectors where exhaustive data is available for methodological processing. Their application is therefore limited to a restricted expert community which hinders wider replicability and provides few space for generalization in project appraisal. In this study we aim at testing these new methods and their pertinence to adaptation in international development cooperation by adopting "light-touch" approaches that capture intrinsic concepts of formal applications without losing their economic rationale. To do so, we use the ongoing National Adaptation Action Plan process of the Revolutionary Government of Zanzibar within the United Republic of Tanzania (URT) where stakeholders identified clove plantations as one of the key priorities to be addressed. From the perspective of project finance application we first develop a cost benefit analysis of a simplified clove agroforestry systems focusing on Pemba Island. We assess the profitability of different adaptation options that aim at resilient clove plantations in Zanzibar both with and without climate change. We then extend the analysis to ROA and RDM light-touch uncertainty treatments to verify their relevance for the adaptation practitioner community in the field. Results of our case study show "light-touch" applications of uncertainty treatment can provide the analyst with additional information that can be valuable to decision makers in four ways: by better disclosing and framing the variety of uncertainties the decision is subject to (i), providing complementary results as to how outcomes change with varying uncertainties or challenging traditional cost benefit results (ii), providing opportunities for iterative adaptation management through stakeholder engagement (iii) and forcing the analyst to consider alternative "in project", flexible and robust adaptation options that avoid locking in present decisions (iv).

#### **4. Urban SIS: Demonstration and impact assessment of using spatially and temporally distributed extreme rainfall inputs to urban flooding modeling**

Lena Strömbäck, SMHI

Presently, urban hydrological climate change impact assessment is highly limited by the comparatively coarse resolution in available climate projection data ( $>10 \times 10 \text{ km}^2$ ), in which small-scale rainfall extremes is difficult to adequately describe. In the project Urban SIS, climate projections are downscaled to  $1 \times 1 \text{ km}^2$  grids over European cities which makes it possible to describe the expected changes in short-duration rainfall extremes, and in turn assess urban flood risk, with higher accuracy. The presented study demonstrates the use of the urban SIS as input to local Hydrological and Hydraulic models and local assessments.

New methodology of downscaled precipitation data is together with high resolution land use data used as inputs to hydraulic modelling of urban flooding using the software in the MIKE package. The project comprises quantifications and evaluation of the consequences of a dynamic rainstorm moving over Stockholm, for present conditions as well as for a scenario in a future climate (a 5-year period around year 2050). The novelty lies in that the precipitation input is variable in space as well as time, which mimics the real dynamics of the intense rainfall events that are expected to become more common in the near future. The demonstrated rainfall events comprise short duration, high intensity storms over limited areas. At these instances, urban drainage systems are generally overfilled, implying that a large proportion of the rainfall will be transported as surface flow.

Also, the modelling is made monthly varying averages of soil moisture, hence demonstrating the interdependency between surface runoff and runoff coefficients. The monthly averages for soil moisture has been derived using the S-HYPE hydrologic model in present, as well as in a future climate, providing a means to quantify how these properties may change over the coming century and to visualize the consequences related to urban flooding that may be associated with this temporal change.

The study is performed in parallel for two case studies in Stockholm, Sweden as well as Bologna, Italy, which facilitates the comparison of urban flooding scenarios using downscaled, high-resolution precipitation data at two hydrologically and hydraulically different cities.

#### **5. Interactive session using game-based tools**

Karianne de Bruin, Wageningen UR & CICERO and Thordis Thorarinsdottir, Norwegian Computing Center

## 6.14 Defining a Blueprint for Climate Adaptation Enabling Services - Learning from a Variety of Approaches in the UK and Ireland

*Barry O'Dwyer, University College Cork*

### Participation and co-production

#### Governance

1. World Café session featuring 5 tables:
  1. THE SECTORAL APPROACH - England – Climate Ready programme (Liz Parkes, Environment Agency, England)
  2. THE WEB BASED APPROACH - Ireland – Climate Adaptation Platforms in Practice (Barry O'Dwyer, University College Cork)
  3. THE REGIONAL APPROACH - Northern Ireland - The Climate Northern Ireland Programme (Jane McCullough, Climate Northern Ireland)
  4. THE PEER-TO-PEER APPROACH - Scotland – Adaptation Scotland programme (Anna Beswick, Sniffer)
  5. THE LOCAL APPROACH - Wales – Building Local Confidence (Jim Poole, Natural Resources Wales)
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**Keywords:** Climate change, adaptation support, challenges, partnerships, boundary organisation, decision making, local, sector

Changing climatic conditions have the potential to impact every aspect of social and biophysical systems and the global effects are already well documented. In response, policymakers at all scales are introducing a range of adaptation policies and initiatives to help societies and economies to cope with ongoing and projected changes. Despite this adaptation planning remains at an early stage in many countries with progress being reported primarily for freshwater management, flood risk management and agriculture.

Effective adaptation responses at scale are frequently supported by a suite of organisations and partnerships involved in data generation, interpretation, scientific research, the design and evaluation of policy instruments, the provision of climate adaptation services and advice to different communities and stakeholder groups. Mechanisms employed to support adaptation decision-making adopt a wide variety of approaches and are at differing stages of development and with no underlying 'best practice' yet identified. This session will explore and help define 'best practice' and a design plan for such organisations by considering and analysing the range of methods used by such organisations to facilitate identifying ongoing and potential climate impacts and developing strategies to offset adverse impacts and take advantage of opportunities that climate change might bring.

Using the shared expertise of a range of support services in the UK and Ireland and those of participants, this session will define the key elements of good practice in adaptation support service and create a design plan or blueprint for effective support services. Via a series of case studies and with a view to informing others' action, this session will explore the range of approaches and mechanisms of adaptation support deployed in the UK and Ireland, the lessons learned and the challenges faced within their policy setting.

Key learning outcomes for participants:

- Explore a variety of organisations and partnerships in place to support adaptation;
- Illustrate success stories and successful mechanisms with case studies;
- Understand the challenges overcome to support adaptation and what was successful, both within the country/region and also within different sectors;
- Define the key elements, blueprint of a great adaptation support service.

## **Significance to adaptation practice, policy and/or business**

The development of approaches and mechanisms to support adaptation is dependent upon understanding key levers, drivers and challenges. By better understanding these, more focused and useful tools and advice can be developed and communicated by those working to support adaptation. By highlighting and unpacking good practice at the forefront of adaptation planning support, the session aims to foster collaboration and peer-to-peer learning in order to facilitate the identification of practical solutions and tools at scale.

### **1. The Sectoral Approach - England – Climate Ready programme**

Liz Parkes, Environment Agency – England

Research by the English Climate Ready Support Service showed that there was a significant diversity in users and their needs, and there was a requirement for a tailored approach to adaptation information, framed around different sectors. Existing tools and resources were too complex and inaccessible for a mainstream audience and barriers such as a lack of opportunities to share information on best practice between stakeholders makes adaptation action challenging. The Climate Ready Support Service aimed to overcome these barriers in a tailored way, focusing on different diverse sectors to provide the best support service.

We will explore the adaptation needs of different sectors side by side and how the support service effectively enabled and intervened to date in England for others to learn from or add to. This will include supporting a range of sectors: agriculture, infrastructure, business and the built environment and draw out what and how effective support can be provided to these sectors in the future.

We will also demonstrate some of the key tools and support that the Climate Ready Support Service developed and provided 2012-16 and their diversity of mechanisms, accessibility and language to support differing stakeholder needs. For example, how do you manage a large number of stakeholders such as those found in agriculture? Or facilitate the collaboration of a diverse range of infrastructure operators? How do you deliver highly detailed climate impacts information to support adaptation decision making in an accessible way? The session will draw out the mechanisms and techniques used by climate ready to engage different sectors, and what we can learn and transfer to other applications.

### **2. The Web Based Approach - Ireland – Climate Adaptation Platforms in Practice**

Barry O'Dwyer, University College Cork, Ireland

As adaptation policy progresses, it is important that decision makers have access to relevant and high quality information that can be used to support development and implementation of adaptation. Web-based climate change adaptation platforms are considered an effective means of servicing this requirement by collecting, assimilating and communicating relevant evidence, experience and knowledge to stakeholders including policymakers, practitioners and the general public. Currently, the number of existing or planned national and transnational platforms is growing with 14 national adaptation platforms established in EEA member countries to date. Of the 14 in place, 7 are directly linked to the implementation of a National Adaptation Strategy or Action.

In Ireland, the Climate Action and Low Carbon Development Act (2015) puts the development of National Adaptation Frameworks (NAF), sectoral and local adaptation plans on a statutory basis. The EPA-funded project 'A Climate Information Platform for Ireland' (ICIP) has been developed in tandem with the development of adaptation policy in Ireland. ICIP has adopted a phased approach to development. The first phase of development assessed available information and developed a prototype climate information platform for Ireland. The second phase of development further developed this prototype with a specific focus on supporting decision-making for climate adaptation at the local level while the third and current phase development extends this support to sectoral decision-making.

Drawing on experiences of supporting adaptation planning in Ireland through the development of ICIP, this presentation will outline the potential role of Climate Information Platforms in supporting adaptation decision-making at the local level in Ireland, highlighting the lessons learned through such an approach.

### **3. The Regional Approach - Northern Ireland - The Climate Northern Ireland Programme**

Jane McCullough, Climate Northern Ireland, Northern Ireland Environment Link

Due to the interdisciplinary nature of climate change adaptation, partnership working between government, industry, academia and voluntary sector organisations is necessary to provide a cohesive action. The Climate Northern Ireland Programme works to support climate change adaptation through a regional partnership approach, incorporating use of local expertise and resources to raise awareness, promote action and support policy development.

The Northern Ireland Assembly is required by legislation to publish a regional climate change adaptation plan every five years. The current plan calls for action from central government, however departments recognise that an adapted region cannot be delivered by government alone. The Climate Northern Ireland programme is funded by government to facilitate engagement with non-government stakeholders and to stimulate wider climate change adaptation.

Developing a regional partnership approach can be challenging, but it enables access to, and co-ordination of, essential local and specialist knowledge when considering the unique vulnerabilities of a region. Involving stakeholders throughout the adaptation journey also encourages buy-in to adaptation planning and implementation.

This presentation will share experiences from the development of a regional partnership structure which aims to support sectoral and interdisciplinary knowledge exchange, planning, and action on climate change adaptation. It will explore the challenges faced in developing and maintaining the network and the various ways in which this structure has been used including provision of evidence for the UK Climate Change Risk Assessment

(CCRA), identification of sectoral planning and capacity building needs and use of a collective cross-sector voice to encourage embedding of adaptation in government policy and legislation. The presentation will focus on lessons learned and will reflect on successes and limitations of the regional partnership structure.

### **4. The Peer-To-Peer Approach - Scotland – Adaptation Scotland programme**

Anna Beswick, Adaptation Scotland, SNIFFER

Scotland has legally binding climate change legislation that requires public sector organisations to support delivery of the Scottish Government's statutory Scottish Climate Change Adaptation Programme (SCCAP).

The Adaptation Scotland programme is successfully building the capacity of organisations, businesses and communities to deliver the aims and objectives of the SCCAP in line with local needs and priorities.

This presentation will share experiences of bridging the gap between national and local policy and decision making and will provide examples of how adaptive capacity is being developed through Adaptation Scotland's peer to peer Adaptation Learning Exchange (ALE).

The session will focus on the benefits of going beyond tools and resources. It will provide an overview of the ALE process and look at the opportunities and challenges involved with bringing policy makers and practitioners together through capacity building programmes. It will include practical examples of progress made by participating organisations and reflect on the local and national benefits of this approach.

## 5. The Local Approach - Wales – Building Local Confidence

Jim Poole, Natural Resources Wales

The way we manage climate change in Wales is to a largely determined by two new pieces of legislation that complement the UK Climate Change Act 2008. The Environment (Wales) Act 2016 supports the sustainable management of Wales' natural resources and is key to tackling climate change as well as enhancing our environment and enabling green growth. The Wellbeing of Future Generations (Wales) Act 2015 is focused on improving the social, economic, environmental and cultural well-being of Wales. To make sure we are all working towards the same vision, the latter Act puts in place seven well-being goals, which describe the kind of Wales we want to see, and a suite of indicators to measure progress.

A key provision of the Wellbeing of Future Generations (Wales) Act is the establishment of public services boards (PSBs) reflecting local authority boundaries in Wales, made up of key public bodies, who will work collectively to improve the well-being of their areas. As a Wales-wide body, Natural Resources Wales (NRW) sits on every PSB. Each PSB must carry out assessments of local economic, social, environmental and cultural well-being in their areas. In doing so, they must consider the most recent UK Climate Change Risk Assessment (CCRA) prepared under the Climate Change Act 2008. Each PSB must then prepare and publish a plan setting out its objectives and the steps it will take to meet them. When producing their assessments and plans, PSBs must consult widely. We need, therefore, to explain climate change in straightforward terms, which recognise explicitly the local context. Furthermore, the adaptation actions that we take must be clearly visible in practical terms; they must tie in with other local priorities – and not fight against them.

This session will describe how, working with other strategic partners, NRW is providing a bridge between the national CCRA and local adaptation planning. The value of the CCRA is that it represents a rigorous, peer-reviewed assessment of climate risks. The strength of the PSBs is that, collectively, their members have a thorough understanding of the local context. Bringing the two together should, therefore, lead to sound adaptation planning, which is likely to work in practice. Key to achieving this will be persuading the PSBs that they have all the information and tools they need to address climate change with **confidence**. This session will explore the various techniques we have adopted to build this local confidence. In short, the aim will be to develop **generic** advice on how to build adaptation in any **particular** place.

## 6. The Science-Policy Approach – UK Climate Projections and impacts data

Megan Gawith, Climate Change Scientist, Environment Agency

In our experience from supporting projections services (CP09), many decision-makers find information on the impacts of climate change more meaningful and relevant than pure climate change information. We want to engage users in identifying relevant impacts information derived from the forthcoming UKCP18 climate change projections. Based on existing climate information experiences this session will look at what products have worked well for users previously including CP09, how future impacts information could be presented and what mechanisms could be used to produce impacts information via CP18.

UKCP18 is a major Met Office led project to develop the next set of climate change projections for the UK, building on previous information from UKCP09. Due for release in March 2018, the UKCP18 projections will provide crucial information about how we can expect our climate to change over future decades.

The UKCP18 project recognises that many decision-makers also want climate change information translated into impacts information. This session will explore what impacts information users need to complement UKCP18 outputs and support successful adaptation.

There will be an opportunity to discuss these user requirements and the ideal mechanisms to support adaptation. The workshop will invite academics and practitioners to help shape new climate change impacts products, and determine how they might be developed.



## 7.3 Discussing coherence: from national adaptation planning to achieving global adaptation and sustainable development

*Manuela Di Mauro, UK Committee on Climate Change*

### Governance

### Climate justice

1. Assessing progress made in achieving the global goal on adaptation (Annett Moehner, UNFCCC)
  2. Loss and Damage from Climate Change. Concepts, Principles and Policy Options for UNFCCC's Warsaw International Mechanism (Swenja Surminski, London School of Economics)
  3. Implementing the Sendai Framework for Disaster Risk Reduction (Luca Rossi, UNISDR)
  4. UK-China collaboration to develop global and regional climate change risk indicators (Manuela Di Mauro, UK Committee on Climate Change)
  5. European-wide indicators on climate change impacts and vulnerabilities (André Jol, European Environment Agency)
  6. Measuring adaptation progress in OECD countries (Michael Mullan, OECD)
  7. Protecting health from climate change in Europe: WHO perspective (Vladimir Kendrovski, World Health Organization)
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**Keywords:** impacts, vulnerability, coherence, metrics, Sendai Framework, Paris Agreement, Sustainable Development Goals

The Paris Agreement (2015) adopted a long term adaptation goal of “enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal”. The UNFCCC has since initiated discussions with Member States on which metrics and methods should be applied to monitor the implementation of this goal, and whether these should be consistent within countries to achieve a “global stock take” of adaptation.

Achieving this goal is one of the main pillars of the UN Sustainable Development Goal (SDG) on “taking urgent action to combat climate change and its impacts”. The UN is committed under its Agenda 2030 to develop comprehensive indicators to assess progress toward the SDGs, including those adopted by the UN Member States ratifying the Sendai Framework for Disaster Risk Reduction 2015-2030. Such indicators focus on assessing the processes (e.g. existence of policies) and outcomes (e.g. reduction of disaster losses) that contribute to sustainable development.

At national level, countries have been carrying out national assessments of climate change impacts, vulnerability, risk and adaptation, setting up country-specific monitoring and evaluation (M&E) frameworks to assess the implementation of National Adaptation Plans. These assessments use different metrics and methods according to each country's specificity and needs. For example, some M&E frameworks focus on assessing processes, or on adaptation outcomes or on both, and it is recognized that adopting a one-size-fits-all approach is not appropriate (e.g. GIZ, 2015).

However, some of these national adaptation M&E metrics cover common areas, including for example emergency management, spatial planning, governance, knowledge and capacity. These areas are also covered by the Sendai indicators.

This session will look at these metrics and indicators from a global perspective, aiming to discuss around these questions:

- What is the level of consistency needed between the indicators supporting the Sendai Framework and the national adaptation planning metrics?
- How could these indicators and metrics be used to feed into the global adaptation stock take, to monitor the implementation of the Paris Agreement?
- Is it necessary or important to achieve global coherence?

This session will consist in a series of short (7 minutes) presentations from the panellists, followed by panel discussion around the above questions (35 minutes), a Q&A (30 minutes) and a final round of conclusive remarks from the panel (5 minutes).

### **Significance to adaptation practice, policy and/or business**

This session will be of interest of any practitioner, policy maker and academic audience interested in global adaptation. It would be particular relevant for national policy makers and practitioners reporting on national adaptation planning, providing National Communications to UNFCCC and on progress against the Sendai Framework.

### **1. Assessing progress made in achieving the global goal on adaptation**

Annett Moehner, United Nations Framework Convention on Climate Change (UNFCCC) secretariat

The UNFCCC secretariat supports the intergovernmental process on climate change as well as countries in the implementation of the Convention, its Kyoto Protocol and most recently the Paris Agreement, which for the first time established a global goal on adaptation. The panellist will provide an overview of countries' deliberations on ways to assess progress towards the goal and on reviewing the adequacy and effectiveness of adaptation, including related metrics and indicators as well as recent efforts of enhancing the integration of adaptation with the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction.

### **2. Loss and Damage from Climate Change. Concepts, Principles and Policy Options for UNFCCC's Warsaw International Mechanism**

Dr. Swenja Surminski, London School of Economics

This presentation shares the results of a comprehensive stocktaking exercise highlighting the state of the art of research, political debate and policy options that have evolved around the UNFCCC's Loss and Damage from climate change and the debate on risks "beyond adaptation." The presentation is facilitated by the Loss & Damage Network, which was founded in 2015 by researchers at IIASA, Deltares and the Grantham Research Institute, bringing together academic experts, policymakers and practitioners in a trans-disciplinary science informed forum. In 2013, the Warsaw Loss and Damage Mechanism (WIM) has been set up by climate negotiators at COP 19 for "dealing with climate-related effects, including residual impacts after adaptation." Until today, the discourse about L&D has focused on two broad aspects: the framing of L&D in the wider context of climate change adaptation and disaster risk reduction and the identification of technical challenges for assessing and addressing L&D, including questions of implementation. While endorsed by the Paris Agreement the exact focus and form of this mechanism is largely unclear. Some see it as a compensation mechanism while others consider it as an extension of ongoing activities on climate adaptation and disaster risk management. The presentation will highlight multiple perspectives on Loss and Damage, with a particular focus on climate extremes and climate risk management, and the ethical and normative issues central to the discourse. It will build on from a dedicated Loss and Damage session at the ECCA 2013 in Hamburg, of which the resulting synthesis paper can be found here: <http://www.lse.ac.uk/CATS/Events/EventsDocs/ECCA-Synthesis-paper-Loss-and-Damage-final.pdf>.

### **3. Implementing the Sendai Framework for Disaster Risk Reduction**

Luca Rossi, United Nations Office for Disaster Risk Reduction (UNISDR)

The United Nations Office for Disaster Risk Reduction (UNISDR) is the focal point in the United Nations system for the coordination of disaster reduction. One of the roles of UNISDR is to support the implementation, follow-up and review of the Sendai Framework for Disaster Risk Reduction 2015-2030. The panellist will discuss the work that UNISDR, in consultation with Member States, is currently carrying out to develop indicators and guidelines to assess national and global progress against the Sendai Framework, and to develop national disaster risk reduction strategies. The Sendai Framework specifically recognizes the opportunity to enhance coherence across policies, institutions, goals, indicators and measurement systems for implementation and seeks to ensure credible links, as appropriate, between these processes.

### **4. UK-China collaboration to develop global and regional climate change risk indicators**

Manuela Di Mauro, UK Committee on Climate Change

The China National Expert Committee on Climate Change and the UK Committee on Climate Change are collaborating on a project to promote collaboration, communication and coherence in understanding and collating climate change risk information. One of the aims of this project is to investigate the potential for developing global indicators of exposures to current and future climate 'high end' risks. This project has also assessed the feasibility to identify indicators of 'systemic risks'. These risks are those arising when climate impacts on food supplies, water resources, critical infrastructure, or commercial activity, are amplified and cascaded, particularly within fragile economic, social and political systems. The panellist (person TBC) will share the preliminary findings from this project, particularly focusing on barriers and possible solutions to identify global indicators.

### **5. European-wide indicators on climate change impacts and vulnerabilities**

André Jol, European Environment Agency (EEA)

The European Environment Agency supports and informs policy development and implementation in the area of mitigation and adaptation to climate change by means of data, indicators and assessments in the EEA member countries. EEA has published various assessments on climate change impacts, vulnerability and adaptation actions in Europe, in close collaboration with member countries, researchers and other organisations. The panellist will provide examples and experiences on monitoring and evaluation of national adaptation policies across Europe, as well as European-wide indicators on climate change impacts and vulnerabilities on ecosystems, society and human health.

### **6. Measuring adaptation progress in OECD countries**

Michael Mullan, Organisation for Economic Co-operation and Development (OECD)

The OECD supports countries' efforts to prepare for the effects of a changing climate by providing impartial analysis, policy advice and supporting the sharing of experiences between the public and private sectors. To help countries in developing effective adaptation policies, the Organisation has carried out extensive analyses of adaptation planning, policies and practice around the world. The panellist will share lessons learnt from different countries with regard to measuring adaptation progress, and discuss reporting requirements that would be needed to achieve a global adaptation stock take.

### **7. Protecting health from climate change in Europe: WHO perspective**

Prof Vladimir Kendrovski, World Health Organization, European Center for Environment And Health

Climate has a serious adverse impact on health, as well as on future economic prosperity, political stability and societal productivity. A World Health Organization (WHO) assessment concluded that climate change is expected

to cause over 250 000 additional deaths per year between 2030 and 2050. European populations will not be spared – climate change and its impact recognize no borders. Twenty-four of fifty-three Member States of the WHO European Region have included health in national adaptation strategies or plans. In addition, eight Member States of the Region developed health-specific national or subnational adaptation plans. Significant further support is needed to strengthen health in national adaptation plan development, the promotion of whole of government approval and the evaluation of the effectiveness of those strategies or action plans over time. Evidence suggests that there is a very high benefit-to-cost ratio for health adaptation, with higher benefits being achieved with early action on adaptation. The WHO European Environment and Health Process provides an ideal platform to further advocate for adaptation action as well as monitoring developments and sharing lessons learnt. The Paris agreement provides a critical opportunity to advance public health as a central element not only of the response to climate change, but of the overall 2030 Agenda for Sustainable Development.

### 2.2 Data and information tools for adaptation planning

*Christopher Reyer, Potsdam Institute for Climate Impact Research*

#### Climate services

1. How well can we model climate change adaptation? (Calum Brown, University of Edinburgh)
  2. Impact sensitivity to climate and socio-economic change across sectors and European regions using the impact response surface approach (Stefan Fronzek, SYKE)
  3. Using downscaled SSPs and RCPs to improve the resilience of regionally fragile ecosystems - the case of the Baltic Sea (Kari Hyytiäinen, BalticAPP project)
  4. From global climate science to local resilience strategy: Identifying evidence-based urban interventions to address climate risks (Andy Mace, Arup)
  5. How resilient are forest management plans under climate and societal change? (Michal Petr, Forest Research)
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**Keywords:** Models for adaptation, uncertainty, scenarios, robust decision making

The last decade has seen incredible advances in climate change science. Climate data, including wide ranges of future scenarios, which were only available to a small circle of highly-experienced climate researchers, are now accessible to the wider climate vulnerability, impacts and adaptation community. The available climate data is increasingly being combined with biophysical model simulations and socio-economic data in transdisciplinary research approaches to better plan adaptation. This session presents a wide range of approaches and projects that provide innovative methods, indicators and tools to assess and plan climate change vulnerability, impacts and adaptation in different systems.

#### Significance to adaptation practice, policy and/or business

This session provides examples how recently developed methods, indicators and tools can be used to better understand vulnerability and climate change impacts in order to plan adaptation.

#### 1. How well can we model climate change adaptation?

Calum Brown, University of Edinburgh

Adaptation to climate change is a complex problem that depends upon perceptions and realities of climate impacts, adaptation options and capacities. Modelling can play a crucial role in understanding the processes and outcomes of adaptation, and in projecting these into future climatic and socio-economic scenarios. However, in order for models to accurately represent adaptation, they need to account for a wide range of interacting factors in human and natural systems, including the ways in which individual, social, institutional and governmental behaviours affect decision-making. Models that neglect these factors can easily mislead about future climate impacts and responses, and do not allow for evaluation of the consequences of future change for human activities and the natural environment. However, despite the importance of models of adaptation, their current capabilities have rarely been reviewed, leading to uncertainty about how and to what extent they can be improved.

As part of the IMPRESSIONS project, we review existing models of adaptation to climate change in land-based and water sectors in order to assess the current state-of-the-art in model design, coverage and usage. We include climate change impact, adaptation and vulnerability (CCIAV) models and behavioural models (e.g. agent-based models), and identify the coherence of their approaches to modelling adaptation individually and in combination. We do so partly on the basis of a typology of adaptation characteristics, informed through a literature review,

including a number of dimensions such as intent or purpose, timescale, spatial scale, beneficiaries and providers, type of action, and sector.

We find that many characteristics of adaptation are currently under-represented or entirely absent from models of adaptation, with most models adopting a simplistic, top-down approach that fails to account for ineffective or inappropriate adaptation, human decision-making, triggers that motivate actions or the time-lags and constraints that may limit uptake and effectiveness. Even behavioural models tend to assume economic rationality, and treat adaptation as a response to economic, rather than climatic, drivers. Behaviours such as diffusion, interaction, anticipation and learning remain under-represented. Furthermore, the majority of models are strongly sectoral in nature, precluding consideration of the strong and important interactions that occur within socio-ecological systems under climate change. We use these findings to identify a number of constraints on the ability of models to represent adaptation, but conclude that current practice lags well behind its potential, and suggest a number of specific priorities for improvement.

## **2. Impact sensitivity to climate and socio-economic change across sectors and European regions using the impact response surface approach**

Stefan Fronzek, SYKE

Responses to future changes in climatic and socio-economic conditions can differ substantially between sectors and regions. A rich body of studies on climate change impacts, adaptation and vulnerability (CCIAV) quantifies these sensitivities for selected scenarios in sectoral and in some cases also cross-sectoral studies. However, the differential sensitivities to climate and socio-economic changes across sectors or regions are poorly studied and a concise overview is lacking. We use a synthetic approach, impact response surfaces (IRSs) with a number of CCIAV models that illustrate a range of sectors, to address the question: What sectors and regions in Europe are most sensitive to future climate and socio-economic change?

A suite of nine global and regional CCIAV models has been employed to simulate the impacts of climate change on selected sectors (health, agriculture, biodiversity, forestry, hydrology and coastal flooding) in Europe. A sensitivity analysis was conducted for these models to assess changes in key climate and socio-economic variables such that two variables were modified at a time. The changes also included those implied by high-end scenarios that may lie outside the conventional application of many models. The variables modified were temperature and precipitation, sea-level rise, population, GDP, technological change and land use. Impact results were aggregated to eight European sub-regions and plotted as IRSs that depict the simulated behaviour of an impact variable in response to changes in two key explanatory variables. These can be overlaid with climate and population projections, thus allowing a quantified risk assessment.

Results clearly indicate substantial increases or decreases for different parts of each IRS. A key benefit of the IRS approach is its systematic way of analysing the sensitivities of modelled impacts. It also provides an opportunity to test model performance across a wide range of conditions, including those found at the high-end of projected changes. Examples are shown for estimating impact risks by combining the IRSs with probabilistic climate change and population projections.

## **3. Using downscaled SSPs and RCPs to improve the resilience of regionally fragile ecosystems - the case of the Baltic Sea**

Kari Hyytiäinen, BalticAPP project

The Baltic Sea is an ecologically vulnerable aquatic ecosystem that is greatly influenced by human activities and the climatic system: i) diffuse and point nutrient loads from agriculture, industry and waste water treatment plants have particularly over the past 60 years caused strong eutrophication and large areas of dead sea bottoms in the Baltic Sea, threatening a range of important ecosystem services; and ii) perhaps increasing runoff

integrated over the entire Baltic Sea catchment area in future climate, which in turn accelerates nutrient loads to the sea, while the resilience of the marine ecosystem is weakened due to higher surface water temperatures.

Actions that improve the resilience of regionally important and fragile ecosystems, such as the Baltic Sea, serve as one adaptation strategy to reduce the overall damages of global climate change. Global climate futures, i.e. Representative concentration pathways (RCPs) and socioeconomic futures, i.e. Shared socioeconomic pathways (SSPs) were initially developed to address global challenges to mitigate and adapt to climate change. These can also be directly applied as tools when analyzing solutions to regional environmental problems under different scenarios of future climatic and socio-economic futures.

We present a collaborative and interdisciplinary effort to translate global climate and socioeconomic futures into regional drivers and pressures that drive pollution in the Baltic Sea. We propose sectoral narratives of the sustainability pathway (SSP1), the Middle of the Road (SSP2), Regional Rivalry (SSP3) and Fossil Fueled Development (SSP5) along with quantifications of the drivers impacting nutrient loads and the different levels of pressures in terms of total nitrogen and phosphorous loading up to 2100. We combine the SSP/RCP matrix structure with the analytical frame of DPSIR (Drivers, Pressures, State, Impacts and Responses).

Results indicate a plausible range of different adaptation responses needed under the different SSPs in order to ensure a good environmental status of the Baltic Sea, with and without climate change, up to 2100. The approach exemplifies the potential for applying scenario analysis stemming from climate research to regional environmental challenges, which are impacted by climate change.

#### **4. From global climate science to local resilience strategy: Identifying evidence-based urban interventions to address climate risks**

Andy Mace, Ove Arup and Partners Ltd.

The scientific evidence and projections about climate change are typically available at the global, regional or – at best – national level. Meanwhile, climate hazards are experienced at the local level and this is the scale at which action is required. Cities and local governments need to downscale the data and analyse it in the local context to identify their local risks and adaptation priorities, such that practical and effective interventions can be made for future resilience.

This presentation will demonstrate how scientific information about climate hazards and climate change trends can be analysed together with spatial and socio-economic data from cities, to highlight local risks and signpost interventions required at the policy, strategy and programme/project levels.

The session will be structured per the best practice framework for climate change adaptation planning defined by the Climate Risk Assessment Framework and Taxonomy (CRAFT) developed by Arup, C40 Cities Climate Leadership Group and Bloomberg Philanthropies. CRAFT proposes a six-step climate adaptation process, which includes vulnerability assessment, stakeholder engagement, adaptation planning, implementation and monitoring. Starting with the vulnerability assessment, we will present evidence from Arup's work on heat risk in London and flood risk in Glasgow, for which we have used currently available climate and socio-economic data combined with future climate projections to assess the exposure and vulnerability of people and infrastructure. Data has been aggregated from global, national, city and neighbourhood sources to provide insight into potential local impacts. We have engaged with local authorities and other institutions to ensure that these insights are appropriate to inform decision-making.

As participants in 100 Resilient Cities, pioneered by The Rockefeller Foundation (100RC), Arup is engaging with local authorities and stakeholders in both London and Glasgow to undertake a comprehensive process of resilience planning, implementation and monitoring. Climate change is a critical challenge for both cities, and our scientific analyses feed directly into identifying appropriate local design, planning and policy responses. The

presentation will provide examples of how we have transitioned from scientific information to practical urban interventions.

We will be joined in the session by representatives from the Resilient Glasgow team, to provide a city government perspective to complement Arup's expertise in the scientific, spatial, design and engineering aspects of climate change.

## **5. How resilient are forest management plans under climate and societal change?**

Michal Petr, Forest Research

To make robust climate change adaptation decisions in forest planning and to support policy development, decision makers need relevant information and approaches to evaluate forest plans with their objectives. In the context of forest adaptation and policy, we do not know how information from impact models affect decisions related to forest objectives under deep uncertainty. This uncertainty relates, among others, to climate change, social as well policy development. Still, we are missing approaches to effectively co-develop with and communicate adaptation options to forest planners while addressing and capturing inherent uncertainty. Therefore, we used action expiration charts combining climate change impacts on forest ecosystem services (ES) with forest objectives to support robust forest planning.

To incorporate and address climate change uncertainty in forest plans, we used the action expiration chart in the case study of Rogate forest in England. This chart has been previously used in Scottish forestry to help evaluate the future feasibility of forest objectives and policy needs. We used simulation data from the climate change impacts on a range of forest ecosystem services to assess the viability and urgency of forestry management objectives and to highlight adaptation options. The main objective for forest plan in Rogate forest is to transform managed non-native woodland to native or woodland pasture while maintaining key ecosystem services, such as tree growth and recreation value, and to better and clearly communicate these outputs to stakeholders. We also consulted with forest planners what are the potential limits to forest management actions, such as managing for biodiversity, and related amount of ecosystem services. The final created action expiration chart shows when forest objectives can reach their limits due to climate change impacts on ES, when foresters define their own limits to forest management actions, and also how much time is available for transformation to native woodland. In addition, it is a communication method synthesising the current evidence about climate change impacts.



## 2.9 Pathways to climate-ready infrastructure: progress and challenges

*Erika Palin, Met Office and Mike Keil, Consumer Council for Water*

Urban, energy & infrastructure

### Pathways and transformation

1. Climate-resilient infrastructure: Getting policies right (Michael Mullan, OECD)
  2. Effective knowledge exchange to support adaptation action (Roger Street, UKCIP)
  3. Research on quantification and managing risks to ageing rail networks (Irina Stipanovic, Infra Plan Consulting, Croatia and Kenneth Gavin, Technical University of Delft)
  4. Sharing lessons and enabling action – identifying how to move from understanding your climate risk to embedding it in decision making (Amanda Crossfield, Yorkshire Water and Lisa Constable, Network Rail)
  5. Current progress in understanding adaptation in transport sector (Andrew Quinn, University of Birmingham)
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**Keywords:** Adaptive capacity, utilities, transport, enablers, infrastructure, barriers, collaboration, knowledge exchange

Adaptation is already taking place across all infrastructure sectors. In this session we consider the key enablers that help facilitate effective adaptation action. We look at the “line of sight” between pure academic work and practical projects on the ground.

Adaptation challenges for the infrastructure sector include:

- The numerous actors in the sector (owners, operators, users...);
- Comparatively long asset lifetimes that may be at odds with strategic planning cycles;
- Making cost-effective adaptation decisions in the face of uncertainties in climate change and demographics.

In this session we show:

- Good policy can set the right direction;
- Infrastructure organisations can learn from their peers in other countries and in different sectors;
- The importance of a strong evidence base to support business cases.

The session will bring together academics, stakeholders and policymakers to present examples of recent research and explore ways to support collaborative activities across the European infrastructure sector.

This session also highlights how involvement from many different sectors and disciplines are necessary to deliver action on the ground. We also show that for more adaptation action to take place practitioners, policy makers and academics need to think more broadly.

### Significance to adaptation practice, policy and/or business

This session will be valuable to all the different disciplines involved in climate change adaptation, including scientists, practitioners and policy-makers. The session considers the steps from the underpinning science to delivery on the ground in order to highlight the key enablers that facilitate adaptation.

### 1. Climate-resilient infrastructure: Getting policies right

Michael Mullan, OECD

The (upcoming) OECD paper presents four main ways in which OECD countries are supporting the resilience of their national infrastructure, through information provision, exemplary investment practices, regulation and

standards, or by encouraging the disclosure of climate risks. The main findings from each of these categories are presented below.

The majority of OECD countries have published analyses of the risks faced by their energy, transport and water infrastructure, albeit predominantly qualitative. Some provide finer resolution climate projections and dedicated tools to support climate risk assessment for infrastructure developers and local authorities. Providing evidence for decision making also requires investing in capacity-building and several governments have implemented programmes and created fora to exchange best practices targeting both local authorities' spatial planners and private sector operators.

Countries are increasingly referring to the need for climate resilience in their national infrastructure planning documents. However, there is currently little evidence that climate risks are being explicitly considered in infrastructure projects financed or commissioned by governments or infrastructure banks. Experience of climate risk screening and infrastructure adaptation is much more documented by national and multilateral development providers and, to a lesser extent, in some multilateral financial institutions investing in OECD countries. Climate adaptation is not considered as a criterion in public procurement, but a better knowledge of climate risks may change the current risk sharing practices in public-private partnership.

Public policy and regulation offer many levers to support the private sector to integrate climate resilience in infrastructure planning and management. Climate resilience has been mainstreamed in some countries' policies such as spatial planning, mainly through the Environmental Impact Assessment, as well as technical and economic regulation which influence infrastructure. Over a third of OECD countries are revising one or more national technical standard(s) for infrastructure, and two major international organisations for standardisation have started reviewing their technical and management standards to account for climate change adaptation

There is increasing interest by governments and the financial sector in climate risk disclosure, but this is still at an earlier stage than reporting for mitigation. There are no commonly agreed methods of reporting climate risks. Several new voluntary initiatives are emerging from investors, as they increasingly recognise this information's relevance for their investment decisions. There is scope for Governments to support privately-led information collection and sharing regarding climate change risks, with a particular focus on critical infrastructure.

## **2. Effective knowledge exchange to support adaptation action**

Roger Street, UK Climate Impacts Programme (UKCIP), School of Geography and the Environment, University of Oxford, South Parks Rd, Oxford OX1 3QY, UK.

Actions to adapt infrastructure to meet the challenge of future climate change need to be informed and guided by the latest science, systems understanding and research modelling capability. At the same time, providing relevant and useable scientific evidence to inform the decision-making process requires a sophisticated understanding of the complex issues that characterise existing policy and practice frameworks within which stakeholders must address adaptation.

Recognising the need to broker effective knowledge exchange between stakeholders and researchers, the UK Adaptation and Resilience in the Context of Change (ARCC) Network has been enhancing the capacity of researchers, policymakers and practitioners to work together to seek solutions to adaptation and resilience challenges, including within the infrastructure sector. By bringing together policy, practice and research communities, the ARCC network aims to facilitate the effective integration, communication and mobilisation of information to better inform decision-making processes, as well as to improve the quality and relevance of research.

This presentation will demonstrate approaches being used by the ARCC network to drive the effective development and exchange of knowledge to inform adaptation and resilience within the infrastructure sector,

and to help ensure the provision of useable scientific evidence to motivate adaptation action. Specific examples of recent activities will illustrate latest accomplishments and on-going challenges.

In particular, this presentation will focus on the joint initiative between the UK Environment Agency's Infrastructure Operators' Adaptation Forum (IOAF) and the ARCC Network. By working with the IOAF (representing infrastructure regulators, utility owners and operators), the ARCC network is seeking to add value through targeted science-policy/practice dialogues and themed knowledge exchange initiatives. Topics being covered include infrastructure dependencies & interdependencies with respect to operations and/or planning. Activities include developing guidance on good practice to support integration of interdependencies into risk assessments, and identifying and synthesising relevant information on the latest research and innovation outputs to inform resilience planning.

Reflecting on the experience of the ARCC network, we will demonstrate the benefits and characteristics of effective researcher-stakeholder relationships and argue that openness, flexibility and shared perspectives make for research outcomes that genuinely inform adaptation action.

### **3. Research on quantification and managing risks to ageing rail networks**

Irina Stipanovic, Infra Plan Consulting, Croatia & Kenneth Gavin, Technical University of Delft, Netherlands.

The European rail network is ageing and lack of investment has meant that many critical infrastructure elements (such as earthworks, tunnels, bridges etc.) are in poor condition. Whilst rail has continued to be one of the safest forms of surface transport, a number of high profile failures of rail infrastructure have occurred in recent years, with the incidence appearing to increase in response to climate challenges and aging networks amongst other factors. The issue has been addressed in a number of European projects include the Horizon 2020 project Destination Rail which aim of Destination RAIL is to provide solutions for a number of problems faced by EU infrastructure managers using novel techniques for identifying, analyzing and remediating critical rail infrastructure leading to a reduction in costs of up to 20% along with improved reliability of the asset leading to improved train performance. These solutions will be implemented using a decision support tool, which allows rail infrastructure managers to make rational investment choices, based on reliable data. At present Infrastructure Managers (IM's) make safety critical investment decisions based on poor data and an over-reliance on visual assessment due to a lack of current data on the state of the asset. The paper describes the key problems faced by infrastructure managers and using the example of earthworks, presents a risk based decision support tool. The reasons that these tools be based on probabilistic rather than deterministic methods are outlined. A number of mitigation measures will be presented that can reduce risk and the impact that these might have on the network operations is considered explicitly.

### **4. Sharing lessons and enabling action – identifying how to move from understanding your climate risk to embedding it in decision making**

Amanda Crossfield, Yorkshire Water and Lisa Constable, Network Rail

Infrastructure organisations tend to have long lived assets and expect their assets to deliver essential public services for many decades into the future. Recognising that climate change could impact their ability to deliver these essential services, many infrastructure operators have carried out a climate change risk assessment.

Embedding this risk information into decision making can however prove more challenging than it may first appear. Process and procedural barriers such as short payback periods or narrow cost benefit assessments, behavioural barriers such as unsupportive leadership, and external barriers such as a lack of clarity from regulators or a clear mandate from customers, can mean that organisations have assessed their climate risks, but are not yet fully accounting for these risks in their planning, operation or designs. This could mean that sub-optimal decisions are being made.

The question then is how can we overcome these barriers and embed risk understanding in decisions, and to what extent is this required for different infrastructure providers? The academic literature has identified various attributes of well adapted organisations, and provides a number of different frameworks for understanding how organisations evolve and learn. One such framework is the concept of adaptive capacity. Adaptive capacity illustrates how well embedded climate risk considerations are within decision making, and how mature an organisation is, or needs to be, in order to mitigate its climate risks.

Assessing adaptive capacity helps organisations identify and overcome barriers preventing climate risk from being mainstreamed into decision making, and highlight good practice which should be protected and/or accelerated. This assessment can be used to develop a structured and prioritised action plan for improving adaptive capacity, thus ensuring the continued delivery of essential services. In delivering these actions it becomes possible to continually update strategy and policy from delivery experience, and ensure good practices are identified and scaled across the organisation and its respective networks.

Consideration of this challenge at the UKs Infrastructure Operators Adaptation Forum led to the establishment of a working group to examine tools and resources for assessing adaptive capacity, with the aim of applying one of these to a cross section of infrastructure operators. This presentation will discuss the findings of the Capacity Diagnosis and Development (CaDD) assessment used to evaluate adaptive capacity across five organisations from the rail, water and power sectors, highlight common themes identified across the participants, and demonstrate the benefits of assessing adaptive capacity as a tool to progress actual adaptation on the ground.

## **5. Current progress in understanding adaptation in transport sector**

Andrew Quinn, University of Birmingham, UK

Extreme weather events have often caused major transport disruption due to flooding, land slips, heat waves and infrastructure failures, such as those on control and signalling systems caused by interdependencies with power and IT/communication systems. There have now been a number of national and European projects assessing the costs of this disruption, best practice in various sectors and approaches for adaptation. The EU FP7 MOWE-IT project collated operator experiences from across Europe to a variety of major weather events including wind storms, heavy rain and snowfall. These experiences also explored what actions were found to be effective in the preparation, short-term and recovery phases of disruptive events. A further project, 'Tomorrow's Railway and Climate Change Adaptation' (TRaCCA) supported by RSSB in the UK also conducted a survey of weather and climate adaptations currently proposed or in use with networks internationally. A common conclusion from these projects is that a systems engineering approach is vital for successful adaptation of transport networks. Although the technical 'magic bullet' is often imagined to be just over the horizon (geographical or temporal), successful adaptation to weather hazards often owes as much to operational procedures and maintenance or preparation as to technical advances.

Some of the conclusions arising from this work are that cross-sectorial and inter-agency approaches are increasingly necessary in order to achieve effective improvements in resilience of the overall transport system. For example, vulnerability of roads to precipitation driven events can prevent key staff reaching work, and therefore prevent rail operations, even though the railway is functional. Road networks may, inherently, have greater redundancy than rail but with this comes a very different approach to resilience and adaptation. Both have issues with ageing infrastructure of, in some cases, unknown design and construction specification. Therefore, given the multiplicity of potential climatic hazards, a strategy combining a number of different approaches is normally more effective at reducing risk than single 'solutions'. This includes redundancy/diversion options, technical methods of decreasing local vulnerability and improved response to enable rapid recovery. These approaches sometimes also demand improvements in detailed knowledge of individual component location and vulnerability. In planning for adaptation a 'what if' or 'scenario' approach can sometimes be valuable to identify solutions – e.g. designing a railway system, serving a major commuter city, to operate in 40°C would

highlight how this differs from the current situation. However, assessing such designs also requires an improved simulation of extreme weather events.

## 3.2 Climate Services for Business: adapting and building long term resilience to climate change by and for the private sector

*Karianne de Bruin, Wageningen UR & CICERO and Cosima Stahr, adelphi*

### Economics and business

#### Climate services

1. Introduction: Perspective on climate services for business - a network of actors (Karianne de Bruin, Wageningen UR & Asun St. Clair, DNV GL)
  2. Private sector adaptation and resilience (focus on SMEs), with an example case study on fishery in Morocco (Cosima Stahr, adelphi)
  3. Case study: Agrifood - The enabling environment for climate smart agrifood sector: the role of climate services (Ingrid Coninx, Wageningen Environmental Research)
  4. Case study: Evidence for co-benefits and collaboration in private sector adaptation: insights from Rwanda (Christian Kind, adelphi)
  5. Engaging with business for climate services: challenges and lessons learned (Marta Bruno Soares, University of Leeds)
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**Keywords:** Private sector, climate services, adaptation, climate risk, resilience, climate opportunities, co-benefits

To build global resilience to climate change and leadership to strengthen the global market for climate services, there is a need to recognize the complexity, diversity and multiplicity of user needs for climate services. The business community plays a pivotal role and has begun to use climate services to better understand climate risks, identify climate-resilient and climate-smart opportunities.

In this session we explore what creates an enabling environment that allows especially businesses to make use of the extensive information, tools and instruments which are (or could be made) available to inform and support management practices and decision-making.

How can climate services help to identify climate risks and opportunities, to support businesses' long term strategic planning and businesses models towards transformations to sustainability and low carbon societies? How can the private sector be an actor in adaptation? What are the effects of corporate adaptation measures on society? We conceptualize climate services as a network of actors that interact, influence and learn from each other in the production, translation and tailoring of climate information along with other types of information and emphasis the specific connection to adaptation.

The session highlights experience from the private/SME and research sector (both practical and scientific work), including on climate smart agriculture, fishery and coffee & tea, the interactions between climate services users and providers and the complexities of user engagement. The presentations are followed by a facilitated discussion with the audience, inviting the audience and presenters to discuss two propositions on climate services for business the potential of the private sector in shaping the future of adaptation introduced by the business and research convenors of this session.

#### Significance to adaptation practice, policy and/or business

The session is important for both policymakers, practice and business, highlighting experience from both research and private sector on moving beyond climate science to make science actionable for business. The session focuses on how businesses adapt to climate change while at the same time contributing to or, in the case of maladaptation, being detrimental to societal resilience, and what role climate services (can) play. Based on

experience in climate services and climate change adaptation, different perspectives are brought forward and discussed in the light of what role the private sector can play in building long term resilience.

### **1. Introduction perspective on climate services for business: a network of actors**

Karianne de Bruin, Wageningen Environmental Research (Alterra) & Asun St. Clair, DNV GL

This introduction will highlight the conceptualization of climate services for business as a network of actors that interact, influence and learn from each other in the production, translation and tailoring of climate information along with other types of information, and we provide a system thinking lens on existing and potential constraints and enablers for the use of climate services in value chains.

### **2. Private sector adaptation and resilience (focus on SMEs) , with an example case study on fishery in Morocco**

Cosima Stahr, adelphi

This presentation will shed light on SMEs as actors for adaptation. The presentation first focuses on the role of SME adaptation in creating resilient societies. The presentation then focuses on experiences from the practice. As part of the GIZ Project “Private Sector Adaptation to Climate Change” (PSACC, funded by BMZ), adelphi implements the Climate Expert Approach that identifies climate risks and opportunities and helps to develop company-specific adaptation strategies. In Morocco, PSACC worked with companies in the fishery sector and with an industrial zone.

### **3. The enabling environment for climate smart agrifood sector: the role of climate services**

Ingrid Coninx, Wageningen University and Research

This presentation will explore the main barriers that are hampering climate smart agriculture in the agrifood sector and will illustrate some climate services that develop the enabling policy environment in the Netherlands.

### **4. Evidence for co-benefits and collaboration in private sector adaptation: insights from Rwanda**

Christian Kind, adelphi

This short presentation will provide an overview on evidence for co-benefits and collaboration in private sector adaptation from Rwanda. Two types of cases will be presented: vertical collaboration along the value chain between one larger corporation and many smaller suppliers as well as horizontal collaboration between many smaller businesses that are located in the same area.

### **5. Engaging with business for climate services: challenges and lessons learned**

Marta Bruno Soares, University of Leeds

This presentation will focus and highlight the main challenges, trade-offs and lessons learned from our experience of engaging and collaborating with the business sector in the context of climate services development.

## 4.2 Emerging priorities and sensitive topics in adaptation

*Marco Grasso, UNIMIB*

### Climate justice

1. Barrier or Opportunity: Strategic Reframing of the Fragmented Linkage between Migration and Climate Change Adaptation (Jihyun Selena Lee, London School of Economics)
  2. Distributing responsibilities for climate adaptation: The ideal of resilient societies (Neelke Doorn, Technical University Delft)
  3. Adaptation by the least vulnerable - Managing climate risks in a Nordic welfare state (Karoliina Pilli-Sihvola, Finnish Meteorological Institute)
  4. Assessing the relevance of group size for community-based climate adaptation (Anke Wolff, Humboldt-Universität zu Berlin)
  5. Water, Identity and Nationalism in Great Britain (Emily Hines, ECI, University of Oxford)
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**Keywords:** Adaptation theory, reframing, resilience, responsibilities, risk management, discourses, collective action, vulnerability, justice

This session presents and discusses some of the most sensitive topics currently surrounding climate adaptation: justice, shared responsibilities, migration and justice. Simultaneously, these also constitute some of the most pressing policy and practice issues requiring proper responses from both research and decision-making communities involved in the climate change arena.

### Significance to adaptation practice, policy and/or business

The session is expected to provide a wide set of theoretical insights into the multiple elements that characterise and shape emerging priorities and some of the most sensitive topics of relevance for adaptation policy and practice.

#### 1. Barrier or Opportunity: Strategic Reframing of the Fragmented Linkage between Migration and Climate Change Adaptation

Jihyun Selena Lee, London School of Economics and Political Science

With the climate change expected to become one of the primary drivers of migration, climate change - migration nexus has gained an increasing currency among academics and policy makers. As the discourse on the linkage has evolved from a simple geo-deterministic framework to a nuanced comprehension of its multifarious complexities, 'migration as adaptation' – the idea of promoting migration as an adaptation came to light. While such transformative development of the linkage is desirable, migration as adaptation is locked in the phase of formation where the prolific ideas fails to move beyond the narrative. As many have attributed this stagnation to its fragmented development: a lack of common grounds for migration as adaptation, considerable investigations have been carried out. However, they are largely based on theoretical analysis and hardly attended by the multitude of engaged actors. Such disconnect between scholarship and practice not only further obfuscates the problem but also prohibits a thorough observation of the veiled fractures that abound among the different actors. For more critical analysis and advanced understanding of the fragmentation problem, the paper conducted a qualitative research that combines inductive content analysis and semi-structured interview.

Based on the content analysis that identified three major types of the fragmentation problem: migration as adaptation's conceptual framework, operational evaluation and strategic approach that varied depending on the involved actors operational position in adaptation (donor - recipient), profession (academic – practitioner), and expertise (climate change – migration), the paper drew a theoretical framework that categorizes four



predominant groups of fragmented migration as adaptation: Alarmist/Maximalist, Humanitarian, Security and Risk Management, and Sceptics/Minimalist. The subsequent comparative analysis of the findings from the content analysis and interviews verified the existence of measurable fragmentations largely in two-folds: 1) between theory and practice 2) amongst different actors in practice.

The paper concludes that while it is essential that the concerned fragmentations are understood, they need not be eliminated. In dealing with a subject that demonstrates such a high level of heterogeneous complexities by nature, enforced uniformity is not only practically infeasible but also undesirable. What migration as adaptation needs is a new perspective that unlocks the ingenuity of reframing barrier as an opportunity. Based on this insight, the paper argues for a strategic promotion of fragmented governance by demonstrating how this distinctive feature – effective mobilization of the most appropriate ad hoc response to heterogeneous climate migration scenarios - can facilitate an ascendancy of migration in adaptation policy dialogues.

## **2. Distributing responsibilities for climate adaptation: The ideal of resilient societies**

Neelke Doorn, Technical University Delft

In view of the many uncertainties involved, resilience has emerged as one of the leading paradigms for dealing with climate risks. Both in policy circles and in many of the national and European funding schemes, we see appeals to “resilient societies” and “resilient communities” as a way to deal with climate risks.

Resilience as applied to society involves a shift from the prevention of risks to mitigation of the consequences of risks. As such, it also implies a transfer of responsibilities. Safety from climate risks is no longer the sole responsibility of one actor (traditionally, the state), but it is distributed over different actors, including citizens. This transfer of responsibilities prompts important ethical questions. Under what conditions is it likely that people take the required actions? Research has shown that this question is inextricably linked to questions of justice and fairness (Doorn 2016).

First, the distribution of responsibility has an impact on how the risks and burdens are distributed. In flood risk management, for example, many governmental agencies rely on citizens taking out private insurance. This may increase inequality between those who can and those who cannot afford flood insurance. As such, fairness (in the allocation of responsibilities) has an impact on the distribution of risk levels (i.e. social justice).

Second, while admittedly the distribution of responsibility between the state and individual citizens depends partly on one’s view of the state, even in a minimal state view, the state has a responsibility to provide basic protection. Individuals can only be given a role if they have the capacity and resources to respond adequately. It is the state’s responsibility to ensure that these conditions are indeed met before it can transfer responsibility to individual citizens. Additionally, from a democratic point of view, individual citizens should be given a voice when deciding about the objectives of adaptation policy.

Third, even if one does not take into account the fairness of the responsibility ascription for ethical reasons, fairness may still be instrumental to adaptation policy. Empirical research has shown that the extent to which responsibility is actually taken up depends partly on whether people consider it fair that they are given a responsibility.

Drawing upon philosophical literature on responsibility and a review of the relevant literature, I will present a normative framework for evaluating responsibility distributions in adaptation policy.

## **3. Adaptation by the least vulnerable - Managing climate risks in a Nordic welfare state**

Karoliina Pilli-Sihvola, Finnish Meteorological Institute

Climate Change Adaptation (CCA) challenges are different between vulnerable and poor, and low-risk and wealthy countries, particularly with different climatological features. Yet, the framing to analyze the risks posed by climate

extremes and climate change is often the same, most notably the framework of hazard, exposure and vulnerability used by the Intergovernmental Panel on Climate Change (IPCC).

We present a holistic framework to understand CCA in a context of a country with high adaptive capacity and low vulnerability. The chosen case country is Finland, a relatively wealthy Nordic welfare state with low current and predicted climatological risks in global comparison. Based on the framework developed, we will analyze and discuss 1) whether CCA strategies and actions in the public and private sector in Finland are in line and optimal with the risks facing the country; 2) how the risks emphasized in planning processes compare to their estimated actual severity and scale; 3) if there is a chance that major risks are ignored since there might be a general perception that everything is in order; and 4) what strategies and actions there are to harness the potential benefits through CCA.

Our aim is to broaden the perspectives of the academics and practitioners involved in CCA and support in developing tools and approaches that can in practice guide successful adaptation strategy development and implementation. Our analysis is based on two projects: NORDRESS, a Nordic Centre of Excellence focusing on natural hazards and societal resilience and ELASTINEN, a Finnish national project on weather and climate risk management.

#### **4. Assessing the relevance of group size for community-based climate adaptation**

Anke Wolff, Humboldt-Universität zu Berlin

In Germany, self-governed cooperative organizations with compulsory membership – Water & Soil Associations (WSAs) – have a long tradition in water management, including flood protection. These organizations with varying sizes, gathering a community of actors with a common interest in the provision and maintenance of particular pieces of water infrastructure, do not always emerge voluntarily. The law prescribes that the state, acting in the “public interest”, can constitute them with an act of coercion.

Collective action theory establishes a relation between group size and the cooperative behaviour of individuals. Small groups are regarded to be more likely to take collective action, facing lower transaction costs and being driven by social incentives and pressure. On the other hand, larger groups can mobilize more resources and establish a “critical mass” in cases of jointly supplied collective goods. However, it is hypothesized that coercion is needed to provide collective goods to large groups.

In order to test the above empirically, we conduct an institutional analysis, and explore the emergence of WSAs as well as the effect of group size on their ability to adapt to an increasing future flood risk. Data is collected through expert interviews at local and regional levels in different German Federal States, as well as document analysis.

Preliminary findings show that group size in flood-prone areas is difficult to define and of complex relevance. The size of WSAs ranges from a few to a several thousand of members, showing that coercion ensures the provision of collective goods to large groups. However, all associations mainly perform maintenance tasks and are dependent on state support for large-scale investments. Nevertheless, group size determines the financial strength of WSAs and their ability to repair and reinforce their dikes. Expansion efforts of smaller (inclusive) groups are hampered by legislative restrictions and methodological limitations in identifying potential beneficiaries/members. Also, smaller groups with lower exposure are less likely to receive public funding.

#### **5. Water, Identity and Nationalism in Great Britain**

Emily Lorra Hines, MSc Candidate Water Science, Policy and Management, University of Oxford

This paper seeks to identify the use of water in Scotland, England and Wales as a potential tool of nationalism through the transposition of the European Water Framework Directive 2003 into individual regulation. More

specifically, this essay hopes to analyse the use of water as a driver for independence amongst the Scottish Referendum of 2014, ongoing Welsh devolution since 2013, as well as its potential impact during the UK –EU referendum of 2016. Such evaluation is conducted through policy analysis of the WFD and each country's transposition into Water Law, as well as the individual country's Water Acts and interviews with leaders in the British water sector from academic, industrial and governmental backgrounds.

The European Water Framework Directive was enacted by the European Union in 2000 as a national policy for EU members to use to better address water quality issues via an international standard. The Directive calls for member states to reach 'good ecological status' as determined by the WFD by 2015, through the use of River Basin Management Plans (RBMP) as individually determined by each state. The Directive was implemented by Scotland, England and Wales in 2003 into national legislation, with Scotland being the first European Country to transpose the WFD. Each country has implemented the WFD differently, amidst contrasting water pricing, theoretical strategy, use of agents and public participation and awareness. More pressing, each country has implemented the WFD with different political motivations in drastically different political climates, which have only become more partisan in the years since Scottish and Welsh Devolution. Such differing political climates, specifically with an underlying threat and/or fear of nationalism, transposed the WFD into law in diverse manners across Great Britain.

Academic literature has analysed this implementation to a sufficient degree, regarding a large scale of detail (i.e. public participation, use of the River Basin Management Plans, payment schemes, use of Integrated Water Resource Management versus Catchment Basin Analysis), but has failed to provide a holistic view of the reasons behind implementation in each individual state and it's determinacy on success or failure of the WFD. Through the analysis of major historical water events in Wales and Scotland, as well as the recent history of devolution and separation between the three countries – only furthered and broadened by the current BREXIT vote – this paper finds that water is both a political tool for potential independence of Scotland and Wales, as well as a historically and culturally important tool for differentiating between the three counties. This paper will remark on the influence of each country due to their differing aquatic resources, including the related tourism and water supply as well as the collaborative issues regarding water scarcity and ownership throughout Great Britain. This paper will finally demonstrate the possibility for Scottish and Welsh independence from England based on water ownership, or lack thereof, and the likelihood of these events in the immediate years to come.

## 5.3 Learning from co-production of adaptation practice and climate services

*Saskia Werners, Wageningen UR*

### Governance

1. Increasing Resilience in Scotland's Forest Sector: Demonstrating Adaptation at Queen Elizabeth Forest Park (Kate Beauchamp, Forest Research)
  2. Co-creating urban climate adaptation: Experiences and actions from city government-research collaboration in a mid-sized Northern European city (Mattias Hjerpe, Centre for Climate Science and Policy Research)
  3. Adaptation strategies to address climate change impacts on coastal Maori communities in Aotearoa-New Zealand: integrating a geomorphological perspective (Jane Richardson, Massey University)
  4. Business strategies and climate change – prototype development and testing of a user specific climate service product for companies (Peer Seipold, Climate Service Center Germany (GERICS))
  5. Hydro-climatic information services to enable adaptive decision-making in rice production systems in Ghana (Saskia Werners, Wageningen UR)
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#### 1. Increasing Resilience in Scotland's Forest Sector: Demonstrating Adaptation at Queen Elizabeth Forest Park

Kate Beauchamp, Forest Research

Scotland's forests are expected to experience wide ranging impacts under climate change. The Scottish Government and Forestry Commission Scotland are committed to increasing the resilience of Scotland's forests. Forest Enterprise Scotland manages Scotland's public forest which accounts for one third of the forest area. A strategic approach to forest management is maintained through national directions, guidelines and policy; and regional priorities delivered through ten Forest Districts. Local forest management centres around ten-year Land Management Plans which integrate multiple management objectives. Incorporating adaptation to climate change at all levels is essential to developing resilient forests.

To support Scotland's forest sector, adapt to climate change, ClimateXChange, Forest Research, Forestry Commission Scotland and Forest Enterprise Scotland established a 'demonstration forest' at Queen Elizabeth Forest Park (QEFPP) in 2013. The intention was to form connections between policy leads, practitioners and researchers to ground-truth policy and research in practice, and where possible to 'demonstrate' adaptation actions to act as a platform to connect with the wider forest sector.

Through this collaboration, we have identified potential barriers to adaptation, delivered a range of knowledge exchange resources and developed research to support forest policy and practitioner decision making. Where possible, we have integrated adaptation solutions into existing processes and communicate through current channels.

To support adaptation, we have delivered a range of knowledge exchange resources including on-line videos filmed at the Demonstration forest. We have hosted workshops at QEFPP to communicate updates in policy, research and practice and to identify barriers to adaptation. We have produced tutorials for decision support tools and developed a method to assess species diversity, as this is a key adaptation strategy.

Regular meetings with forest policy advisors allows us to co-develop research questions and communicate our results. A key area of research has been to model the impact of climate change and alternative forest management options on forest ecosystem service provision, including carbon storage and timber production. Partnering with the Forest District ensures our research is validated, and in this scenario, it enabled us to develop realistic alternative 'adaptive' forest management options.

This talk will demonstrate how our approach to partnership working has embedded research into practice, encouraged ground-truthing of forest policy and has supported practitioners to incorporate adaptation in their decision making. The end result has been collaborative solutions to the challenges of climate change adaptation.

## **2. Co-creating urban climate adaptation: Experiences and actions from city government-research collaboration in a mid-sized Northern European city**

Mattias Hjerpe, Centre for Climate Science and Policy Research

This presentation share experiences from 18 months' intense city-government (Norrköping municipality) and climate adaptation researcher (Centre for Climate Science and Policy Research, Linköping University) collaboration on urban climate adaptation. A citizen initiative on local climate adaptation receiving support from all political parties created an opportunity for collaboration. A local research group volunteered to assist in realizing the initiative's intention. The mayor and research director decided to collaborate. Jointly, a vast need for knowledge and action on climate adaptation organised around twelve problem areas were identified by local politicians, representatives from local government departments and the researchers. The municipality invested 1 MSEK (100000 Euro) in a pilot study and collaborative research proposals were submitted to a national programme on sustainable built environments and other calls. As of now, three proposals: one on leadership, citizen dialogue and models for public-private collaboration, one on the role of climate adaptation experiments in urban climate transitions, and one on creating an interactive visualisation platform for climate adaptation measures in urban stormwater management have been funded. The presentation will share our experiences on:

- (i) The local government processes and activities that the researchers support and observe such as the inter-sectoral guidelines for climate adaptation, an action plan for climate adapted and sustainable stormwater handling and planning of new infrastructure for public transport, biking and pedestrians.
- (ii) The importance of a process-based approach, involving all relevant local government departments and utilities with active support of local politicians and with an ambition to involve businesses and citizens in climate adaptation.
- (iii) How our roles as researchers, planners and politicians are challenged and deepened through intense collaboration. We will use anonymised examples and demonstrate how awareness of other perspectives is raised.
- (iv) How common outcomes, particularly two interactive visualisation applications: a joint, living climate vulnerability platform and a process-based tool for guiding local urban climate transitions catalyse co-creation
- (v) How co-creation between two open parties evolves in unpredictable ways. Once a platform for collaboration is established, we have received an amazing amount of proposals for further collaboration on urban climate adaptation from other departments, projects and local actors.

## **3. Adaptation strategies to address climate change impacts on coastal Māori communities in Aotearoa-New Zealand: integrating a geomorphological perspective**

Jane Richardson, Massey University

Aotearoa-New Zealand, with its extensive coastline and development concentrated in low elevation coastal zones, is facing significant challenges associated with rising sea level and a changing climate. The current focus in Aotearoa is on adaptation and coastal planning in vulnerable urban areas. However, there is a pressing need to build resilience in rural and semi-rural areas, particularly in light of the economic importance of primary sector production and evidence suggesting that the most recent rate of sea level rise is tracking along the higher end of the IPCC projections. This paper reports on the results of a project developed to address the need for a new, culturally appropriate approach that engages Māori (indigenous) communities in creating coastal resilience in a way that preserves cultural, social, environmental and economic values. The multidisciplinary participatory action

research project blended climate science, geomorphology, Mātauranga Māori (Māori knowledge), landscape design and ecological economics to inform and co-develop a framework for adaptation scenarios to help Māori farming communities in the Kāpiti-Horowhenua region plan for adaptation to future climate change impacts. Integration of a geomorphological perspective in the project assisted in demonstrating the dynamic nature of the landscape across a range of spatial and temporal scales, identified the potential landscape responses to climate forcing and the geomorphic sensitivity to environmental change. Climate change adaptation strategies designed with consideration of the geomorphology of a site, geomorphic processes and geomorphic concepts, work with the inherent diversity and dynamics of the coast, river and catchment, consider the capacity of the natural system to absorb change, enhance the natural resilience and fit within the evolutionary trajectory of the landscape. Integration of a geomorphic perspective when designing adaptation strategies to address the adverse impacts of climate change ensures that effective adaptation responses are developed. The involvement of the local Māori community via workshops and exhibitions has helped inform the visionary nature of the project and ensured community buy-in to the adaptive processes.

#### **4. Business strategies and climate change – prototype development and testing of a user specific climate service product for companies**

Peer Seipold, Climate Service Centre Germany (GERICS)

Climate change challenges companies all over the world, forcing them to take action in climate change mitigation and adaptation. Besides climate change risks driven by changes in physical parameters, and risks driven by changes in regulation also risks driven by changes in other climate-related developments are of high importance for companies. But how should state-of-the-art knowledge on climate change be processed in a way that decision makers in companies are able to integrate it into their business strategies? And what is the role of climate service providers for doing so?

For this purpose, we developed a so called modular company toolkit that has been implemented as a prototypical instrument for creating user specific climate services. The company toolkit bundles adaptation relevant areas of activity within specific topics. Each topic contains appropriate instruments, methods or information. The company toolkit currently consists of six module groups, as follows: i) evaluation, ii) communication, iii) networks and partnerships, iv) creating awareness and problem analysis, v) regulation as well as vi) opportunities. In close cooperation with company's decision makers, this approach aims to identify individual needs for support in an efficient and user specific way.

The first prototypical implementation and testing of our toolkit took place within the joint activity "business strategies and climate change" together with the German 2° Foundation and eight of their supporting companies (Xella International GmbH, Schüco International KG, Deutsche Telekom AG, Otto Group GmbH & Co KG, Deutsche Rockwool Mineralwoll GmbH & Co OHG, Puma SE, Gegenbauer Holding & Co. KG und Schwäbisch Hall AG). The 2° Foundation is an initiative founded by chief executive officers, chairmen and family businesses.

An essential component of the project was the so-called "framework of reference", which was used for 35 interview with decision-makers from the participating eight companies. The "framework of references" includes 55 questions regarding 36 subtopics on all relevant organizational areas of business, like i) management and leadership, ii) market, iii) finances, iv) infrastructure, v) production and logistics as well as vi) employees. In a tight dialogical exchange with companies, a main focus was to raise awareness of the risks and opportunities regarding climate change impacts. Our presentation focuses both on the concept of the company toolkit as well as practical experiences and results from the cooperation with the 2° Foundation.

#### **5. Hydro-climatic information services to enable adaptive decision-making in rice production systems in Ghana** Saskia Werners, Wageningen University & Research

Due to climate change, water availability (too much, not enough, too late or early) is becoming erratic and farmers cannot rely only on their own experience anymore to plan farming operations. Improved information services about current and future water availability promise to allow farmers to better plan their production systems.

For these services, it is necessary to tailor hydro-climatic forecasting systems to the decisions and information needs of farmers and water managers. This includes balancing needs for forecast accuracy with timeliness of information. Integration of local information is vital when aiming to provide tailored advice about agricultural production (e.g. timing of planting certain crops, management of sluices, when to irrigate) to different types of actors (e.g. water manager and farmers). Whereas the first-generation information systems mostly supported scientific processes of knowledge creation and limited communication with users, a second generation focuses more on knowledge co-creation and stakeholder interaction. This second generation does not only engage scientists but also non-scientists in the knowledge co-creation process.

This research reports on the design and development of tailor made water information services with and for rice farmers in Ghana to improve water and food security. Increasing rice production in Ghana has become an important governmental objective to reduce its agricultural import and ensure future domestic food security. However, water supply for rice production is becoming less reliable due to both increased climate variability and higher water demands. Uncertain water availability undermines agricultural practices resulting in amongst others reduced yields and low quality of rice. Addressing these challenges requires improved information on future water availability so as to allow for more adaptive management of the water and food system. This is done by 1) combining mobile information technology with latest insights on knowledge sharing; 2) integrating weather model results with observations of farmers and other stakeholders; and 3) attuning knowledge about adaptive decision making and enabling governance structures to local situations.

Through co-production and use of the information service, we study whether the connective action enabled by the information service can help to build ownership of the information system, and stimulate the development of a participatory innovation system in the context of an irrigated agricultural system under stress. Thus, it adds to our understanding of the conceptual framework and design conditions for information systems that can make local governance more adaptive.

## 6.6 Inclusive and local adaptation studies

*Simona Pedde, Wageningen UR*

### Participation and co-production

1. Building capacity through the simultaneous creation of 26 Municipal Strategies for Adaptation to Climate Change in Portugal – ClimAdaPT.Local project (Filipe Duarte Santos, cE3c, University of Lisbon)
  2. The Dynamics of Livelihood Assets to Support Survival under Climate Variability (Arya Hadi Dharmawan, Bogor Agricultural University)
  3. Participatory coastal adaptation – a good practice example of Timmendorfer Strand, Germany (Nico Stelljes, Ecologic Institute)
  4. Does size matter? Assessment of Scale and Governance Issues for City and Regional Climate Adaptation Frameworks: Case Study of Glasgow (Ellie Murtagh, University of Strathclyde)
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**Keywords:** Adaptation processes, Participation, Local stakeholders, Integrated solutions, Urban and rural planning, Scale, Governance

The five presentations in this sessions all report on local adaptation studies, often using participatory methods to engage a range of stakeholders, aiming at creating a strong local community and working towards successful adaptation options and their implementation as part of a broader package of integrated solutions. The first presentation introduces the ClimAdaPT.Local project that had the goal of starting a continued process of adaptation at the local level in Portugal. Regional climate change scenarios were provided to the municipalities and used to evaluate future impacts and vulnerabilities at the local level and to produce a set of adaptation measures that were prioritized using multicriteria and cost-benefit analysis. The project developed tools and products which enabled the formulation and implementation of the climate change strategies. The second presentation draws from empirical research in villages of East Nusa Tenggara in Indonesia. It relates to the increase in climate variability as a result and most direct impact of climate change, especially farmer households. The study states that local institution on the management of water resources significantly determines different type of adaptive mechanism. They conclude that a more complex adaptive mechanism including the use of livelihood assets guarantees much stronger farm households survival. The third presentation reports on a good example of an adaptation process and measure implemented in the small coastal touristic community in Germany. An already implemented example is analysed in detail with focus on the evaluation of the measure combined with a cost-benefit analysis. Different solutions were found, for example part of the hard coastal defence measures were integrated in the natural dune system. Promoting good examples of adaptation can encourage others to also get engaged in the adaptation process. The fourth presentation asks the question how historical relics to adaptation are relevant to today's challenges and possible solutions. The ethnographic research explores a unique situation in Bolivia where these ancient landscapes are re-emerging as relevant in the face of current-day climate change. It also highlights factors important in autonomous adaptation at the local scale, and perceptions, knowledge and assets that determine its success. The fifth presentation explores the formation and effectiveness of both city wide and regional climate adaptation groups and actions in Glasgow. The multi-level governance requirements are examined to identify best practices and the impact of austerity on climate adaptation is questioned, using methods to encourage stakeholder participation.

### Significance to adaptation practice, policy and/or business

All presentations in this session relate to a (local) concrete adaptation process often linked directly to adaptation action plans and provide valuable information for adaptation practitioners. As such, the methods and results are directly useful for adaptation practice. Through a geographical spread methods and solutions in different continents are presented. A broad range of stakeholders, e.g. local municipalities, regional associations, and



indigenous communities, was directly involved in the work. This resulted in direct impact for (local) policy making. In short, local adaptation practice and related policies are instrumental in all presentations.

## **1. Building capacity through the simultaneous creation of 26 Municipal Strategies for Adaptation to Climate Change in Portugal – ClimAdaPT.Local project**

Filipe Duarte Santos, cE3c, University of Lisbon, Portugal

Portugal is one of the countries in Europe most vulnerable to climate change, with high potential impacts and relatively low adaptive capacity. The most relevant impacts result from: decrease in the annual precipitation, increase in the annual average temperature, more frequent and stronger extreme events, particularly droughts and heat waves, and sea level rise. The ClimAdaPT.Local project (2014-2016) had the goal of starting a continued process of adaptation at the local level in Portugal through the elaboration of Municipal Adaptation Strategies in 26 Municipalities in Continental Portugal, Azores and Madeira and its integration in municipal planning tools. The 26 Municipalities were chosen on a regional basis and were fairly diversified in terms of population, geography and vulnerability to climate change. Two members of the municipal staff of each municipality were trained in climate change adaptation using a methodology based on the UKCIP Adaptation Wizard. Municipal awareness to climate change adaptation and mitigation was raised through workshops that involved more than 2000 local stakeholders. Regional climate change scenarios obtained from GCM models were provided to the municipalities and used to evaluate future impacts and vulnerabilities at the local level and to produce a set of adaptation measures that were prioritized using multi-criteria and benefit-cost analysis. The project developed tools and products (e.g. climate change scenarios, vulnerability assessment guidelines, adaptation manuals) which enabled the formulation and implementation of the climate change strategies. Most objectives of the project were achieved. They contributed substantially to: raising awareness and embedding the climate change adaptation dimension at local level governance in Portugal; creating a community of municipal actors, aware of climate change issues, vulnerabilities and risks and trained to use decision support tools for adaptation; promotion and provision of local adaptation knowledge particularly in the definition and prioritizing of strategies, planning and implementation of measures and results communication. Furthermore the project developed a Climate Change Adaptation National Network of Municipalities to promote adaptation among all the 308 Portuguese Municipalities. This presentation will present the methodologies used, shared experiences, lessons learned, main drawbacks encountered, recommendations of best practices and how this methodology might be further used for wider replications (within Portugal and in other European countries). The presentation will highlight some of the climate change monitoring indicators that were periodically assessed by the Municipalities and technicians involved in the project.

## **2. The Dynamics of Livelihood Assets to Support Survival under Climate Variability**

Arya Hadi Dharmawan, Bogor Agricultural University, Indonesia

The effect of global climate change has significantly hits many places around the world, especially in tropical regions including Indonesia. In specific regions, climate change comes as a climate variability which particularly can be determined by the difficulty to predict the length of the season. Rain season and drought season, as the specific form of climate change, nowadays, are no longer predictable. This condition causes ecological change, ecological damage, and socio-economic crisis to rural households, especially farmer households, who are really dependent on the natural resources. In order to survive through this critical condition, rural households set up adaptation strategies for the sake of resilience. Rural household basically have five livelihood assets, which specified into natural capital, physical capital, human capital, financial capital, and social capital. These livelihood assets have significantly formed the adaptive capacity into different types, depending on the sufficient sources that are available. This paper is drawn from an empirical research in villages of East Nusa Tenggara. The studies found that local institution on the management of water resources significantly determines different type of adaptive mechanism in these two villages. The farm households in Noelbaki, which is located near the water resources, forms a more complex adaptive mechanism than farm households in Oesao. The farmer households in

Noelbaki utilized natural capital, physical capital, and social capital to survive through the critical condition. On the other hand, farm household in Oesao only utilized human capital as one of the survival strategy to obtain non-farm occupations. A more complex adaptive mechanism including the use of livelihood assets guarantees much stronger farm households survival. The study took place in villages of two different arid areas, namely Oesao and Noelbaki villages, East Nusa Tenggara. The study uses survey method as the main approach and uses statistic in the data analyst. It is concluded that there is a strong link between climate variability, livelihood assets, resilience, water and food security. Once farm households failed to produce food due to the limited use of livelihood assets. It means that food production and their income becomes insecure. The result of this study can practically become an adaptation practice which can be applied by the other tropical regions that have similar situation as Indonesia. The result of the study can also become solutions to solve the problems of food insecurity which practically formed into a policy.

### **3. Participatory coastal adaptation – a good practice example of Timmendorfer Strand, Germany**

Nico Stelljes, Ecologic Institute

“Do something good and speak about it” – this slogan sometimes gets forgotten in the adaptation contexts when it comes to reporting about successful adaptation measures. In our case, we want to present a good example of an adaptation process and measure implemented in the small touristic community Timmendorfer Strand, located at the German Baltic Sea coast. This measure has been fully implemented and covered a time span for over 10 years. Within the project BASE, we analysed this already implemented example in detail with focus on the evaluation of the measure combined with a cost-benefit analysis (CBA). The community Timmendorfer Strand is located in the interior of the Bay of Lübeck in the Baltic Sea, roughly 70 km northeast of Hamburg and has around 9000 inhabitants. Before this process started in 1999, the community, located in lowlands, and had natural coastal protection of dunes which was not sufficient for extreme events. was not protected by coastal protection. With the main economic focus on tourism, coastal defence infrastructure was rather seen critical within the community. With an intensive participatory process, with different workshops and discussions, and an accompanying assessment of economic values (at possible threat because of flooding) located in the community the stakeholders attitude changed. With the decision to secure the coastline a discussion started about the different possibilities of coastal defence measures. Different solutions were found, for example part of the hard coastal defence measures were integrated in the natural dune system and therefore not noticeable for visitors or glazed retentions walls are integrated so guests can still enjoy the sea view. These kinds of flexible solutions increased the support in the local community. Within the project BASE we used a CBA to show that the implemented measure pays off in the long term. The high upfront investment costs of the coastal protection measure (and a parallel implemented landscaping and finishing project) are exceeded by the benefits of the implementation. It can be seen that the investment costs are the major type of costs and the main benefits type is avoided damages by storm surges; also the additional tourism shows substantial benefits. Promoting good example of adaptation encourage others to also get engaged in the adaptation process. In telling the story of the adaptation process, we will conclude with different success factors that were essential for the implementation of the coastal defence measure.

### **4. Does size matter? Assessment of Scale and Governance Issues for City and Regional Climate Adaptation**

**Frameworks: Case Study of Glasgow**

Ellie Murtagh, University Of Strathclyde

Climate change and urbanization are defining trends of the 21st century. As a result, there have been a plethora of funding calls, initiatives and research focused on enabling cities to adapt to climate change. Whilst cities may be hotspots of risk, the ecological and social systems upon which they depend will also be impacted, and these may lie beyond the city boundaries. A key challenge in climate governance is the potential disconnect between problem scale and governance scale. The utility of working across jurisdictions at a regional level through partnerships could create innovative solutions and make more efficient use of available resources to enhance

resilience; however there has been limited comparative research on regional and city approaches. This paper explores the formation and effectiveness of both city wide and regional climate adaptation groups and actions in Glasgow City and the wider Clyde Valley Region (Scotland, UK). The evolution of Glasgow's Climate Adaptation Framework and the innovative Climate Ready Clyde (a cross sector partnership for region wide climate adaptation) will be studied and variations in adaptation approaches across the city and regional scale will be explored. The multi-level governance requirements for both will be examined to identify best practices for sharing information and resources across scales to enable climate resilience. Furthermore the impact of austerity on climate adaptation will be questioned, and the extent to which regional approaches may assist with pooling resources for joint benefits researched. With regards to formation of the city and regional groups, methods to encourage stakeholder's participation will be identified and the evidence needs at both scales to enable appropriate adaptation described. In addition, the wider socio-economic issues which will be impacted by climate change and the scale upon which they are governed will be addressed, including transport and housing. Glasgow was one of the first cities to be chosen to participate in the Rockefeller 100 Resilient Cities initiative, and is the first city in the UK to release a city resilience strategy. As such the extent to which resilience thinking, gained as part of Glasgow's participation in the 100RC process, influences climate adaptation processes and if these learnings are transferable beyond city limits will be examined. This research will be undertaken using a case study approach benefiting from mixed method techniques, including policy analysis, semi-structured interviews, social network analysis and a validation workshop. This paper hopes to build upon Bauer and Steurer's 2014 paper, Multi-Level Governance of Climate Change Adaptation: The Role of Regional Partnerships in Canada and England.

## 8.2 Dealing with the complexity of multiple sectors, scales, stakeholders, risks and benefits

*Henrik Carlsen, Stockholm Environment Institute*

### Governance

1. Trading-off the water-food-energy-environment nexus under climate change in northern India (Andrea Momb Blanch, Cranfield University)
  2. Mapping the water-energy-food-climate nexus (Marian Scott, University of Glasgow)
  3. Revealing the Economy-Wide Effects of Climate Change Adaptation - A Macroeconomic Assessment of Adaptation Funding for the Case of Austria (Gabriel Bachner, University of Graz)
  4. Accounting for Adaptation Challenges in a Globalized World: Using Input-Output Data to Quantify Transnational Climate Impacts (Olle Olsson, Stockholm Environment Institute)
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**Keywords:** nexus, water, energy, food, disaster resilience, economic assessment, input-output

The water - energy - food - climate/environment nexus is discussed in the first two papers. In the first, the nexus is studied in two river basins in northern India, through working with stakeholder to develop adaptation policies for water resources management. The second paper shows that systemic mapping of the WEFC nexus identifies its topology and dynamics; the structure and flows of power, knowledge, money and other resources throughout the network. This is the only way to identify interdependencies, feedbacks, trade-offs, bottlenecks, disconnects, synergies, critical system elements and vulnerabilities, many of which are currently hidden by the complexity of the nexus. These represent the entry points for transformational improvements such as alignment of policies, practices and resource allocation across sectors and scales, increased efficiency and effectiveness of targeted interventions, protection of critical system elements through reinforcement, exploration of multi-functionality, and increased resilience by enabling informed adaptive management.

Moving then to more quantitative assessment, the third paper integrates bottom-up information on benefits and costs of certain adaptation measures into a top-down macroeconomic computable general equilibrium (CGE) model. The authors find that even at benefit-cost ratios below unity, positive macroeconomic and welfare effects can emerge from adaptation. The last paper aims to develop a climate change adaptation index that accounts for business exposure to global climate risks, by taking both the local and the global context into account. Results show that specific sectors in countries that are deemed fairly resilient to climate change score significantly worse if scaled according to the international origins of their respective economic input, due to large share of input from countries that are vulnerable to climate change effects.

### Significance to adaptation practice, policy and/or business

Understanding the water-food-energy-climate/environment nexus is critical in policy and practice, the challenges are of national and international strategic importance. Mapping the nexus offers the opportunity to manage a highly complex set of inter-connected systems in an efficient and holistic way. Multi-stakeholder collaboration to achieve the goals of disaster risk reduction is a way to implement adaptive governance of interest to all decision makers. Quantitative approaches for assessing adaptation challenges are important for individual business sectors. They are also important for national as well as international policy regarding e.g. risk sharing between the public and private sectors.

## **1. Trading-off the water-food-energy-environment nexus under climate change in northern India**

Andrea Momblanch, Cranfield University

Climate change studies in the Indian Himalayas generally agree that annual average temperatures will increase by around 0.5°C/decade under the RCP 8.5 scenario. Conversely, changes in future precipitation are still uncertain. Despite this uncertainty, the effect of increased temperature on snow and glacier behaviour is expected to bring about significant impacts on the hydrology of river basins in the area, affecting both the amount and seasonality of water resources. Higher temperatures will also lead to increased transpiration demand of crops, which will bring about increased irrigation requirements and energy demand. Population growth and economic development in India will also translate into higher water demands for people and hydropower uses. All these changes call for adaptation measures that minimise water scarcity and potential water-food-energy-environment conflicts in the region.

The SusHi-Wat project aims to support solutions to these global change impacts in the Beas and Sutlej River Basins, located in the state of Himachal Pradesh in northern India, through working with stakeholder to develop adaptation policies for water resources management. A systems-based perspective to integrating these competing water demands within the basin has been implemented using the WEAP ("Water Evaluation and Planning") system. We compare the performance of the river basins considering several scenarios that integrate climate change, socio-economic and water management assumptions. The difference between the current and global change scenarios provides an estimation of the impacts if no adaptation measures are implemented. As global change scenarios, we consider high-end climate change and socio-economic change in the medium and long term futures. Later, we explore the trade-offs among water uses to identify critical aspects that provide insight for the definition of adaptation water management strategies. Within the presentation, we will look into the water management adaptation measures in the hydropower, environment, agriculture, and water supply sectors which best help to balance the trade-offs and exploit potential opportunities.

## **2. Mapping the water-energy-food-climate nexus**

Marian Scott, University of Glasgow

This presentation explores data-driven applications within complex systems, specifically aiming to assess interconnections between the water-energy-food-climate nexus across a range of spatial and temporal scales. The emergence of nexus thinking in the wake of the 2011 Bonn Nexus conference has triggered changes in the way we think about and manage our natural resources. The feasibility and utility of WEFC nexus mapping relies on an appropriate interpretation of the available data and models, drawn from a wide variety of sources, including administrative, business and scientific sources. The latter includes measurement and monitoring of the physical and ecological environment, using both traditional but also more modern sensor development, (process, statistical, behavioural and lifecycle) models, and qualitative data sources drawn from the diverse stakeholder communities, using recent developments in participatory mapping, crowd sourcing and social media. In spite of these data assemblages, our understanding of the interconnections, synergies and feedbacks that exist between water, energy, food and climate systems remains limited across the academic, business and regulatory sectors. Whilst some examples of modelling approaches and integrated analyses have emerged to enhance these sectors, a greater emphasis on establishing data sources, trends, risk and opportunities to advance collaboration and progress across these complex systems is needed. We discuss the data requirements and access issues to undertaking WEFC nexus assessments at contrasting scales assessing individual to national scale assessments of interconnections, intra-connections and feedbacks. There are spatial and temporal scale issues with all WEFC mapping. The WEFC nexus does not have 'inherent' spatial or temporal boundaries, scale issues include where (spatial), who (stakeholder group) and when. A coherent approach to the spatial and temporal elements of the WEFC nexus presents considerable challenges. Systemic mapping of the WEFC nexus identifies its topology and dynamics; the structure and flows of power, knowledge, money and other resources throughout the network. This is the only way to identify interdependencies, feedbacks, trade-offs, bottlenecks, disconnects, synergies,

critical system elements and vulnerabilities, many of which are currently hidden by the complexity of the nexus. These represent the entry points for transformational improvements such as alignment of policies, practices and resource allocation across sectors and scales, increased efficiency and effectiveness of targeted interventions, protection of critical system elements through reinforcement, exploration of multi-functionality, and increased resilience by enabling informed adaptive management.

### **3. Revealing the Economy-Wide Effects of Climate Change Adaptation - A Macroeconomic Assessment of Adaptation Funding for the Case of Austria**

Gabriel Bachner, University of Graz

Economic assessments of climate change adaptation are highly needed, as climate change is becoming visible and adaptation is gaining more importance. A widely-used tool for economic assessment is cost-benefits analysis (CBA), where the generated benefit of adaptation - expressed as avoided damage - is compared to the costs of adaptation. CBA is typically applied at the sectoral, business or project level, thus relying on bottom-up information for both, the costs and benefits of adaptation.

We argue that traditional CBA is too short sighted since possible economic *indirect* effects from interlinkages across economic sectors and agents are neglected. Such indirect effects, as for example labour market effects, might lead to additional positive macroeconomic or welfare effects, but could also reduce the expected benefit from adaptation.

We thus integrate bottom-up information on benefits and costs of certain adaptation measures into a top-down macroeconomic computable general equilibrium (CGE) model. We build upon a recently finished assessment on the "costs of inaction" for the case of Austria, which aimed to reveal the macroeconomic costs of climate change without any planned adaptation efforts. For the most vulnerable fields of impacts, namely riverine flooding, forestry and tourism, we implement planned adaptation measures which are based on bottom-up information.

We find that even at benefit-cost ratios below unity, positive macroeconomic and welfare effects can emerge from adaptation. In some cases, the macroeconomic costs of climate change are even set off completely by adaptation, meaning that co-benefits derived from adaptation outweigh residual damages, at least on the economy-wide level.

Our results lead us to the question of adaptation financing. While the macroeconomy clearly benefits from adaptation, a sectoral benefit-cost ratio below one might disincentivize private adaptation within specific sectors. We therefore investigate how public adaptation as well as public support for private adaptation (information provisions, subsidized loans etc.) can increase the uptake of adaptation.

### **4. Accounting for Adaptation Challenges in a Globalized World: Using Input-Output Data to Quantify Transnational Climate Impacts**

Olle Olsson, Stockholm Environment Institute

A traditional attitude in climate change policy discussions is that mitigation is a challenge on a global scale whereas adaptation is more of a local nature. Recently, this view has been challenged argue that in a globalized economy, climate change impacts in one place will have international effects, implying the need to acknowledge the global nature of adaptation. In this study, we combine the ND-GAIN index of climate vulnerability with Input-Output data for 34 economic sectors in 61 countries. Our objective is to develop a climate change adaptation index that accounts for business exposure to global climate risks, by taking both the local and the global context into account.

Conclusions from the study include the finding that specific sectors in countries that are deemed fairly resilient to climate change (low ND-GAIN), score significantly worse if scaled according to the international origins of their

respective economic input due to large share of input from countries that are vulnerable to climate change effects (high ND-GAIN). A notable example here is the petroleum refining sectors, where many climate resilient countries are highly reliant on inputs from countries with high ND-GAIN values, primarily due to the fact that the latter tend to be located in climate change-exposed regions and in countries with less-than-stable institutional frameworks. The study also shows that climate change exposure of individual business sectors is a lot more complicated than what is by the climate change exposure of the country in which the sector is based.

We are only starting to explore the complexity of transnational climate impacts, but it is clear that in order for sectorial adaptation to be effective, it is crucial to develop indicators that are suitable for a globalized world, where local climate change effects can have long-ranging spillovers.

## 12.2 Adaptation in Coastal and Marine Ecosystems

*Paolo Scussolini, Institute for Environmental Studies (IVM)*

### Coastal

#### Ecosystem services and NBS

1. A novel approach for modelling the impact of sea-level rise on global coastal wetlands (Mark Schuerch, University of Cambridge)
  2. Tackling the implementation challenge of nature-based flood defence solutions (Stephanie Janssen, Delft University of Technology)
  3. Added value of ecosystem services for the Delta Programme (Ron Franken, PBL Netherlands Environmental Assessment Agency)
  4. Shifting whales and changing climates - emerging challenges for the whale watch industry (Jan-Olaf Meynecke, Griffith Centre for Coastal Management)
  5. From vulnerability assessment to the identification of adaptation measures for the lagoon of Carmen-Pajonal-Machona (Tabasco) (Emiliano Ramieri, Thetis)
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### 1. A novel approach for modelling the impact of sea-level rise on global coastal wetlands

Mark Schuerch, University Of Cambridge

In response to global sea level rise (SLR), coastal wetlands around the globe may be in immediate danger of disappearing in the course of the coming century. Ecosystem services at threat include globally relevant carbon sequestration, support of commercially important fisheries, local to regional scale coastal protection through dissipation of hydrodynamic energy, nutrient cycling, and deposition of pollutants and fine sediments. In recent decades, a wide range of local- to regional-scale impact models have been developed to quantify the potential loss of coastal wetlands in response to rising sea levels. While local-scale models commonly attribute coastal wetlands a high resilience to drowning by increased sediment accretion in response to SLR, many of the existing regional- to global-scale modelling approaches suggest a dramatic decrease in global wetland area by the end of the century. These models, however, have been criticized for not incorporating the bio-physical feedback mechanisms that are important for the capacity of coastal wetlands to adapt to SLR by vertical sediment accretion and lateral expansion, thus overestimating expected losses.

Utilizing the existing framework of the current Dynamic Interactive Vulnerability Assessment Wetland Change Model (DIVA-WCM), and its underlying database of global coastline segments, we now present a novel global wetland modelling approach that addresses these shortcomings. This revision allows for improved estimates of how global wetland areas will respond to future SLR as well as to a variety of different coastal adaptation strategies. We find that global changes in coastal wetland areas are highly sensitive to both the chosen SLR scenario as well as the adaptation strategy in terms of how much of the coastline will be protected by dikes and seawalls. Coastal wetlands in many regions appear to be highly resilient due to their ability to accumulate sediments and as such vertically grow with rising sea levels. At the same time, they appear to substantially suffer from reduced accommodation space. The reduction in accommodation space is likely to be not only triggered by coastal protection infrastructures but also by other types of infrastructure, such as coastal roads and railways.

Accounting for the fact that about 10% of the global population now lives in coastal areas below 10 m of elevation and that this proportion is projected to significantly increase in the future, we expect the major pressures for coastal wetlands will be large scale reduction of accommodation space, unless ecosystem conservation is more widely implemented in coastal adaptation strategies.



## **2. Tackling the implementation challenge of nature-based flood defence solutions**

Stephanie Janssen, Tu Delft - Delft – Netherlands

Climate change effects such as rising sea levels and increasing storminess are a major concern in coastal flood risk management. The intensive use of coastal regions and their socio-economic as well as ecological importance require sustainable solutions for flood risk management. Nature-based flood defence (NBFD) solutions have been promoted as a more sustainable, no-regret and flexible flood risk management strategy. In NBFD solutions natural ecosystem elements (e.g. mangroves, salt marshes, oyster reefs) attenuate waves, stabilize shorelines, create a direct flood barrier or support the natural redistribution of sand and sediments.

Nature-based adaptation to climate change has been attracting increasing global attention over the last decade. For example, ecosystems form a central element in achieving a number of the Sustainable Development Goals and are central in the Sendai Framework for disaster risk reduction. In addition, NBFD knowledge is rapidly progressing, resulting in advanced techniques for effect assessment, real-life pilot studies and the development of NBFD concepts for different coastal systems. With regard to full implementation however NBFD is facing at least two main barriers. First, the multiple user functions complicate NBFD decision-making. The introduction of 'nature' parties in the flood risk management domain changes coalitions and introduces trade-offs between nature values and flood risk management objectives. Second, NBFD is inherently unpredictable and more uncertain than common flood defence solutions such as dams, dikes or breakwaters. Ecosystems naturally evolve in dynamic and non-linear ways, making NBFD highly unsuitable for conventional 'command-and-control' management in which limited room exists to cope with unpredictable behaviour. Therefore, other governance approaches are needed that are better suited to facilitate a more adaptive and learning approach in flood risk management.

In our research, we have investigated actor-interactions in the decision-making of different Dutch NBFD case studies such as the sand engine, shore dike and Afsluitdijk. We used game theory to structure and understand the NBFD games that were played in a systematic manner. Based on the case study analyses we: (1) identified exemplary NBFD games, (2) provided explanatory factors for NBFD implementation and (3) identified solutions to the games that enable NBFD implementation. NBFD games can be influenced by changing players' valuation of outcomes, changing the rules of the game or affecting players' perceptions. Games played at higher level are crucial for determining NBFD games and implementation potential in daily flood risk management.

## **3. Added value of ecosystem services for the Delta Programme**

Ron Franken, PBL Netherlands Environmental Assessment Agency

As part of the Natural Capital Netherlands programme, PBL explored the possible roles of nature in the implementation of the Dutch Delta programme for flood protection. Explicit attention was paid to the added value of 'nature-inclusive' solutions for biodiversity. Two projects served as case studies: reinforcement of the sea dyke between Eemshaven and Delfzijl, and construction of a flood channel at Varik- Heesselt. The first study concerned the Wadden Sea area. In this study, various innovative concepts for improving the sea dyke between Eemshaven and Delfzijl were compared in terms of their effects on biodiversity and perspectives for economically valuable ecosystem services. The second study concerned the river Waal in the Betuwe area. This study explored the importance of ecosystem services in various options for constructing a secondary flood channel in the river at Varik-Heesselt, and identified opportunities for a nature-based solution. Commissioned by PBL, both studies were carried out by Deltares and Alterra Wageningen UR.

Both studies followed the approach developed by the PBL Natural Capital Netherlands programme (Natuurlijk Kapitaal Nederland, NKN for short), and evaluated its usefulness for strategic decision processes. The NKN approach is based on the TEEB studies (The Economics of Ecosystems and Biodiversity) and includes the following steps: 1. Mapping and identification of ecosystem services; 2. Quantification and valuation of ecosystem services;

3. Capitalization (sustainable utilisation and conservation) of this value. Both studies covered all three steps (mapping, valuation and capitalization). An explicit distinction was made between the economic or social value of ecosystem services and the effects on biodiversity. Each study included two workshops with local stakeholders to identify concrete opportunities for nature-inclusive solutions. Based on workshop results and follow-up analyses, the prospects for biodiversity and various ecosystem services were identified and, where possible, valued in monetary terms, making use of expert knowledge of the research institutes involved. Furthermore, insights gained in other studies in the Betuwe and Wadden Sea area were integrated where possible. Finally, discussions were held with the most important stakeholders to evaluate how the information provided by the NKN analysis had influenced the planning and decision processes in the flood safety projects involved.

#### **4. Shifting whales and changing climates – emerging challenges for the whale watch industry**

Jan-Olaf Meynecke, Griffith Climate Change Response Program, Griffith Centre For Coastal Management, Humpbacks & High-rises Inc

Whale watching is a billion-dollar industry worldwide. One of the most popular species for whale watching is the Humpback whale (*Megaptera novaengliae*). The migratory corridors, feeding, resting and calving sites, which are used for whale watching may be influenced by changing ocean currents and water temperatures. Whales are responding through a shift in migration time, behavior, abundance and distribution. Whale watching is an important industry on the east coast of Australia, particularly for the Gold Coast region where there are five whale watch operators with a daily carrying capacity of about 1 000 customers. The growth of this industry is mainly attributed to the recovery of well-known whale species and the concomitant increase in their density, which has prompted many operators to now offer a money back guarantee if there are no sightings. Recent and projected shifts in the East Australian Current (EAC) are linked to dramatic effects both on the physical and biological marine environment, which could influence the whale migration dynamics with associated impacts on the local (Gold Coast) whale watching industry.

We have investigated the calving rates and migration patterns of Humpback whales over 4 years at a popular whale watching location. Findings suggest that the whales are shifting their breeding grounds southward into the study area and that migration corridors change with sea surface temperature. Whale watch operators responded by travelling to different locations and spending increased time with newborn calves. In addition, we have estimated the impacts of increasing bad weather conditions that led to loss of days at sea and estimated impacts based on future projections for the regions. Our research illustrates how the monitoring and assessment of whale behavior and climate conditions can assist local tourism operators and authorities in making rational coastal zone management decisions. Our study also encourages the development of adaptation instruments for natural resource-based tourism.

#### **5. From vulnerability assessment to the identification of adaptation measures for the lagoon of Carmen-Pajonal-Machona (Tabasco)**

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The Carmen-Pajonal-Machona lagoon system (CPM) is located on the Gulf of Mexico in the State of Tabasco. It is a low-depth coastal wetland which is separated from the sea by a fragile sand bar. It communicates with the sea through two inlets and hosts important habitats (including mangroves) and small human communities, which strongly rely on the lagoon ecosystem services for their livelihoods.

The Consortium formed by Thetis, CMCC and Coastal Environments run a project funded by the World Bank and technically managed by the Instituto Nacional de Ecología y Cambio Climático, aiming at designing adaptation measures to decrease impacts from climate change and other human-induced impacts.

The project was developed through different steps: (i) data collection and field activities, (ii) analysis of the current vulnerability of the lagoon system, (iii) elaboration of climate change scenarios at the regional level, (iv) assessment of climate change impacts, (v) identification of adaptation measures and possible sites for their implementation, (vi) recommendations for institutional strengthening. Stakeholder engagement was considered essential and two interactive workshops were organised: one focusing on the assessment of current and climate change related impacts and a second on the validation of adaptation measures proposed. Both workshops involved local decision makers and experts (day 1) and representatives of local communities (day 2).

The current state of and main impacts on CPM were identified in the initial phase of the project also based on the EEA DPSIR conceptual approach. Main outcome highlighted that the socio-ecosystem is highly impacted: erosion of the littoral bar separating the lagoon from the sea, high social and physical vulnerability to flooding, lack of treatment of wastewater and bacteria contamination of the lagoon, loss of mangrove habitats, saltwater intrusion and salinization of soil, local soil contamination due to oil extraction, consequent impacts on agriculture and fishery, and high vulnerability of local communities.

Based on the elaboration of regional climate change, sea-level rise and subsidence projections (accordingly to RCP4.5 and RCP8.5 scenarios and considering 2030 and 2100 timeframes), the project analysed how climate change can exacerbate those impacts (e.g. increased erosion or break of the littoral bar, increased frequency and intensity of flooding events, expansion of areas affected by soil salinization) and induce other effects (e.g. mangrove inland migration).

Afterwards, the project identified the most vulnerable areas, and the most appropriate adaptation measures that might be implemented to improve the system's resilience. A number of criteria were considered for the identification of measures, including: technical feasibility, replicability, possible adoption of ecosystem based solutions, coherence with existing programs and plans and in particular relevance for local communities and the possibility to rely on their capacity for the construction and management of the measures. The five most promising measures were selected in the second stakeholder workshop where participants contributed to assess the relative effectiveness of the proposed adaptation measures. Finally, recommendations for institutional strengthening on climate change adaptation were provided, referring specifically to the finally selected adaptation measures.

## 6.15 Tackling the challenge of adaptation, lessons learned in the Netherlands

*Stéphanie IJff, Deltares and Erin Hoogenboom, Ministry of Infrastructure and the Environment/Rijkswaterstaat*

Ecosystem services and NBS

Flooding

1. Introduction to the water management policy cycle (Stéphanie IJff, Deltares)
  2. Case 1: The Hoeksche Waard challenge (Janneke van Bergen, Atelier 1:1)
  3. Case 2: The Nijmegen Room for the Waal challenge (Mathieu Schouten, Municipality Nijmegen)
  4. Case 3: Monitoring the Sand Motor (Stéphanie IJff, Deltares)
  5. Interactive discussion: sharing experiences (Karsten Schipperheijn, Room for the River Waal Nijmegen/P2)
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**Keywords:** Flood risk, multi-level governance, adaptation practice, integral design process, nature-based solutions

In the past decade we have built up experience in the Netherlands in implementing measures for flood risk management by integrating them into broader area developments. In this session we share lessons that we learned from several projects in The Netherlands that aim to improve the resilience against flooding, by using natural processes. We use the flood risk management cycle as framework to discuss dilemmas that occur in different stages of the adaptation process. Three case studies are presented to illustrate these dilemmas in riverine, estuary and coastal environments.

Climate adaptation measures at the Hoeksche Waard show how system understanding and the (spatial) design process guide the local bottom-up process and lead to a more strategic agenda for adaptation. The Room for the Waal project is an illustration of private initiatives that shape the flexible design and implementation, which can incorporate new insights during the process. Although elaborate monitoring and evaluation of adaptation measures are not straightforward, the Sand Motor is an example in which a large-scale monitoring programme gives new insights that are used to make nature-based solutions for coastal erosion more effective in the future.

Dilemmas that are discussed in this session include co-operation between different levels of government together with stakeholders, dealing with conflicting interests and developments within the area and the necessity of a sound evaluation programme.

In this session, 'theory meets practice'. Experienced project managers of three climate adaptation projects will present the dilemmas that they have faced during the execution of their projects. What choices did they make during the different phases, and what choice would you have made if you were in the same position? What can we learn from each other? In addition to presentations of the projects and dilemmas, all participants are invited share their own experiences in an interactive discussion.

### **Significance to adaptation practice, policy and/or business**

Before adaptive measures are successfully implemented, many hurdles have to overcome. In this session practitioners, policymakers, NGO staff, scientists, consultants, designers and planners learn from each other about practical solutions to tackle (potential) dilemmas regarding nature-based solutions for flood risk management in different steps of the adaptation process. It enhances their capability to deal with these kinds of hurdles themselves.

## 1. Introduction to the water management policy cycle

Stéphanie IJff, Deltares

In this presentation, Stéphanie IJff will give a general introduction how the flood risk management cycle applies to the implementation of nature-based solutions (NBS) in the Netherlands. The flood risk management cycle consists of four stages, each with its own specific challenges: 1) system understanding and issue identification; 2) strategy building: design, assessment, decision-making; 3) implementation; and 4) monitoring and evaluation. For successful implementation of measures for flood risk management, each phase asks for specific knowledge regarding socio-economics and governance, understanding of the morphological and the ecological system. By using the flood risk management framework in the approach of implementing NBS, mismanagement can be prevented. Instead, it enables us to work towards cost-effective, sustainable and feasible measures for climate change adaptation. In that way, it is a valuable tool to enable sustainable NBS implementation worldwide and as such it also contributes to the global sustainability goals.

## 2. The Hoeksche Waard challenge

Janneke van Bergen, Atelier 1:1

The region of Hoeksche Waard has been appointed as strategic reserve for climate adaptation in the future. But this rural region is also addressing a decline in inhabitants and economy; therefore the region is now promoting new recreational development along its shores. This raises dilemmas, for example about how to address long-term climate adaptation in a short-term regional agenda through design.

This presentation shows how the (spatial) design process is utilised to guide a local bottom-up process for adaptation. To address dilemma's in the design phase, local (private) initiatives and a cohesive regional development that prepares for climate change are made transparent by (literally) putting them on the map:

- (conflicting) interests of different stakeholders and initiatives are made visible by joint design. In this early stage, design offers the opportunity to put plans together in a fictive environment. This can lead to joint discovery of dilemmas, but also contributes to common grounds and 'bridges' between different insights.
- second, it offers mappings of regional processes to embed local initiatives and connect them to a wider economic and spatial context.
- Last but not least, spatial design enables local initiatives to connect to the 'water agenda'. By discussing water as a quality (rather than just a necessity), it can be embedded in the local initiatives and connected to strategic water issues, with design as cohesive force.

Examples are:

- using depoldering and nature development as innovative way to create more room for the river and bio-based dike-reinforcement
- using recreation development to uplift and safeguard the fresh water reserves for the future.

This makes spatial design a vital instrument to guide local politics to a long-term water strategy.

## 3. The Nijmegen "Room for the Waal" challenge

Mathieu Schouten, Municipality Nijmegen and Karsten Schipperheijn, Room for the River Waal Nijmegen/P2

The Room for the Waal project is one of the projects along the river Waal that will give more way for the river. The dyke has been moved 350 meters inland and an ancillary channel is constructed in the new flood plain. This will create an island in the Waal and also a unique urban river park in the heart of Nijmegen with room for housing, recreational activities, culture, water and nature. Room for the Waal results in several major changes to the appearance of the city of Nijmegen. The municipal government has taken the opportunity to use the

necessary flood control improvements for a major development of the area. The project is integrated in the urban development around the river. This included the construction of the city bridge De Oversteek, development of the central area De Hof van Holland in Nijmegen-Noord, the transformation of an industrial area into the residential neighbourhood Waalfront, and a facelift for the Waal quay and surrounding area. For combining work on water safety and urban development, the project won the Waterfront Centre Award in New York in 2011.

Until recently urban development was driven by economic growth, but now it is focussing more and more on creating a sustainable habitat. Incorporating resilience demands that adaptation measures are incorporated in these developments and this requires a shift from stakeholders to shareholders. The government should give inhabitants room for private initiatives to reach the goals, guided by a unique regionally adapted approach in which the identity of the place is (re)defined. This means that a new planning and design process is needed that is flexible and can incorporate new insights. In the project Room for the Waal, a firm foundation for future urban developments was created, without a blue print of the next steps in the process.

#### **4. Monitoring the Sand Motor**

Stéphanie IJff, Deltares

The Sand Motor on the Delfland Coast was created in 2011 as a peninsula covering 128 hectares. It is an innovative pilot project for coastline management. The intention was that this mega beach nourishment contributes to coastal protection in the long term, but at the same time creates an additional appealing area for nature and leisure activities on the Delfland Coast. Opportunities for nature and leisure that were not available previously on this part of the coast were mud-flat environments, a sheltered lagoon and large beach plains. Because this type of nourishment has never been done before, the generation of knowledge and innovation was also an important objective of the construction of the Sand Motor, especially insight in the extent in which coastline maintenance can have added value for leisure activities and nature.

A monitoring programme has been conducted for the purposes of knowledge development and in order to evaluate whether the policy objectives have been met (did we get what we intended?). The results of the first five years have been published in 2016. The evaluation report describes how the large amount of sand changed under the forces of nature, which ecological developments were triggered and which leisure activities were possible. In terms of knowledge development major advances have been made in terms of our understanding of mega-nourishment operations and the effects of nourishment operations on ecology and dune development. The close monitoring teaches us a great deal about sediment composition and ecology in the surf zone, and about the area targeted by sand nourishment.

The monitoring programme will continue for five more years, assuring on-going possibilities for knowledge development on the morphological responses and how this steers ecological developments. The monitoring of the 'added value' for society of the Sand Motor is however, as in the last five years, rather poor. An international audit committee advised in 2016 to put more attention to this added value. In 2017 decisions must be made whether we can actually evaluate the added value of the Sand Motor. The challenge we are now facing, is how to best apply this knowledge to new projects. If we succeed, the evaluation results could help us to develop a framework for such evaluation in other Building with Nature projects.

#### **5. Interactive discussion: sharing experiences**

Led by Karsten Schipperheijn, Room for the River Waal Nijmegen/P2

## 1.9 Learning from failures in communication: Sharing lessons from research and practice

*Tanya Wilkins, ARCC Network, UKCIP and Celeste Young, Victoria Institute Of Strategic Economic Studies*

### Communication, art and culture

1. Communicating climate change adaptation – how values-based communication can break the climate silence (Jamie Clarke, Climate Outreach)
  2. Common shortcomings and limitations of science communication in adaptation policy (Gregor Vulturius, Stockholm Environment Institute)
  3. What does an adapting place look like? (Anne Marte Bergseng and Joe Hagg)
  4. Lessons from the trenches in a polarised communication setting (Lisa Dilling)
  5. Effective communication and engagement to motivate adaptation action – learning from the built environment and infrastructure sectors. A network approach. (Tanya Wilkins, ARCC Network, UKCIP)
  6. The uncomfortable conversation - why we are hard wired to avoid climate change communication (Celeste Young, Victoria Institute of Strategic Economic Studies)
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**Keywords:** communication, engagement, audience, lessons, mistakes, planning, implementation, research

**“I could fill a whole forum with stories of things that didn’t work”**

*State Government Practitioner Australia*

Because adaptation is an area of innovation often things don’t go according to plan. However, when it comes to talking about adaptation (particularly in public forums) the focus often centres on “success stories”. Although these narratives are inspiring they can sometimes lack the deeper learning that practitioners and decision makers can gain from each other through discussing what didn’t work and why. These useful and at times entertaining narratives are key to the development of adaptation communication practice. This is an area that is often overlooked at conferences, yet is something that is relevant for all those engaged in science, policy and practice.

The objectives of this session will be to take stock of practical and conceptual shortcomings of climate change communication, with respect to issues including:

- climate change communication characteristics
- role of communication in adaptation policy
- value-driven communication
- practical examples of tool development and reaching new audiences.

Insights in relation to how our responses to risk can make it difficult to communicate climate change.

Most importantly, this session will be a frank discussion from both the speakers and attendees around the failures to achieve particular outcomes using communication and how this has informed and shaped their practice.

This session is divided into two parts, the first part is a series of short snappy key presentations from leading communication researchers and practitioners. Delivery will be through a ‘so what? now what?’ framing that will engage with researchers, practitioners, communication professionals and managers across all areas of adaptation.

The second aspect of this session would be a facilitated workshop to explore what has and has not work in their communication and their observations in relation to this. Its aim is to provide a safe space using smaller groups

where open dialogue is possible and people can share their experiences in a way that promotes learning and knowledge sharing and identifies future emerging needs.

Outcomes of the session will be synthesised into a journal paper for the likes of Nature Climate Change or Wires Climate Change. This session will also seek to identify what further research is needed in the future to grow the field of climate change communication research, and support an ongoing network of climate change communicators.

### **Significance to adaptation practice, policy and/or business**

This session will offer research and practitioners a platform to gain a more critical understanding of the shortcomings of communication and how to address them in research, business and policy making.

#### **1. Communicating climate change adaptation – how values-based communication can break the climate silence**

Jamie Clarke, Executive Director Climate Outreach

Communicating climate change is not easy. Despite more than two decades of awareness raising and campaigns, and a sprawling academic literature on the subject, public engagement remains (for the most part) stubbornly stuck in 'second gear'. For citizens of nations where climatic conditions are generally moderate, climate change is too easy to dismiss as something that happens to other people, in other places (Weber, 2010). And even when extreme weather events do occur, it is difficult to make simple statements about their relationship to underlying changes in the climate (Marshall, 2014b). 'Encountering' climate change via extreme weather is certainly no guarantee that people will engage with the issue more generally (Reser et al, 2014). In many countries, there is a climate silence even after an extreme weather event.

The temptation to shovel-in 'more science' to deal with this puzzling shortfall in public engagement, the information deficit model, has largely been discredited by empirical evidence, it also embodies the old-fashioned idea that public engagement is a one-way process, rather than a dialogue. More recently the principles of 'social marketing' have been adopted from the advertising world, and approaches such as the 'nudge' technique have grown in popularity. But while they are well-suited to piecemeal behavioural changes, for a complex challenge like climate change, they are the wrong tools for the wrong job.

Effective engagement starts by understanding how people's values underpin their views about climate change an issue that has been shaped by political and cultural factors in a way few others have. This practical 'how-to' guide introduces the concept of values based climate change communication for adaptation based on social research. It will provide clear, concise summaries of the principles of engagement, combined with practical examples of how academics, public bodies, businesses and NGOs can use and tailor these principles in their work.

#### **2. Common shortcomings and limitations of science communication in adaptation policy**

Gregor Vulturius, Stockholm Environment Institute

This study takes a critical look at the role of science communication for adaptation policy. Science communication is expected to raise awareness about climate impacts, build support for adaptation policies; drive personal behaviour change to reduce vulnerability, and mobilize collective action for transformative change. Many policy approaches to science communication however suffer from a linear understanding of science-policy interaction and human cognition by simply assuming that providing the public with more information will automatically lead to desired policy outcomes. At the same time, research has also question if more communication and participation necessarily leads to better policy making.

The objective of this study is to develop a comprehensive understanding of conceptual and practical shortcomings and limitations of science communication in adaptation policy. Results are based on a review of past studies and reports on adaptation plans, programs and strategies that used communication. The analysis will look into the



objectives and purposes of communication efforts in the policy process, what type of methods they relied upon and if and how their outcomes have been evaluated and monitored. Key focus of the analysis will be on how different examples of communication addressed values and beliefs of targeted populations, how they tailored information and knowledge to the practical needs of people, and how communicators dealt with the issues of trust and scientific uncertainty of climate impacts and effectiveness of adaptation measures. Results of the analysis will help scientists, policy makers and practitioners to better understand and address different and often opposing values, practical needs, interests and frames of reference that mark different audiences. Furthermore, the study will also shed a light on the challenges of using communication and stakeholder participation to evaluate and improve adaptation policies.

### **3. What does an adapting place look like?**

Anne Marte Bergseng, Sniffer and Joe Hagg, Sniffer

With adaptation, a process of on-going adjustments in response to climate and non-climate drivers it can be difficult to imagining what this adapting place may look like. Decision makers at both local and national level struggle with how adaptation differs depending on how local assets and lives will be impacted by a changing climate.

This was the motivation behind developing the innovative Climate Ready Places tool – designed to communicate climate impacts and options for adaptation. The resource shows six typical Scottish places – Uplands, Lowlands, Coast, Infrastructure, Suburbs and City, in an ‘unadapted’ and ‘adapting’ state, developed for use online, with a toggle on/off layer of adaptation efforts and links to examples and case studies.

The presentation will discuss:

- the experience of developing the tool – gathering adaptation experts from a range of sectors to workshops with live scribing to create the visuals, and
- using visualisations as a tool - how to make the visualisations relevant across locations, from rural and remote coastal communities to busy cities and industrial areas.

We will also look at how stakeholders didn’t take the on-line tool and ‘run with it’. And how a range of opportunities to engage off-line re-focussed how the visualisations are used. The Climate Ready Places are now available as printed posters and info sheets for each location, which have been used extensively in workshops and at events.

### **4. Lessons from the trenches in a polarised communication setting**

Lisa Dilling, University of Colorado<sup>1</sup>

The mission of the Western Water Assessment (WWA), working in the area of Colorado, Wyoming and Utah in the western United States, is to conduct innovative research in partnership with decision makers, helping them make the best use of science to manage for climate impacts. Much of our activity depends on communication with a variety of groups, including water managers at all scales, municipal staff, farmers and ranchers, state policy makers, and other academics. Operating now for over 15 years, we have had much opportunity to learn from mistakes. Because much of what we do is experimental and on the boundary between research and practice, there is no “handbook” of how to succeed. The area in which WWA operates is a region with diverse cultures, livelihoods, history, politics, and urban and rural landscapes. “Knowing our audience” has come only through trial and experience, and seeing how audiences and partners have reacted to information over the years. For example, while discussing something like “transformation” or musing about different ways to allocate water in an academic conference might seem perfectly acceptable, those words can be confrontational in a real-world setting. Similarly, starting off a workshop with a presentation about climate change and showing the latest IPCC scenarios

might be perfectly perfunctory in a climate meeting, but a group of cattle ranchers must be approached completely differently. We have learned that it is important to “meet people where they are” in terms of climate awareness. This may mean learning first how someone’s business operates, what events are the most stressful to their bottom line, and how they view risk. Understanding the context of their decision making and their existing relationship with climate gives insight into what messages can even be heard and accepted in a given situation. Many communication failures can stem from mismatched expectations and goals for the workshop or meeting in the first place. Is your goal to help support decision making or to try to communicate what you think is important for others to know from your own perspective? Why is the group attending your meeting, what do they hope to learn or get out of it? Understanding these basic foundations for any communication opportunity can help one navigate dialogue and communication in a potentially politically-charged situation.

## **5. Effective communication and engagement to motivate adaptation action – learning from the built environment and infrastructure sectors. A network approach.**

Tanya Wilkins, ARCC Network, UKCIP

Engaging, communication and knowledge exchange are a key focus on the UK *Adaptation and Resilience in the Context of Change* (ARCC) network. This project is managed by UKCIP, and has a portfolio of over 35 research projects (£40m) in the built environment and infrastructure sectors funded by the Engineering and Physical Sciences Research Council.

The ARCC network explores opportunities to engage and communication in new and innovative ways to accelerate the update and use of evidence from research. This includes extending combinations of traditional and online communication with policy and practice communities to improve decision-making work with uncertainty and to enable innovative responses to climate change.

This presentation will explore the lessons learnt relating the communication of research outcomes using methods that incorporate the needs of the end-users, and using the language that resonates with the audience. Specific case studies will focus on large-scale industry communication and engagement through UK Construction Week and Eco Build, as well as more targeted approaches such as the use of green infrastructure as a building service, and engineering air quality solutions.

## **6. The uncomfortable conversation – talking action to support implementation of adaptation**

Celeste Young, Victoria Institute of Strategic Economic Studies

Effective communication is where participants actively respond to and engage with the information presented which can be difficult and frustrating for practitioners in climate change. Often, they are faced with unexpected response to the information they are communicating. One of the key parts of this puzzle is to understand how and why people respond to climate risk the way they do and what can be changed and what has to be managed through communication.

This presentation will draw on cases studies from work undertaken over the last 10 years as an adaptation practitioner and researcher in the public, private and research sector with organisations such as BAE Systems, The Western Alliance for Green House Action, the Victorian Centre for Climate Change Adaptation Research and The Victorian Institute for strategic Economic Studies. It will explore why this type of communication is so specific and why there is a need for practitioners to understand the systemic nature of not only the risk but also of the communication itself. It will discuss the challenges of working across diverse stakeholder groups and present some of the key communication lessons learnt from co-designing projects through these collaborations. It will also show how to working more effectively using risk communication as a starting point can promote better understanding and support more active responses.

## 2.8 Increasing Resilience: Integrating climate change adaptation and disaster risk reduction in planning. European and national level policy approaches and practices

*Sergio Castellari, European Environment Agency and Markus Leitner, Environment Agency Austria*

### DRR

1. Climate change adaptation and disaster risk reduction in Europe - Enhancing coherence of the knowledge base and policies (Sergio Castellari, European Environment Agency)
  2. The planned review of the EU Strategy on Adaptation to Climate Change: an opportunity to further reinforce the coordination between CCA and DRR (Max Linsen, European Commission, DG CLIMA)
  3. A new European Commission initiative: the Disaster Risk Management Knowledge Centre (Karmen Poljansek, European Commission, DG JRC)
  4. Linkage between Adaptation Strategy, Action Plan and Disaster Risk Management and inclusion in project planning – the Austrian case (Markus Leitner, Environment Agency Austria)
  5. Integrating adaptation needs into policy instruments, the case of Germany (Clemens Haßle, German Federal Environment Agency)
  6. Interactive Panel Discussion on experiences and lessons to be shared (Markus Leitner, Environment Agency Austria)
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**Keywords:** Climate Change Adaptation, Disaster Risk Reduction, climate proofing

Climate Change Adaptation (CCA) and Disaster Risk Reduction (DRR) provide a range of complementary approaches for managing the risks of weather and climate related extremes. At the European Union (EU) and national levels efforts of linking and integrating the knowledge base and policies of CCA and DRR are on the way. This session will present recent approaches and show good practices.

In 2016 the EU Action Plan on the Sendai Framework for Disaster Risk Reduction 2015-2030 has been launched and gave a new impetus for further coordinating disaster risk reduction throughout the main EU sectoral policies. Since 2013 the EU Strategy on Adaptation to Climate Change paved the way for mainstreaming climate change related concerns into relevant policies, EU funding mechanism and encouraged the EU Member States (MS) to adopt national and subnational adaptation strategies. In 2018 the European Commission (EC) will evaluate the state of implementation of the EU Adaptation Strategy, including MS adaptation actions, and prepare a report to the European Parliament and the Council.

In details this session will:

- Discuss the current state of linking CCA and DRR policies and practices in Europe and identify opportunities for bridging current gaps towards an increased coherence between CCA and DRR;
- Share good examples of linking and integrating CCA and DRR at national and regional levels;
- Discuss the available methods and approaches, as well as existing guidance for climate proof project level planning;
- Identify barriers and opportunities to mainstream climate change adaptation into project planning.

The discussion will be fostered by 5 targeted presentations focused on: (1) a new report on increasing coherence of the knowledge base and policies between CCA and DRR prepared by the European Environment Agency (EEA);

(2) the EC work on evaluation of the EU Strategy on Adaptation to Climate Change; (3) the EC work on the Disaster Risk Management Knowledge Centre's report on the State of Science on DRR; (4-5) National Cases: available methods, approaches and guidance in Austria and Germany.

As roundup an interactive discussion will be conducted on good practices, how climate change adaptation can be incorporated into project planning and how coherence between CCA and DRR can be enhanced.

### **Significance to adaptation practice, policy and/or business**

The session will increase the awareness of the advantages of adapting to climate change at European, national and regional levels. Thus it aims to enhance and transfer knowledge on the risk of natural hazards and effective policies and practical solutions for a more resilient and less vulnerable society in the face of climate uncertainty. The session is of interest for funding bodies, practitioners, project implementation organisations, project developers/promotion, project planners, competent authorities, climate change adaptation and disaster risk management experts.

## **1. Climate change adaptation and disaster risk reduction in Europe - Enhancing coherence of the knowledge base and policies**

Sergio Castellari, European Environment Agency (EEA), Copenhagen (Denmark)

By September 2017 EEA will publish a report entitled "Climate change adaptation and disaster risk reduction in Europe - Enhancing coherence of the knowledge base and policies". The report provides an overview of the policies and practices at European and national level on CCA and DRR with particular focus on differences, opportunities and synergies between DRR and CCA policies and measures. It covers also observations and projections of selected natural hazards and their related impacts on relevant EU sectors including socioeconomic losses. Finally the report describes selected successful solutions at National and subnational levels, and provides overview of opportunities on how to better enhance the coherence between CCA and DRR in policy and practice.

The target audience of the report are decision-makers in EU institutions and in EEA member countries, both at national and subnational levels, who are involved in the development and implementation of DRR and/or CCA policies. The report can also be useful to policy advisers and scientific/technical experts.

The report has been prepared by EEA together mainly with its Topic Centre on Climate Change impacts, vulnerability and adaptation (ETC/CCA). It received inputs from DG JRC and PLACARD H2020 project and other international organizations. During the consultation process, experts from the EEA member countries provided valuable comments. During this presentation particular attention will be devoted to introduce a notion of "good practice" of CCA and DRR integration and real good practices cases as described from the new EEA report and from a survey conducted by EEA with EEA member countries in 2016.

## **2. The planned review of the EU Strategy on Adaptation to Climate Change: an opportunity to further reinforce the coordination between CCA and DRR**

Max Linsen, European Commission, DG Climate Action, Brussels (Belgium)

On 22 April, 175 countries signed the Paris Agreement on climate change, including the EU and its 28 Member States. This first-ever universal, legally binding global climate deal is a major milestone in global efforts to fight climate change. Many of the outcomes of the Paris Agreement and the Sendai framework on disaster risk reduction, agreed at the United Nations World Conference on DRR in March 2015, are mutually reinforcing in their goal to promote resilience to natural disasters and reduce the vulnerability of people exposed to climate change impacts. The synergies between CCA and DRR were well recognized in the EU even before Paris. The 2013 EU Adaptation Strategy recognizes the importance of linking climate adaptation to DRR and the need to implement adaptation policies in synergy and full coordination with the disaster risk management policies that the EU and the Member States are developing. Climate risks should be part of the national risk assessments, and

DRR-DRM approaches should inform adaptation planning at national and local level. Finding the best tools to strengthen this link both at the policy and operational level can save human and financial costs for Europe in the years to come. Now, that we are starting to translate the commitments made in Sendai and in Paris into concrete actions, it is even more important to build on synergies and shared objectives. The European Commission's work in mainstreaming climate adaptation in disaster risk reduction policies and plans, inclusion of climate adaptation in risk assessment and on insurance can be examples of this effort. Moreover, the planned review of the EU Strategy on Adaptation to Climate Change (tentatively in 2018) could provide a timely opportunity to further reinforce the coordination between these two areas.

### **3. A new European Commission initiative: The Disaster Risk Management Knowledge Centre**

Karmen Poljansek, European Commission, DG JRC, Ispra (Italy)

A new European Commission initiative, named Disaster Risk Management Knowledge Centre (DRMKC), was launched on 30 September 2015. DRMKC implements a networked approach to translate complex scientific data and analyses into usable information at all aspects of the disaster risk management (DRM) – response, reduction, recovery – and at all levels – local, national, European and global - to provide science-based advice for DRM policies. Particular emphasis is put on linking disaster risk reduction with climate change adaptation, as well as with other aspects such as critical infrastructure protection. The DRMKC contributes to global agreements including the Sendai Framework for Disaster Risk Reduction and the Paris Agreement on Climate Change. One of the most visible outcomes of the DRMKC will be periodic DRM science reports published as multi-author monography edited by the JRC. The first in the series “Science for disaster risk management 2017: knowing better and losing less” was published in May 2017. The preparation of the report succeeded in pulling together a network of 273 contributors - scientists, practitioners and policy makers - from 26 mostly European countries and 172 organizations. It has been endorsed by 11 European Commission Services. The first DRMKC report provides reviews of the scientific solutions and its practical use in various areas of DRM in Europe. It is comprehensive in scope but selective in topic and written in a format that is intended to be accessible to the well-informed practitioner and decision makers. The reviews of the scientific evidence base are summaries of (1) recent advances/outcomes of EU research projects, (2) relevant national work and (3) relevant international work. The report is aiming to bridge science and policy as well operation communities. Therefore, the final scope of the report is naturally divided into three distinct parts: understanding risk, communicating risk and managing risk. The intended audience consists of well-informed practitioners and policy makers, seeking to understand the scientific issues of relevance to their work, specifically civil protection operations and disaster risk policy, but equally climate adaptation policy. The audience includes government officials at EU, national, regional and local level interested in finding ways to better use science, but also scientists to understand work in other disciplines and needs from practitioners.

### **4. Linkage between Adaptation Strategy, Action Plan and Disaster Risk Management and inclusion in project planning – the Austrian case**

Markus Leitner, Environment Agency Austria (EAA), Vienna (Austria) and PLACARD project

The political, socio-economical, scientific, legal and technical issues underpinning natural hazard management have undergone considerable change during the past years. Special attention must be given to the consequences of Climate Change, which will have impacts on the frequency and magnitude of future hazardous events. Therefore conventional protection concepts are no longer adequate in covering all aspects relevant for modern natural hazard management, especially in terms of social responsibility, capacity building, resilience are leading policy development and implementation.

To overcome these limits and to tackle the challenge of rising natural hazards and related risks in Austria, policy has started investing in concepts that support people at risk in terms of more ownership of risk, a step towards balancing public and individual demands and interests in natural hazard management. Further capacity building,

awareness raising, interdisciplinary communication and (international) co-operation were identified as key factors of such a concept.

In the OECD's Environmental Progress Report 2013, Austria's National Adaptation Strategy (NAS) is one of the most comprehensive. Its development built on strong domestic research capacity and extensive stakeholder engagement. DRR-related aspects are mainly part of the sectors "natural hazard management", "disaster management", and "water management". Some other aspects are part of other sectors (14 areas of action are covered in the Austrian NAS), e.g. forest fire protection is dealt with in the "forestry sector" and drought management in the "agricultural sector".

The current NAS to maintain and keep flexibility of all that are concerned by natural hazards and risk in Austria even under a changing climate can be summarised as follows:

- Limiting existing risks for human health, material assets, economic activities and the environment to acceptable levels and to prevent new unacceptable risks, in order to preserve the basis for sustainable, hazard- and climate-proof development in a long-term and foresighted perspective (e.g. by implementing the EU-Floods Directive);
- Reviewing the climate change fitness of existing structural protection measures regarding the current condition of these structures, their functionality and operability and keeping the data/information about the review up-dated;
- Keeping hazard and risk maps at the state-of-the-art by permanently taking into account all relevant alterations in natural and man-made systems;
- Further enhancing coordination and co-operation between spatial planning and risk management;
- Mainstream DRR and CCA into project planning and development;
- Strengthen individual preparedness and precaution.

## **5. Integrating adaptation needs into policy instruments, the case of Germany**

Clemens Haße, German Federal Environment Agency, Dessau (Germany)

Since 2008 Germany has a national Strategy for Adaptation to Climate Change in place, complemented by adaptation action plans in 2011 and 2015. The overall aim is to create a national framework for action in order to avert dangers to the public, natural habitats and the national economy. This framework is intended to make it easier to identify impacts and adaptation needs, and to plan and implement measures. For instance, early incorporation of adaptation aspects into planning can save climate-related costs in the future. This is especially true for the area of reducing risks from extreme weather events via climate-proofing.

However, integrating CCA and DRR in existing policies is a long-term duty. The presentation gives an overview on how key policy instruments in Germany have been evolving over the last years and what could be done in the future. A special focus will be set on the EU Directive on Environmental Impact Assessment and the new need for project planners to take into account also changing climate and climate impacts.

### **Interactive Panel Discussion on experiences and lessons to be shared**

Experiences and lessons learned will be based on the following guiding questions:

- What has already been achieved in terms of aligning CCA and DRR?
- What is still needed in terms of better enhancing coherence in CCA and DRR?
- What are the priority fields where action is still needed?

Moderator: Markus Leitner

Participants: all speakers

## 5.5 Participatory modelling in climate change adaptation – methods and experiences

*Sadie McEvoy, Deltares / Delft University of Technology*

### Participation and co-production

1. Guided coupling of climate adaptation models: from software to stakeholders (Alexey Voinov)
  2. Hydroinformatics approach to collaborative modelling: tools and technologies for engaging stakeholders in water-related decision making (Andreja Jonoski, UNESCO IHE Institute for Water Education)
  3. Group Model Building for Stakeholder Participation in Planning Urban Adaptation to Climate Change – how does it compare to other methods? (Sadie McEvoy, Deltares)
  4. US - Canada negotiating of Great Lakes levels regulation using a collaborative modelling (Guillermo Mendoza)
  5. Collaborative modelling in the Dutch Delta Programme Rivers: engaging stakeholders in long-term decision-making for adapting to climate risks (Andrew Warren, Deltares)
  6. Knowledge co-production allows the emergence of new information for climate change adaptation planning (Marta Olazabal, Basque Centre for Climate Change )
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**Keywords:** Stakeholder participation; collaborative modelling; adaptive planning; co-production of knowledge

Models play a central role in adaptation planning. We model to predict changes in our climate, to estimate the impacts and to predict the responses of social, technical and environmental systems. In addition to providing information outputs, the process of modelling itself offers valuable learning.

Involving stakeholders in modelling processes is a growing area of practice and research, broadly called 'Participatory Modelling'. Participatory Modelling is popular for its promise of improving model quality, increasing human capacity through social learning and creating ownership of the models and support for their outputs. To be relevant and useful, models must include the complexities and uncertainties of the systems they represent. Engaging stakeholders in modelling activities can enrich the model and make it more representative. At the same time, through their participation, stakeholders develop ownership and better understanding of their systems.

The potential for Participatory Modelling in climate change adaptation is widely recognized and there are many methods being employed in practice. Different types of participatory modelling are being used, based on the purpose of the model, the type of participation and the context in which it takes place. To support and improve this growing field, it is important to share experiences and methods from cases and research. This is a first step to developing best practices for practitioners and scholars, as well as identifying knowledge gaps that should be addressed.

This session aims to be an interactive knowledge platform that brings together individuals from different institutes and backgrounds to discuss and exchange knowledge on participatory modelling, existing methods and tools, and their application to climate change adaptation in different countries.

The session will begin with an introduction to the concepts of participatory modelling and their relevance to climate change adaptation. Short presentations from international scientists and practitioners will follow. Their presentations will offer a range of experiences with different methods and tools, adaptation applications and contexts. The session will end with an interactive moderated panel discussion on knowledge gaps, lessons learned and standards for practice.

## **Significance to adaptation practice, policy and/or business**

Participatory Modelling is a promising way of engaging stakeholders in adaptation planning. It facilitates the integrated and representative approach needed to address the complex challenges of climate change. Better models support better informed policies and decisions. Building the capacity of stakeholders, including businesses and vulnerable communities, allows them to engage in adaptation planning and policy making; processes to which they may not traditionally have access. To promote positive results from Participatory Modelling, best practices are needed. This session will support researchers and practitioners of Participatory Modelling share experiences and develop standards for practice in climate change adaptation.

### **1. Guided coupling of climate adaptation models: from software to stakeholders**

Alexey Voinov, University of Twente

Systems analysis and spatio-temporal modelling are long recognized as powerful tools for decision support. A key challenge is the need to synchronize our understanding of systems gained from models, with human perceptions, beliefs, values and preconceived notions about systems. Modelling results may go contrary to preferences and priorities. We find it then difficult to act based on the models and the logic of system 2 type thinking, when it clashes with the intuitive system 1 thinking. Integrated modelling has been successfully developing as a way to bring together knowledge from various disciplines and to use legacy models and code. We see a lot of potential in taking model integration beyond the software coupling, and in addition to computer models consider mental models developed by stakeholders. In natural sciences, there are many successful implementations of integrated modelling through module coupling. Complex climatic simulations are built using this approach. Climatic models are then linked with hydrological or plant growth models. The assumption is that it makes more sense to use existing well developed and tested models as building blocks rather than build the whole system each time from scratch. Further linking to socio-economic models so far has been rare. Model integration should deal with coupling of all sorts of models, including software components and conceptual models produced by stakeholders.

Engaging stakeholders in the modelling process in a participatory way can help resolve some of the contradictions between qualitative and quantitative reasoning, though in many cases it is difficult to organize and conduct the process properly, and it is easily compromised by increasing uncertainties associated with information production and sharing, group thinking, and clustering along cultural, educational or party lines. New technologies inspired by social media and wide access to the Internet deliver opportunities for broad democratic engagement of the public in science and decision making. For socio-economics, where there is even more uncertainty, subjectivity and systemic change implied than in natural science, we advocate for a stakeholder guided process of module integration and call for more transparency and participation in the modelling process. For example, the Distributed Model Integration Framework is based on web service type coupling and is geared towards more open ended and collaborative module identification and assessment. It allows models to be accessed and linked in a standard web browser, making it much easier for stakeholders to use them and understand what the models mean and do.

### **2. Hydroinformatics approach to collaborative modelling: tools and technologies for engaging stakeholders in water-related decision making**

Andreja Jonoski, UNESCO IHE Institute for Water Education

Hydroinformatics is concerned with modelling of water systems and development of information and communication infrastructure that support water management. Over the past couple of decades considerable hydroinformatics research efforts have been put into the design and adaptation of existing modelling, information and communication systems for purposes of enabling active participation of stakeholders and citizens in water-related decision making processes. This presentation gives an overview of lessons learned from these developments, as implemented and tested in several research projects. Three major themes will be addressed: 1) role of models and modelling systems as tools for stakeholder engagement, 2) evolution of networked decision



support and assessment systems (web-based and mobile phone based) for stakeholders' and citizens' participation and 3) emergence of citizens' observatories as systems for active engagement of citizens in environmental management.

The first theme has its deep rooting in the field of hydroinformatics. Aspects of modelling systems such as improved process descriptions, data management and user interfaces have been continuously addressed by modelling experts. However, inclusion of broader groups of stakeholders with diverse knowledge needs and backgrounds introduced new requirements for the modelling systems such as data (dis)aggregation and adaptation of modelling results in both content and form. Suitability of existing models and modelling systems for such applications, as well the needs for their adaptation became active area of research. This also led to the research of the second theme addressed here, about utilization of networks (web, and later mobile phone) for development and deployment of model-based applications for stakeholders, with further content customization, as well as components for negotiation and collaboration. Results from research projects that will be presented, mainly related to flood management problems, demonstrate the feasibility and effectiveness of the proposed web-based collaborative modelling approaches, but also indicate future challenges. There is a clear need for creating open and adaptive applications for stakeholder collaboration that will meet the dynamic and evolving knowledge needs of the stakeholders. This is crucial for sustaining the stakeholder engagement beyond a particular project. The importance of the sustained stakeholder engagement leads to the last theme addressed here, namely the approach of citizens' observatories. A couple of recent research projects show how crowd-sourced data from citizens can complement data sets from existing monitoring networks, and how transparent presentation of the value of such contributions in applications can further engage stakeholders in environmental management.

### **3. Group Model Building for Stakeholder Participation in Planning Urban Adaptation to Climate Change – how does it compare to other methods?**

Sadie McEvoy, Deltares

Participatory approaches to planning urban adaptation are increasingly popular. In cities around the world different methods are being used to engage stakeholders in the planning process. Participatory modelling is one way this is being carried out in practice. Group Model Building (GMB) is a method of participatory modelling that is traditionally used in organizational and operational settings. The method aims at creating shared understanding of complex systems through social learning. In GMB, a facilitator-led group develops a system model, using causal loop, system dynamics or stock-and-flow diagrams.

In a series of experiments, in 2015 and 2016, GMB was used in participatory planning for urban adaptation to climate change. In the experiments the process and outcomes of groups using qualitative GMB were compared to groups using three different types of participatory planning methods – a quantitative map-based planning support tool, a stepwise guideline and the traditional approach. In the experiments, groups of graduate students were assigned stakeholder roles and given the same district-level design challenge. In the full-day workshops student groups were assigned one of the four planning methods and supported by facilitators. Questionnaires, process records, observations and the final plans were used to analyse the effects of each method on the participatory planning process itself and the outcomes that were produced.

Compared to the other methods in the experiments, groups that used GMB showed higher rates of learning and convergence in perception of the problem. These effects were robust for groups that started with disparate views of the problem and potential solutions. Other findings were that GMB groups developed adaptation plans with more holistic and integrated views of the problem than groups using other methods; GMB also appeared to support the most successful cooperation in working groups during the experiments. Participants in GMB groups valued the model building process and the model itself, finding it useful for identifying key drivers in the system

and potential solutions. Surprisingly, satisfaction with the technical quality of designs was not lower for groups using GMB than groups that used the data-driven planning support tool.

In this presentation, the findings of the experiments will be discussed, along with experience from field cases. Focus will be given to the implications of using GMB in urban adaptation planning.

#### **4. US - Canada negotiating of Great Lakes levels regulation using a collaborative modelling**

Guillermo Mendoza, US Army Corps of Engineers Institute for Water Resources

The Great Lakes are an enormous body of water with an extension of 245,000 square kilometres and 540,023,000 cubic kilometres of water. It consists about 20% of the world's total freshwater and 90% of the United States' total. It is a very important water body for economic, social, and environmental interests of the US and Canada. As a result, a century-old commission exists to help the two countries address challenging issues.

In 2007 after a series of droughts and floods that affected navigation, hydropower, recreation, property damages, and environment interests, the US and Canada recognized it was necessary to update previous operation treaties from 1952 and 1956 that affect Lake Ontario and the Saint Lawrence Seaway. In specific, the Commission's 1956 Orders of Approval and regulation of the flows are not able to adequately address both economic and ecosystem. Research had shown that about 26,000 hectares (64,000 acres) of shoreline wetlands were degraded.

In 2009, the International Joint Commission (IJC) embarked on a Shared Vision Planning study, a collaborative modelling initiative, to determine a new regulation plan to be negotiated by the trans-boundary interests, to include the various stakeholder interests, and regional, local and tribal governments. The Shared Vision Planning framework was proposed by the US Army Corps of Engineers and subsequently adopted because after many years of studies, researchers were not able to lead 'the board' (the decision makers) into decision making. The challenge was that there were little understanding of the multiple planning objectives on which to structure the study, the system was very complex with many uncertainties, and there was no clear and structured way to evaluate trade-offs across the various interests by the various interests. Moreover, the IJC did not have a consistent structured planning process, or protocol to couple technology and science into decision making across the various agencies. The consideration of climate change also led to a new way of thinking about addressing uncertainty. The recommendations were complete and approved in 2014.

This presentation will present this Shared Vision Planning study that led to recommendations to meet the various demands of the diverse interests in the Lake Ontario and Saint Lawrence Seaway, while protecting against water extreme water levels, restoring wetlands and preparing for climate change.

#### **5. Collaborative modelling in the Dutch Delta Programme Rivers: engaging stakeholders in long-term decision-making for adapting to climate risks**

Andrew Warren, Deltares

The Netherlands is currently one of the most heavily protected deltas in the world. However, the impacts of future climate change present a number of serious risks to the country. These include the possibility of increased peak river discharges that exceed current protection standards and cause widespread damage to low-lying areas of the country. The timing and magnitude of any such future discharge extremes remain uncertain; nevertheless, it is in the interests of Dutch society to anticipate these potential futures and implement adaptation measures to reduce vulnerabilities and mitigate these risks. For this reason, the Dutch government launched the Delta Programme in 2010.

Many of the adaptation options considered during the Delta Programme involved land use changes that would cause significant disruption to communities (e.g. relocation). A key pillar of the Delta Programme was therefore the involvement of large numbers of stakeholders throughout the adaptive policymaking process. For the Delta

Programme Rivers, this was achieved using a collaborative modelling approach. A computational model, called the 'Planning Kit', was developed and used with various groups of stakeholders to better inform their policymaking discussions about the effectiveness of different adaptation options in mitigating flood risks.

This oral presentation will analyse and critique the implementation of this collaborative modelling approach during the Delta Programme Rivers. It will identify those characteristics, structures, and processes of collaboration and modelling that were important in achieving programme objectives, in addition to identifying those features of the approach that the stakeholders involved most valued and appreciated. It will demonstrate that the approach relies upon the highly-structured involvement of large numbers of stakeholders at different levels of participation. It will also suggest that the approach could be adapted to similar situations and contexts where many different stakeholder values and opinions proliferate, but where the scientific knowledge base is largely certain or uncontested.

## **6. Knowledge co-production allows the emergence of new information for climate change adaptation planning**

Marta Olazabal<sup>1</sup>, Aline Chiabai<sup>1</sup> Sébastien Foudi<sup>1</sup> and Marc B. Neumann<sup>1,2</sup>

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In decision-making related to climate change adaptation, approaches that contemplate multidisciplinary environments from an integrated and cross-sectoral viewpoint can be useful to understand the mechanisms under which a phenomenon can impact a certain system and its dynamics. Creating an arena where social, institutional and scientific agents can be brought together broadens our understanding of the impacts and assists in developing meaningful scenarios of adaptation. This paper aims at analysing this hypothesis by means of a participatory modelling tool based on cognitive mapping that allows the integration of different agents' views each expressing particular knowledge or experience of a distinctive part of the system. We illustrate the analysis for the case of heatwave impacts in the urban environment of Madrid (Spain). We interview 24 decision-makers and researchers with expertise in different sectors: urban planning, green infrastructures, energy, water, health and climate change. We collect individual maps from the agents that illustrate their understanding about the impacts of heatwaves in the city as well as their perceptions on feasible adaptation options. We combine this information in an aggregated map with the view of uncovering cross-sectoral and multilevel impacts of heatwaves. Preliminary results show that the collected maps vary considerably in size and complexity. Positive impacts are more easily perceived and there is evidence of contradictory observations in some cause-effect interactions showing possible trade-offs. Based on the analysis of the final combined map, we conclude that the "super-stakeholder" who could provide full knowledge on the system's mechanisms, does not exist. The maximum explanation by an individual is 25% of the final map. Researchers and decision-makers provide similarly complex maps; however, neither of the two groups are able to explain more than 60% of the final map. Finally, we find evidence that the combination of individual maps not only provides a broader and more integrated perspective on the system's dynamics but also, information about unexpected interactions among its elements, evidencing the emergence of new knowledge. Our findings support current theoretical literature that asserts the importance of knowledge co-production approaches and call for the need of new interactive ways of combining knowledge from science and policy to reduce some of the uncertainty involved in climate change adaptation planning.

## 4.7 Institutional economics of climate change adaptation

*Alexander Bisaro, Global Climate Forum*

### Economics and business

#### Governance

1. Institutional Analysis and Climate Adaptation: a Systematic Review (Matteo Roggero)
  2. Adaptation governance: Addressing problems of fit by rescaling institutional arrangements (Marco Pütz, Swiss Federal Institute for Forest, Snow and Landscape Research )
  3. Enterprise, Adaptation and Olsonian Actors: When, why and how are corporations engaging in water allocation reform to deliver collective adaptation goods? (Dustin Evan Garrick, University of Oxford)
  4. Attracting private finance for coastal adaptation: aligning public and private investor interests (Alexander Bisaro, Global Climate Forum)
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**Keywords:** institutions, governance, institutional economics, commons, adaptation policy

Implementing adaptation measures involves a range of interdependencies between public and private actors. Whereas adaptation has traditionally been considered the remit of public actors, as both fiscal and climate policy discourses have increasingly emphasized private involvement in adaptation, new configurations of private and public roles are emerging. Emerging governance arrangements, such as public-private partnerships, entail different interdependencies between public and private actors in regards to adaptation in, e.g. coastal protection, water management or agriculture. While for private adaptation measures, e.g., green roofs, public actors are experimenting with various policies to incentivise private actors through, e.g., subsidies or capacity building measures.

Such interdependencies are regulated by institutions and thus understanding the role institutions play in enabling and constraining adaptation is crucial. For example, the IPCC Fifth Assessment Report emphasises that “governance structures, and institutions to resolve conflicts” are needed to advance adaptation. Indeed, the now substantial literature on barriers to adaptation identifies cognitive and institutional barriers to adaptation. Yet despite this growing awareness, institutions in adaptation have largely been studied descriptively. Developing a more theoretically-grounded institutional analysis in adaptation research is therefore an important way forward. Theory is key in understanding the complex processes associated with adaptation and institutional change, allowing analyses to focus on specific drivers and dimensions. Moreover, well-tailored theory moves analysis from identifying problems to understanding the processes underlying them so as to formulate robust policy recommendations.

This presents a significant opportunity for adaptation researchers to engage with institutional economics scholarship, as the latter offers a wealth of theories and approaches for understanding interdependencies and overcoming barriers directly relevant to climate adaptation. Contributions such as the IAD framework, transaction costs economics, volitional pragmatism all offer insightful perspectives to understand the role of institutions in regulating public and private interdependencies in adaptation. Indeed, recent adaptation scholarship has pointed to opportunities to integrate empirical findings with well-developed theory in other closely related domains, e.g. the commons or public goods literatures, as these literatures have developed policy recommendations based on extensive research in a variety of different settings.

Taking stock of these developments, this session builds on momentum generated by sessions convened at previous ECCAs, which highlighted the diagnostic approach of institutional analysis and the role of transactions costs in effective governance arrangements, expanding the previous focus to include a deeper integration of

theories of public goods and institutional fit and further flesh out the policy recommendations generated by such perspectives.

### **Significance to adaptation practice, policy and/or business**

The session is significant to adaptation policy because the papers develop insights on the basis of institutional economics theory and thus it is envisioned that robust policy recommendations will be developed, both for the sectors specifically addressed, i.e. water, forestry, flood risk management, and for adaptation policy more generally. Because the session builds on previous sessions at ECCA, and is drawing a growing group of scholars that has coalesced around the idea of developing theoretically-grounded approaches to institutions in climate change adaptation, the session promises to deliver a mature set of policy recommendations drawing on the toolbox of institutional economics.

### **1. Institutions and autonomous and public adaptation to climate change: theory and the case of fluvial flood risk**

Jouni Paavola, Centre for Climate Change Economics and Policy, School of Earth & Environment, University of Leeds, UK

This paper examines autonomous and public adaptation to climate change, with an emphasis on the role institutions play in demarcating, fostering and hindering them, as well as in potentially combining them. Much of the attention of adaptation scholarship as well as adaptation finance has focused on public adaptation: the delivery of adaptation plans and measures by public bodies. Yet, most adaptation will take place autonomously by households, businesses and non-governmental entities. While both types of adaptation have their own promoters in the literature, it is still poorly understood what are their relative strengths, weaknesses, overlaps and complementarities, and how they map on to incremental and transformative adaptation. This paper draws from institutional economics to shed light on these issues. It will suggest that while autonomous adaptation can be both incremental and transformative, it will be undertaken within restricted opportunity space that the adapting agents are not well placed to restructure. Public adaptation can also be incremental and transformative, but while it also has capacity to transform opportunity space it may fail to do it so as to actually foster autonomous adaptation. That is, autonomous action may be mal-adaptive because it is restricted to second-best alternatives, while public action may be mal-adaptive because public measures may fail to align with private needs and priorities. Polycentric institutions may have potential to combine bottom-up autonomous adaptation and top-down public adaptation in a way that fosters the transformative capacity of autonomous adaptation. The paper exemplifies these arguments by examining adaptation to increased fluvial flood risk in developing and developed country settings.

### **2. Adaptation governance: Addressing problems of fit by rescaling institutional arrangements**

Marco Pütz, Swiss Federal Institute for Forest, Snow and Landscape Research WSL Economics and Social Sciences

Adaptation governance is multi-level, cutting across different sectors and policy domains, and involving a wide range of stakeholders, increasing the complexity of decision-making. Institutions play a key role to handle the challenges of climate change adaptation and capacity building needs. Adaptation practice is understood as being shaped and constrained by a set of institutions that govern individual and collective behavior. According to North's classic definition (1991) institutions are the rules of a game in society that shape and constrain the behavior of adaptation agents. The paper uses adaptation governance in Switzerland as an example to study how institutional arrangements are produced and re-produced within a multi-level governance framework. A key challenge of adaptation governance is that policies are developed at the international or national level but climate change impacts are effective at the local level. What is appropriate for the local level might be considered undesirable at a global scale. Furthermore, climate change impacts, vulnerabilities or adaptive capacities can vary tremendously between regions and municipalities. These challenges are usually referred to as problems of fit. Generally, problems of fit constitute a common feature of environmental governance and refer to the mismatch

between the geographical extent of an environmental issue and the territorial scope of institutions affecting its governance. In order to tackle this mismatch, the idea is to create institutional arrangements which are tailored to fit to the geography of the environmental issue. Adaptation governance is used as a case study to look at the institutional arrangements as well as rescaling strategies and projects created to tackle this mismatch. The paper investigates how problems of fit are addressed and analyses in what respect rescaling can be regarded as a response to problems of fit and as a strategy to improve individual and collective adaptation decision-making at various governance levels.

Bridging scientific literature on institutional economics, environmental governance, governance as practice and politics of scale the paper wants to apply scalar thinking and the concept of rescaling to adaptation governance. The paper conceptualises rescaling as a multidimensional phenomenon and proposes four analytical categories: rescaling of transnational coordination, intergovernmental coordination, across issue areas, and science-policy interaction. These analytical categories are used to analyse adaptation governance in Switzerland. Assessing rescaling practices helps to identify benefits, shortcomings and impacts of adaptation governance, to better understand what fosters or impedes climate adaptation, and to design institutional arrangements for effective adaptation.

### **3. Enterprise, Adaptation and Olsonian Actors: When, why and how are corporations engaging in water allocation reform to deliver collective adaptation goods?**

Dustin Evan Garrick, University of Oxford, Smith School of Enterprise and the Environment

Intensified competition for freshwater, coupled with the effects of climate change on water availability and variability, has prompted adaptation to water allocation institutions to cope with water scarcity and climate extremes, including the adoption of caps on water extractions, rules to enable trading across uses and users and mitigation of environmental impacts. In this context, private enterprise has awoken to water risk, signaled by 'water crises' being recognized as one of the top global risks by the World Economic Forum for five years running. The response of the private sector has included pronouncements at the Rio+20, the development of consortia such as the 2030 Water Resources Group and the adoption of the UN CEO Water Mandate, which, inter alia, commits signatories to the development of 'collective action' strategies to steward shared water resources, monitor and disclose water risks and related actions. Despite the emerging rhetoric, little is known about why, when and how private enterprise engages in collective action around water allocation reform. These developments reveal theoretical and empirical gaps in our understanding of corporate contributions to collective adaptation goods in the water sector. This paper examines water allocation reform as an action arena for addressing these gaps, testing factors and institutions shaping the emergence of 'Olsonian actors' – the proposition that builds from Mancur Olson's theory of collective action and public goods to examine circumstances in which the benefits of the public goods to large firms exceed the costs of providing them, incentivising corporate provision of public goods. This paper sets up a conceptual framework to assesses collective action strategies related to water allocation reform across a sample of large firms in the food and beverage sector. The analysis is expected to yield insight about the conditions and contexts under which the rhetoric on collective action delivers actions and outcomes for enhanced (and reduced) adaptive capacity and collective adaptation goods in water allocation reform.

### **4. Attracting private finance for coastal adaptation: aligning public and private investor interests**

Alexander Bisaro, Global Climate Forum

Climate change will impact the world's coasts, raising sea-levels, increasing flood risk, and threatening lives and assets. Coastal adaptation can reduce these impacts and investing now in such measures, though costly, will bring greater benefits over the longer term particularly in urban areas. Investing in coastal adaptation thus presents a win-win opportunity, decreasing flood risk for communities, while providing potential financial returns for investors. Yet many coastal urban areas remain under-protected. An important and under-researched dimension

of this puzzle is the role that financial governance arrangements play in promoting or hindering private investment in coastal adaptation. To address this, we develop a framework to analyse private coastal adaptation investment channels, identifying key actors and financial instruments and characterizing the risks associated with these based on the finance literature. Our analysis identifies several coastal adaptation investment channels that potentially align public actor and private investor interests. We find that in addition to government debt instruments, Public Private Partnership (PPP) equity and debt instruments may be attractive institutional investors, e.g. pension funds and insurers, and PPP equity may be attractive to corporate investors, e.g. project developers, while for public actors, PPPs can reduce balance sheets and maintain control over outcomes. We then survey several cases of coastal adaptation finance in Europe, assessing how the identified investment channels play out in practice, discussing policy instruments, e.g. concessional loans, tax incentives and standards, for further enabling private investment in coastal adaptation. Further, we supplement this overview with a case study of private finance for coastal adaptation in Hamburg HafenCity in which drivers and barriers for attracting private investment are qualitatively discussed. We find in the HafenCity development that while the lengthy review process for bids of project developers is cumbersome, this was balanced by allowing developers' an "option period" for planning without incurring investment costs once a bid was won, thus making HafenCity attractive to private investors. Finally, we conclude that a better understanding of the incentives facing private investors is needed to inform design of policy instruments to enable coastal adaptation; the perspective gained will inform ongoing work in the EC-funded GREEN-WIN project.

## 6.11 Evaluating participatory social change processes for adaptation

*James Butler, CSIRO*

### Participation and co-production

1. An evaluation approach to assess the priming of adaptation pathways governance in Indonesia (James Butler, CSIRO)
  2. Using Transformative Scenario Planning process to stimulate social changes and enable sustainable climate adaptation strategies (Edmond Totin, International Crops Research Institute for the Semi-arid Tropics (icrisat))
  3. Evaluating social learning processes to address climate uncertainties in planning (Susannah Fisher, IIED)
  4. What do scenarios achieve, and how do we know? Assessing change in stakeholder perceptions in a participatory adaptation planning process (James Butler, CSIRO)
  5. Evaluating the Transformative Scenario Planning (TSP) process as a tool for developing sustainable climate adaptation strategies in India (Prathigna Kodira, Indian Institute for Human Settlements)
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**Keywords:** Adaptation pathways, development, social learning, evaluation, monitoring

To achieve effective and transformational climate adaptation requires collective action amongst multiple stakeholders, which is largely dependent upon a shift in their mental models and perceptions. Researchers have been increasingly experimenting with participatory processes and tools which aim to generate social change through learning and reflection. However, evaluating the extent to which such processes have triggered social change is fundamental to improving them, as well as showing causality and value-for-money to funding agencies. This is challenging, since researchers must aim to attribute change to their projects, which is often difficult because impacts are delayed, and are probably influenced by coincidental factors and issues. Evaluation must also aim to understand learning and its characteristics in different social contexts. In addition, it is important to identify the micro-politics and power dynamics which may influence or impede change during participatory learning processes. This session will explore some of the tools and results of evaluations carried out in the developing world. Case studies from projects in southern, East and West Africa, Indonesia and India will present different approaches developed, and their results and utility. The co-convenors are the Commonwealth Scientific and Industrial Research Organisation, the International Institute for Environment and Development, and the Adaptation at Scale in Semi-Arid Regions consortium from Africa and India. The outcomes of the session will be a better understanding of evaluation approaches that work, and the practicalities of using them in developing country contexts where capacity and resources are typically limited, but the necessity for change is great.

### Significance to adaptation practice, policy and/or business

Monitoring and evaluation is central to development, but traditional approaches may not be adequate to understand social change processes, which are typically amorphous and unpredictable. This session will provide both development practitioners and researchers with an opportunity to learn about learning, and the range of tools and methods being developed in different locations and contexts.

### 1. An evaluation approach to assess the priming of adaptation pathways governance in Indonesia

James Butler, CSIRO, Australia

Attaining climate compatible development for vulnerable rural communities demands an alternative approach to planning and decision-making based on adaptation pathways principles. However, this requires existing development planning to transform and apply practices and structures in common with adaptive co-management, which is challenging in developing countries with limited stakeholder capacity and entrenched power dynamics. Using a case study in rural Indonesia, we asked the question 'how can existing development planning processes be transformed to integrate adaptation pathways practice, and how can this process be evaluated?' We conducted a 4-year project which aimed to 'prime' stakeholders in the Indonesian village



development planning process to become change agents, and champion adaptation pathways practices. We designed a participatory evaluation methodology to track the evolution of adaptive co-management and outcomes in terms of a governance transformation of the Indonesian village planning system. The evaluation indicated that the research team became change agents, as did numerous stakeholders at the community and NGO levels as a result of the participatory planning processes and tools. Leadership, trust, cross-scale social networks, knowledge integration, innovation and systems understanding emerged. Numerous innovative adaptation strategies were trialed and adopted by communities, and some were funded by government, NGOs and private sector stakeholders. However, institutional changes within government departments and resourcing of adaptation pathways practice in the planning system did not occur within the project's life due to entrenched centralized planning protocols and vested political interests. This study provides three important insights for adaptation pathways practice: 1) our approach to priming stakeholders was effective; however, the immediate influence of change agents was constrained by entrenched government processes and vested interests; 2) policy 'windows of opportunity' and climate or other shocks may therefore be necessary to trigger governance transformation; and 3) because institutional change occurs slowly, projects aiming to generate governance transformation in Indonesia must expect to continue for long periods (i.e. > 4 years). Overall, we suggest that if repeated on a regular basis, our project's participatory evaluation methodology can 're-prime' change agents to seek windows of opportunity for change.

## **2. Using Transformative Scenario Planning process to stimulate social changes and enable sustainable climate adaptation strategies**

Edmond Totin, International Crops Research Institute for the Semi-Arid Tropics, Bamako, Mali

The Transformative Scenario Planning (TSP) process is often portrayed as a useful tool for grappling with uncertainty and the complexity of social-ecological challenges. TSP holds the promise to provide a platform for social learning and to stimulate changes in 5 potential domains, including language, understandings, relationships, intentions and actions. TSP offers this potential by bringing concerned stakeholders from different perspectives together to reflect on plausible future trajectories in situations that are generally accepted to be untenable in their current form. Our case-studies will build on the Adaptation at Scale in the Semi-Arid Regions – ASSAR – project through which a “simplified” version of a TSP process is being trialed in different historical, social, cultural and agro-ecological contexts of drylands to enable transformational climate adaptation strategies. This research uses a comparative case-study approach to examine whether the TSP process succeeds to enable transformation of social practices through learning across the different regions where the ASSAR project operates. This includes determining what changes can come about through the use of a TSP process and what aspects of the approach bring about change. The following research questions are addressed: i) to what extent and in what form, does TSP transform understandings, language, relationships, intentions and actions? ii) What aspects of TSP caused change to come about/ what triggered the change (e.g. in perspectives)? And iii) how did the external interventions interacting with the TSP process make room for changes? The study is grounded on social context observations, surveys and key informant interviews with participants of the TSP workshops. The methodological approach sought to achieve in-depth insights into local social dynamics and interplays between TSP processes and externalities by building on the baseline and end-of-workshop information to elicit social learning outcomes. The key lessons emerging from the comparative case-studies contribute to channeling collective efforts towards adaptation strategies.

## **3. Evaluating social learning processes to address climate uncertainties in planning**

Susannah Fisher, International Institute for Environment and Development, London, UK

Social learning processes provide a way to address complex problems like climate uncertainty by integrating diverse knowledges and value systems at many different levels. It engages relevant stakeholders in co-framing challenges at community, regional, national and global scales with the aim of mobilizing technical, institutional and social knowledge. Climate change presents several challenges to planning and decision-making because of:

the changing nature of climate risks; the scale of the potential risks; and the significant uncertainties around future climate change. Dealing with uncertainty is not new in policy decision-making. However, what is unique in the case of climate change is that the challenges in forecasting climate and emissions mean that it is impossible to provide accurate probabilistic projections of what the future climate will look like, and this rule out many traditional approaches to risk management. This presentation looks at three case studies from local adaptation planning in India, Uganda and Kenya to understand and evaluate how social learning processes particularly address the challenges of climate uncertainty. It looks at the four key dimensions of social learning – engagement, capacity, iteration and challenging institutions, using the Climate Change and Social Learning (CCSL) project’s evaluation framework – to understand how each dimension contributes to the challenges in uncertain evidence and long time frames of planning in the context of climate change. The presentation will trigger discussion about the development of indicators and methods for ongoing refinement of the CCSL framework.

#### **4. What do scenarios achieve, and how do we know? Assessing change in stakeholder perceptions in a participatory adaptation planning process**

James Butler, CSIRO, Australia

Increasingly, research for development and positive transformation centers on ‘action research’, casting researchers as change agents who partner with implementing agencies and beneficiaries to support collectively-defined outcomes. Participatory scenario planning that explores alternative future visions is a popular vehicle in this regard. Done effectively, it can potentially catalyze single, double, and triple loop learning that can support adaptation to future change. However, little of the scenario planning work to date has been formally or consistently evaluated, creating a gap in our understanding of the roles of both products and processes of future scenario exercises in contributing to adaptation outcomes. Furthermore, effective monitoring and evaluation of scenario processes is necessary to improve accountability to research funders, partners and beneficiaries, and to guide future investments in adaptation research.

In this paper, we discuss evaluation of a scenario planning process through surveys conducted before and after a series of climate adaptation workshops in Nusa Tenggara Barat (NTB) Province, Eastern Indonesia, to assess change in participants’ perceptions during the course of the workshop. Surveys were completed by 109 stakeholders working at multiple organizational levels. This evaluation method was complemented by interviews with project participants at various intervals during the project, discussed elsewhere in this session. Together these approaches sought to identify evidence of participants’ single-, double- and triple-loop learning over the project lifetime and beyond.

Survey questions elicited perceptions of the region’s greatest challenges, the importance of climate change among these challenges, beliefs regarding causes of climate change, feelings associated with climate change, risks and preparedness for climate change, and timeframes associated with the future. After the workshops, more participants strongly agreed that policies were able to cope and associated the future with longer timeframes, but views on the personal risk posed by climate change became increasingly polarized. Well-being, climate, and food security topped the list of challenges before the workshops, but climate, environment, and human resources did after. These results suggest an increase in optimism and empowerment, and engagement with and concern about climate change. While the identification of climate change as a key challenge did not change, concern with well-being and food security shifted to environment and human resources, possibly reflecting recognition of underpinning challenges discussed in the workshop, more systemic collective thinking, and triple-loop learning. Results diverged notably between participants working at different organizational levels, affirming the need for participatory scenario processes to engage stakeholders at all levels.

#### **5. Evaluating the Transformative Scenario Planning (TSP) process as a tool for developing sustainable climate adaptation strategies in India**

Prathijna Poonacha Kodira, IIHS, Bangalore City Campus, Bangalore, India.

Multi-stakeholder participatory scenario planning exercises present opportunities for tackling present day challenges that are marked by increasing complexity, spread across systems and scales and involving multiple actors by actualizing social learning through diverse perspectives. As part of the ASSAR project in India, a modified version of Reos Partner's Transformative Scenario Planning (TSP) process is being trialed as a potentially useful tool to address issues related to the water system in the urban context to enable transformational adaptation. The research site is located in Bangalore city and faces issues such as water scarcity for consumption, pollution and over extraction of ground water and mismanaged drainage systems. The process aims to bring concerned stakeholders together to build stories that illustrate a range of potential futures that could come from taking different paths for dealing with those issues. The proposed outcome is a transformation among participants in 5 domains: language, understanding, relationships, intension, and action that could result in potentially transforming the future. However, evaluating TSP becomes important and necessary in order to understand if transformational change can be achieved through this process, what are the necessary conditions for its success and how does it contribute to building climate adaptation strategies. Following research questions will be addressed in an attempt to unpack the above. i) How and to what extent does the TSP process transform language, understanding, relationships, intension and action among participants? ii) Does the TSP process offer anything novel to developing adaptation strategies? iii) What and how do external factors influence the process of TSP? iv) Does TSP enable 'real' participation of all involved stakeholders? In order to answer these questions, we will use baseline and after-workshop surveys, key informant interviews, social context observation and mapping of power dynamics among participants. Findings from the evaluation will help understand how TSP plays out in an urban Indian setting with its peculiar social, cultural and geographical context and how it contributes to enabling transformational climate adaptation.

## 10.3 Climate change adaptation in agriculture, agroforestry, and fisheries – from knowledge to policy instruments and concrete solutions

*Ana Iglesias, Universidad Politecnica de Madrid*

### Agriculture & forestry

1. Climate Vulnerability in Nordic Agriculture – what can we learn from an interactive assessment methodology? (Tina-Simone Neset, Linköping University)
  2. The impact of soil carbon sequestration on adaptation in Europe's agricultural sector and the potential role of regulatory instruments (Jonathan Verschuuren, Tilburg University)
  3. Farm Woodlands for Ammonia Mitigation and Carbon Sequestration – costs and benefits (William Bealey, Centre for Ecology & Hydrology)
  4. State of play of fisheries and aquaculture in Québec under climate change (Anne Blondlot, Ouranos)
  5. Towards productive and socio-natural urban landscapes – tapping urban agriculture's potential as a tool for sustainable development (Bettina Steuri, Hafencity University)
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#### 1. Climate Vulnerability in Nordic Agriculture – what can we learn from an interactive assessment methodology?

Tina-Simone Neset, Linköping University

This study builds on an interactive geographic visualization tool - AgroExplore (Wiréhn et al 2016). This tool was designed to support dialogues with Nordic agricultural stakeholders to explore the dimensions of agricultural vulnerability, and assess the relevance and thresholds of different variables. We present results from focus groups with Swedish stakeholders and discuss the opportunities and limitations of applying an interactive assessment tool.

Agriculture is one of the most vulnerable sectors to future climate change and has as such been the object of multiple studies concerning vulnerability assessments during recent years. A number of these studies focus on composite vulnerability indices as means of assessing and communicating specific vulnerability scores to inform planning and decision-making. AgroExplore was designed based on the notion that a quantitative score of a vulnerability index can differ strongly depending on the selection of included variables, weighting mechanisms as well as summarizing methods (Wiréhn et al 2015). Therefore, AgroExplore aims at increasing transparency by means of a highly flexible user interface, supporting both the selection and de-selection of variables, weighting mechanisms as well as moving variables between the vulnerability dimensions exposure, sensitivity and adaptive capacity. Variables are presented with their thresholds, which allows for expert discussions on relevance and possible changes. For each variable, the correlation to the vulnerability dimension is given.

The results presented in this study are based on three focus group sessions with agricultural experts, professionally active in the South East of Sweden. Participants represented the national board of agriculture, the county board, as well as branch organizations and private consultancies. Several of the participants were also part-time farmers and referred during the workshops to these experiences in addition to their professional knowledge. The assessment focused on the relevance of variables and thresholds as well as how variables are weighted, what vulnerability dimension they are considered to contribute to and what correlation the selected variables have on this dimension of vulnerability.

This assessment provided valuable insights into aspects of the overall vulnerability of Swedish Agriculture, but also regarding the functionality of AgroExplore as a facilitating tool for vulnerability assessments. The analysis of the qualitative data revealed a rich discussion and evaluation of vulnerability variables included in the

AgroExplore tool, but also a wider discussion regarding the vulnerability of agriculture and other aspects that might not be captured in the tool.

## **2. The impact of soil carbon sequestration on adaptation in Europe's agricultural sector and the potential role of regulatory instruments**

Jonathan Verschuuren, Tilburg University

In agriculture, adaptation usually is considered together with mitigation and food security, as these three factors are interlinked, hence the focus on 'climate smart agriculture' (CSA) as an approach to developing the technical, policy, and investment conditions to achieve sustainable agricultural development for food security under climate change. CSA is composed of three pillars: sustainably increasing agricultural productivity and incomes, adapting and building resilience to climate change, and reducing or removing greenhouse gas emissions (FAO 2013). So far, only a few countries in the world have regulatory instruments in place aimed at stimulating farmers to convert to climate smart practices, although these schemes all have a primary focus on mitigation (Verschuuren, forthcoming). Experiences in these countries, such as Australia, show that, in practice, increased resilience is often a side-effect of carbon-offset projects, particularly of those projects aimed at increased carbon sequestration in agricultural soils, as these lead to more fertile soils and better moisture retention and thus to increased production and better water management. Soil carbon plays an important role in maintaining soil structure, improving soil-water retention, fostering healthy soil microbial communities, and providing fertility for crops (Kane 2015; Lal 2014; Alliaume et al., 2013). Also, soil-carbon projects are often part of the introduction of wider on-farm regenerative practices that focus on soils, water, and biodiversity.

This paper reviews the potential for adaptation of a policy aimed at increased soil carbon in agriculture and discusses the regulatory approaches that the EU can adopt to stimulate Europe's farmers to adopt soil carbon projects. The paper consists of three parts. First, a broad literature study will reveal the current knowledge on the benefits of increased soil carbon sequestration for adaptation. Second, an empirical study into the experiences with soil carbon projects under Australia's carbon farming legislation will show the regulatory approach that was chosen in that country and the stakeholders' experiences with that legislation. Australia was chosen for this empirical research because it is the only country in the world that has a regulatory framework in place that allows farmers to generate carbon credits through increased soil carbon sequestration. Third, current EU climate and agricultural policies will be reviewed with the aim to find anchor points for a policy that stimulates farmers to increase soil carbon sequestration. Focus will be both on the Common Agricultural Policy and the EU's climate policy, in particular the EU ETS and the Effort Sharing Decision.

## **3. Farm Woodlands for Ammonia Mitigation and Carbon Sequestration – costs and benefits.**

William Bealey, Centre for Ecology & Hydrology

The impacts of nitrogen (N) pollution from agricultural practices are a global problem. Nitrogen contributes to a cascade of environmental effects, including eutrophication of terrestrial and freshwater ecosystems, and acidification of soils and lakes. Furthermore, nitrogen cycling affects atmospheric concentrations of three important greenhouse gases: nitrous oxide, carbon dioxide, and methane.

Emissions of reactive N ( $N_r$ ) have increased throughout the 20th century as the world's population grew and needed to be fed. Ammonia ( $NH_3$ ) is a key form of  $N_r$  pollutant dominated by the agricultural livestock sector originating from animal manures and fertilizers. The current levels of nitrogen management of nitrogen is wasteful as 80% of the input of  $N_r$  is lost to the environment.

Mitigation options currently focus on technical measures like decreasing nitrogen content in animal feed or improved methods for storage and spreading of animal manures, and urease inhibitors for mineral fertiliser application. Planting trees around livestock housing to recapture ammonia and increase carbon storage can be seen as an alternative pollution mitigation option. Trees are effective scavengers of both gaseous and particulate

pollutants from the atmosphere due to trees having a higher surface roughness. Trees also lock carbon into both the soil and vegetation.

The cost-effectiveness of the two planting schemes were estimated over a 40 year period examining the co-benefits of sequestering carbon and reducing ammonia emissions. One scheme involved planting trees downwind of animal housing. The second scheme looked at planting trees as a shelter for livestock managed under the trees. Costs to the farmer and social benefits were estimated in terms of damage costs of ammonia and non-traded prices of sequestered carbon.

Results showed that taking social benefits into consideration both schemes were costs effective for both ammonia reduction and carbon sequestration. The main cost to the farmer was the opportunity cost of changing from arable to forest.

There are multiple cross-cutting 'win-wins' in planting farm woodlands around hot-spots of ammonia:

- Reducing nitrogen deposition to nearby semi-natural habitats will lower critical load/level exceedance
- Carbon sequestration contributes a role in achieving the emission reduction targets for CO<sub>2</sub>
- Augmenting afforestation targets for the UK
- Improved animal welfare as trees provide protection from predators and inclement weather.
- Enhanced biodiversity through the integrated farm woodlands and bio-corridors.
- The potential for producing a price premium for produce e.g. woodland chicken or pork
- Visibility impacts can be improved by trees

#### **4. State of play of fisheries and aquaculture in Québec under climate change**

Anne Blondlot, Ouranos

The objective of this study was to build a portrait of the current knowledge and expertise on climate change vulnerabilities, impacts and adaptation related to fisheries and aquaculture in Québec, Canada, a territory that spans over 1 667 712 km<sup>2</sup>.

First, a socio-economic portrait of the different sectors of activity, such as commercial fisheries and aquaculture, subsistence fishing and recreational fishing was elaborated. This section showcases the current fisheries sector situation for the Canadian province and enables an understanding of historical evolutions and recent trends. It is important to mention that Québec is surrounded by two oceans; the Arctic and Atlantic, but is also a reservoir for 3% of the world's fresh water, which includes 4500 rivers and half a million lakes making water a prominent resource. In addition, the fact that the province spans several latitudes makes it a great comparative example for many other locations across the globe. The province is also at the heart of a recreational fishing industry that brings over 1 billion in revenue annually. All of these characteristics make it a prime case study for climate change impacts and implementation of adaptation measures.

Following this socio-economic portrait, a state of knowledge of diverse biophysical parameters (pH, oxidation, salinity, etc.) that will be influenced by climate change exemplifies the potential physical impacts for different water bodies across the territory and different economic sectors. This portrait stems from a 2015 synthesis of climate change and adaptation research for the province called Towards Adaptation that was produced with the contributions of over 80 authors and reviewers.

Subsequently, potential consequences related to the future climate on the different economic sectors is presented such as the impact on food security and livelihoods. These modifications can impose fish migration, changes in distribution or the arrival of invasive species, and thus imply major changes for the industry. These findings will help different stakeholders who are dependent on water resources assess the gravity of the current and future modifications to the environment. Consequently, actual and potential adaptation measures are also

provided to improve solutions for these eminent changes. Finally, knowledge gaps linked to biophysical aspects, impacts or adaptation measures are identified to improve potential important actions of research and development. The ultimate goal of this project is to continue developing knowledge in this field but also to communicate the information to local entities so they can begin adapting to the upcoming changes.

## **5. Towards productive and socio-natural urban landscapes – tapping urban agriculture`s potential as a tool for sustainable development**

Bettina Steuri, Hafencity University

Worldwide, the percentage of people living in urban areas will increase from 50% in 2010 to nearly 70% by 2050. While in many parts of the world, human development is expanding rapidly on the urban fringe and at the expense of rural hinterlands, some cities decided to focus on densifying the built environment. Since densification leads to a quantitative reduction of open spaces, the pressure on the remaining ones is significantly increasing. On the one hand, open spaces should meet the requirements of its users, on the other hand, they have to fulfil expectations regarding climate adaptation and operating efficiency. Thus, to satisfy these claims, urban open spaces have to be endowed with multi-functionality. But is there a sustainable solution that acts across multiple sectors and scales?

Urban agriculture offers indispensable opportunities to deal with urban challenges regarding sustainability, health, economy, society, urban design and local food supply. Due to its cross-cutting and multi-dimensional nature, it has the potential to meet a good many of the requirements on open spaces. Nonetheless, it still inherits a rather low visibility on the agenda of urban planners. This situation could stem from various reasons, whereby a gap in the understanding of urban agriculture`s capability seems to be a major cause. To this day, comprehensive literature on the subject is. While most researches on the subject focus on the missing link between urban planning and food, this study looks at the opportunities given by urban open spaces and provides a comprehensive understanding of urban agriculture and its benefits - both for its users and for the environment. By merging these two principal themes, the reciprocal relationships become apparent and, therefore, substantiate the potential win-win situation. Thus, the purpose of this study is to tap urban agriculture`s potential and to emphasise its *raison d'être* in sustainable urban planning.

The study is structured into five sections, whereby the first and the second one are an analysis of urban open spaces respectively urban agriculture. Both topics are described on the basis of the main pillars of sustainability and on varying scales. The third section is a merging of the two analyses and shows reciprocal relationships between urban agriculture, urban open spaces and the urban environment. The fourth section depicts existing barriers and furthermore, proposes possible strategies to address them. Lastly, urban agriculture`s *raison d'être* in sustainable planning is justified.

## 11.6 Managing rainfall to control flooding and improve water quality

*James Murray, MGSDP Manager, Glasgow City Council*

### Flooding

#### Urban, energy & infrastructure

1. The Metropolitan Glasgow Strategic Drainage Partnership: Vision, Objectives and Guiding Principles (James Murray, MGSDP Manager)
2. Glasgow City Council Surface Water Management Plans and Natural Flood Management Studies (David Hay, Glasgow City Council)
3. Using Natural Flood Management to deliver climate ready infrastructure (Ian Dennis, Royal HaskoningDHV)
4. Flood resilient Sheffield: putting adaptation into practice at city scale (Will McBain, Arup)
5. Domestic garden adaptation for urban flood mitigation (David Kelly, Heriot-Watt University)

**Keywords:** Flooding, resilience, climate-change, green infrastructure, regeneration, surface water, adaptation

- An overview of the MGSDP, the challenges facing the metropolitan Glasgow area and review of key MGSDP partner projects to deliver reduction in the risks / impacts of flooding, improve water quality, facilitate regeneration and growth, whilst meeting the growing challenges of climate change and urban creep.
- Review of natural flood management policy, practice and challenges, and innovative urban green infrastructure approaches to manage surface water runoff and deliver resilient climate change adaptation at a catchment / city scale.
- Summary of innovative green infrastructure approaches, at a domestic scale, for flood mitigation.

#### Significance to adaptation practice, policy and/or business

This session will set the context for the challenges of flood risk, water quality, urban creep and climate change at the catchment / city scale, to identify how working in an integrated and collaborative manner to deliver a mix of traditional and innovative grey / green / blue projects will help to tackle the challenges and set out the long-term vision for delivery of adaptation practice and policy to meet today's challenges and deliver resilience for the future.

#### 1. The MGSDP Vision, Objectives and Guiding Principles

James Murray, MGSDP Manager, Glasgow City Council

The MGSDP is a non-statutory, collaborative partnership between public bodies involved in managing surface water, water quality, flood risk, investment planning and economic development in a regulatory, service provision, asset management and / or infrastructure provision capacity.

This presentation will provide a background to why / how the MGSDP was set up, the current governance structure and partners, review the Objectives, Vision and Guiding Principles, review key projects completed, ongoing and planned and the challenges and successes.

#### 2. GCC Surface Water Management Plans (SWMPs) and Natural Flood Management (NFM) Studies

David Hay, Group Manager, Project Management & Design for Development and Regenerations Services, Glasgow City Council

This presentation will provide a background to the planning process to define the Clyde and Loch Lomond (CaLL), Local Plan District, Local Flood Risk Management Plan (June 2016), review the surface water management plans



and natural flood management studies ongoing and proposed by Glasgow City Council, review the challenges of delivering retrofit surface water management and biodiversity through green infrastructure, and the funding challenge.

### **3. Using Natural Flood Management to deliver climate ready infrastructure**

Ian Dennis, Water Environment Sector Lead, Royal HaskoningDHV

The term Natural Flood Management (NFM) is used to describe a range of techniques that work with hydrological and geomorphological processes and landscape features to manage the way water moves within a catchment. By storing water and increasing residence times in the upstream parts of a river catchment, NFM measures can reduce the size of the flood peak and offer increased flood protection to areas downstream. These measures can be used to deliver significant flood resilience benefits across a catchment, and reduce the requirement for (or standard of protection of) more traditional flood alleviation measures. Natural Flood Management techniques are therefore increasingly being used to increase the resilience of infrastructure and communities to the effects of climate change.

This presentation will summarise the policy context in different parts of the UK and explore the work that Royal HaskoningDHV's Catchment Management team are currently undertaking with various stakeholders to identify, design and implement NFM measures. Focussing on case study catchments in north east Scotland and southern England, this presentation will discuss how a combination of river restoration and floodplain reconnection measures can be used to help protect infrastructure and the built environment from the flood-related pressures predicted to increase in response to future climatic changes.

These case studies will demonstrate the potential conflicts associated with delivering sustainable flood risk management in a changing climate and how they can be overcome. This will include a discussion of the importance of gaining the trust and support of landowners and the need to balance a defined standard of protection for key assets and infrastructure with economically effective protection measures that work with rather than against natural hydrological and geomorphological processes.

### **4. Flood resilient Sheffield: putting adaptation into practice at city scale**

Will McBain, Associate Director, Arup

In the recent National Flood Resilience Review, the UK government identified a clear need to think more strategically about how we plan the defence of our cities from flooding, both now and in the future. With Sheffield as an example, the government hopes that other core cities will adopt the principles of building resilience into the design of their urban development and regeneration, creating additional social and economic value from flood defences. For Sheffield City Council, improving flood resilience has been a fundamental component of the city's flood protection programme for some time. Whilst the programme's core objective is to effectively manage flood risk; wider objectives are to support economic regeneration, increase connectivity and to improve heritage potential, biodiversity, amenity and recreation opportunities - complementing Sheffield's status as the Outdoor City. This programme has already seen work commence on the construction of flood defences to protect key industries in the Lower Don Valley. This area was particularly badly affected by a flood in 2007, when two lives were tragically lost, thousands were evacuated and cars were abandoned throughout the city.

The Council's programme is now entering a new phase. This is involving consideration of the short, medium and long term future of the rest of the city, which is at risk from five separate river systems as well as from urban drainage sources. These sources, and the mechanisms responsible for flooding, are highly sensitive to the impacts of increases in peak river flows and rainfall intensity. So the Council's approach is necessarily long-term, with a focus on managed adaptation to address future climate change hazards. Over three months in summer 2016, the Council undertook a major public consultation programme seeking public views on potential options to manage

flood risk over the coming century. The consultation included outline proposals for a wide range of large scale adaptations – flood storage reservoirs, flood defences and conveyance improvements – but also for measures to “slow the flow”, build resilience and adapt. This presentation will reflect on the outcomes of this consultation, how it informed the selection of a preferred approach and how the programme will integrate with wider public and private investment programmes, longer-term policies and socio-economic and environmental regeneration.

## **5. Domestic garden adaptation for urban flood mitigation**

David Kelly, Assistant Professor, Heriot-Watt University

The management of surface water has become a major challenge for many cities around the world. Factors such as rapid population growth, increased urbanisation, deficient infrastructure, and climate change impacts call for new ways of controlling rainwater in urban spaces in order to minimise flood risk.

In recent years, government policy with the UK has emphasised the need for sustainable solutions to flood management. The Flood and Water Management Act 2010 aims to maintain and restore natural processes to reduce flood risk, whilst the Flood Risk Management (Scotland) Act 2009 promotes the use of space in urban landscapes to store and slow rainfall. The approach now is to control runoff at source using natural flood management and green infrastructure which promotes multifunctionality of land use and support ecosystem services.

There is one land type, however, which forms a significant proportion of the urban land mass which currently remains untapped in terms of urban flood risk management strategies. Domestic gardens contribute between 22-36% of the total urban area, and between 35-63% of urban green space. The natural vegetation and permeable soil surfaces in domestic gardens help to intercept, store, and infiltrate rainwater where it falls and so provides a valuable asset in terms of surface water management. Yet, this asset is slowly being eroded due to growing urban densification where large areas of gardens have been lost to hard paving for car parking and convenience, and used to construct building extensions.

Whilst domestic gardens are currently outside the immediate control of local government, they do present a potentially valuable tool for helping control surface water within the urban environment. This paper presents a new concept for domestic garden adaptation for enhanced flood control using selected natural vegetation and green rainwater drainage systems. It is demonstrated that such techniques could help to address issues of over-urbanised spaces, particularly within the context of climate change impacts. Furthermore, specific strategies for engaging householders and encouraging social motivation towards garden adaptation are presented.

## 8.3 Cross-boundary implementation of climate adaptation plans in Central Denmark Region

*Rolf Johnsen, Central Denmark Region*

### Governance

1. Overview of the climate adaptation challenges and actions in the region (Rolf Johnsen, Central Denmark Region)
  2. A catchment approach for the River Grenaa (Sidsel Kontni Prahm, Norddjurs municipality and Steen Ravn Christensen, Syddjurs Municipality)
  3. Flood-proofing Horsens Town Centre (Rasmus Rønde Møller)
  4. Climatorium in Lemvig (Albert Jensen, Operations manager, Lemvig Water Utility Company, Denmark)
  5. Cross boundary capacity building (Anja Skjoldborg Hansen, Danish Centre for Environment and Energy, Aarhus University)
  6. Cross boundary innovation & business development (Christoffer Buch-Larsen, Business developer, Central Denmark Region)
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**Keywords:** Adaptation plans, cross boundary, water, planning, integration, co-creation, tools, Life IP

Water crosses administrative and geographical boundaries. As a consequence, solutions in one area can cause difficulties in others. Coast to Coast Climate Challenge (C2C CC) is a cross sectoral and cross boundary Life IP project. C2C CC supports the implementation of 21 municipal climate change adaptation (CCA) plans and 4 risk management plans in Central Denmark Region (CDR). It provides decision-makers with a framework for sustainable and integrative CCA planning, mainstreams CCA into local planning and integrates other policy areas. Concrete actions cover capacity-building within all themes in the hydrological cycle, improve multi-level management structures, and carry a total of 24 concrete implementation actions. The CCA plans deal with cities as well as the countryside and coastlines, and include solutions in the hinterlands to prevent flooding in the cities. The 24 concrete actions are divided into the following Sub Categories: Open land, Transboundary issues, Urban challenges and Innovative solutions.

The project consists of 47 (30 core partners and 17 supporters) partners, all committed to ensure integrated climate adaptation. The project is strongly supported by the EU Commission.

During the session, there will be short presentations by some of the key players in the project. Further the audience is engaged via interaction, views and discussions.

### Significance to adaptation practice, policy and/or business

C2C CC deals with CCA projects laid out in the municipal CCA action plans required by the Danish government while at the same time including other EU (legislative) objectives. All in all, 21 climate adaptation plans will be implemented. C2C CC consists of several actions, some developed more than others; some ripe to be implemented during a first phase, others at later stages. The experiences and results from these early actions will feed into later ones, making C2C CC a truly adaptive project.

### 1. Overview of the climate adaptation challenges and actions in the region.

Rolf Johnsen, M.Sc. & MBA, Chief Consultant, Central Denmark Region

To date, the CCA plans in Central Denmark Region have been adopted but implementation of actions are in an early state. The C2C CC project will provide a comprehensive base for this implementation, evaluate the results and the process as well as give local authorities the tools for better integrated planning, taking into account the uncertainties of future climate change.

CCA in the region generally deals with challenges related to managing more water touching upon all aspects of the hydrological cycle: sea and fjords, rivers and lakes, groundwater and rainwater. Rainwater is an issue for the whole region due to an increase in the amount and intensity of rain and cloudbursts. In the western part, the interconnectivity of the elements of the hydrological cycle means that more precipitation causes rising groundwater table and intrusion into houses. Cloudbursts cause flashfloods in many cities, and the increase in rainwater and more incidents with heavy rains cause watercourse floods and damages on infrastructure and urban areas. In the coastal areas, storm surges are increasing causing floods in the cities at the Limfjord in the north and on the east coast. When future storm surges occur simultaneously with heavy rain, most notably cities, but also other areas along the river banks, are in high risk of severe flooding.

## **2. A catchment approach for the River Grenaa**

Sidsel Kontni Prahm, M.Sc. project manager Norddjurs Municipality and Steen Ravn Christensen, M. Sc. Project manager, Syddjurs Municipality

The Grenaa catchment area (480 square kilometers), is high prioritised in the CCA plan of the municipalities of both Norddjurs and Syddjurs. The cities and the agricultural areas of the project area are under extreme pressure from the climate change and the municipalities are forced to plan the future development for the area.

The challenge is especially complex due to the size of the area, and differences – conflicting – interests. E.g. the Grenaa catchment area has over the past years been subject to much debate. On one side the strong interest in maintaining the existing land use for agriculture, and on the other side restoring the old landscapes with wetlands. In the area is Kolindsund (Reclaimed land), a 26 square meters' drainage association for agriculture, before in the 18<sup>th</sup> century it was the largest lake in Jutland.

Taking into consideration the present land use, future climate changes (more precipitation, greater quantities of water in catchments, rising groundwater, rising water level in Kattegat and – possibly – salt water intrusion), as well as cost-benefit and societal analyses, a number of realistic CCA scenarios will be elaborated and analyzed to provide a robust and valid basis for political decision-making.

Where relevant, these scenarios will be extrapolated 25, 50, and 100 years to take into account for future climate developments. The results of the 3D-modellings of water cycle is combined with biodiversity, Environment, CO<sub>2</sub>, socio-economic benefit and legal questions analyses.

Among others, the following elements will be included:

- Risk assessment
- Climate-proofing of the city of Grenaa, the Kolindsund and other infrastructure in the project area (minimizing flood risk, controlled flooding, unsanitary conditions as a consequence of the overflow of the waste water systems)
- Technical requirements for climate protection in relation to agricultural production
- Implications of possible salt water intrusion for the agricultural production and the supply of drinking water
- Improved CO<sub>2</sub> score due to CO<sub>2</sub> retention from reintroducing wetlands
- Assessments of societal values (existing nature, outdoor recreation, settlement, and other recreational values)

The needed Holistic approach in the project is integrated by workshops with representatives from knowledge institutions, NGO's and local's stakeholders and especially by the crosscutting activities in C2C.

### **3. Flood-proofing Horsens Town Centre**

Rasmus Rønde Møller, M.Sc., Project manager, Horsens Municipality, Denmark

The city of Horsens DK, founded around the Viking age has an aim to climate proof the local harbour situated very close to the city centre. In the local municipality's CCA plan, Horsens town centre is outlined as the prime focus area. The area has a special focus on the basis of flood risk combined with economic and cultural value.

Horsens City is challenged with water from the hinterland and location at the Horsens Fjord. Large parts of the central city are lower than 1.5 meters above sea level. With climate changes following increased precipitation and higher sea levels, there is a need to ensure the lowest lying parts of Horsens City from flooding.

In addition, Horsens is having (in Danish scales) a large growth of population, and new residential areas, infrastructure etc. are being developed. The port area is under transformation from a commercial harbour into partly a residential and recreational area. Primary roads through the city are planned restructured and the city council recently decided to redirect the main stream in inner city.

The main focus of the project is to incorporate Climate Adaption, planned and carried out simultaneously with the transformation of the city. Elements are:

- A holistic approach for the flooding from the whole catchment areas and the fjord, and for planning in the inner city as well.
- A model complex including streams, sewer systems, flooding on terrain combined with water levels in docks and in the fjord.
- Scenarios and analysis related to total flooding will be carried out.
- Possible actions is to establish wetlands in the catchment area, use a high way construction as a dike and roads will be raised in the city, utilized as dikes and there will be established sluices and pumps at the river outlets.
- Innovative tools for local weather forecasting combined with measurements for water levels and run off to lakes and streams in order to pre-emptying lakes and docks, to use them as retention ponds and rainwater basins. Innovative solutions is necessary and development and capacity building will be made in the cross cutting activities in C2C CC.
- An ambition also is to make accessible and aesthetic solutions, attractive for recreational use in the transition areas from land to water.
- The city's wastewater company is an important partner and stakeholders is involved.

The needed Holistic approach is challenging and the crosscutting activities in C2C CC, in terms of capacity building, will contribute that local authorities improve their general ability to work holistically with climate change adaption in close collaboration with stakeholders, during and after the duration of the project.

### **4. Climatorium in Lemvig**

Albert Jensen, Operations manager, Lemvig Water Utility Company, Denmark

The Climatorium is created as a showroom based on companies, innovation, entrepreneurs, researchers, authorities, organizations and tourist actors within water and climate change. The house will be open for holiday- and corporate tourists with exhibitions on the ground floor, special climate tours in the area, presentations of CCA technologies and research, as well as innovation seminars with the companies and organisations in-house.

There are 8.3 million coastal tourists from all over Europe per year in the Central Denmark Region, mainly related to the west coast (Dansk Erhverv, 2013), and besides the coast itself Jesperhus Blomsterpark (250,000 tourists per year), Klitmøller surf area, and Nationalpark Thy (Natura 2000 area) are well known tourist attractions, which target group the Climatorium supports.

The purpose of the Climatorium is to gather knowledge, business and tourism on CCA aspects within an innovation house. This house will have shared office spaces for companies and research institutions (for researchers as well as master and Ph.D. students). The objective is to increase innovation through day-to-day interaction and planned in house seminars.

The Climatorium is pivotal in the establishment of a CCA Cluster on coastal environment in Central Denmark Region. As a start, other C2C CC actions, dealing with the coastal environment will use the Climatorium for communication and innovation. The Climatorium and AquaGlobe (another exhibition centre) will complement each other by their different locations in the region and their focus on saltwater and freshwater, respectively. The two actions thus collaborate on ideas, exchange of data, research, tourism, exhibitions etc.

In the core of the house a dynamic climate exhibition will inform about climate change and illustrate selected solutions for the visitors of the house as well as tourists. The Climatorium showroom will be expanded continuously with the best practice from C2C CC and with new CCA knowledge in general.

The Climatorium is planned to be established on the harbor front in the city of Lemvig, a central location in the region in regard to saltwater and coastal challenges. Further the location supports and benefits from other climate activities in the area, e.g. Geopark West Jutland (in consideration at UNESCO Global Geopark), which focuses on the geology, groundwater, historical landscape changes and sustainability of the area. Climate change has an impact on west coast of Denmark physically. The “events” already now attracts ‘climate’ tourists in bad weather. The local weather and climate conditions set demands for the solutions developed. The location itself and the innovative solutions will be of inspiration for others.

## **5. Cross boundary capacity building**

Anja Skjoldborg Hansen PhD, Chief Consultant, DCE – Danish Centre for Environment and Energy, Aarhus University

The main objective of C2C CC has its core in strengthening resilience, including vulnerability and adaptive capacity. Within adaptive capacity lies also an understanding of resilience as a process, where capacity to cope with change can be developed and strengthened, and where change could be seen as a possibility to innovate. Therefore, capacity building plays a key role in strengthening resilience throughout the region. Capacity building is included in C2C CC through extensive and focused thematic capacity building activities in the crosscutting activities and by establishing a committee consisting of at least three university partners, functioning as a capacity building task force. The role is to advice on crosscutting issues such as:

- How climate change adaptation may support sustainable transition of existing systems and practices
- How to create added value across different sectors including environment, biodiversity, liveability, health and job-creation
- How to realize in practice inter-sectoral and inter-disciplinary collaborations in integrative planning processes involving network governance
- How to engage and mobilize private actors including citizens involvement and to create new forms of co-creation and co-operations
- Create synergies between the 17 demonstration projects and 7 cross-cutting capacity building actions
- In general, answer questions from the beneficiaries on technical issues related to the specific actions.

The project will engage with the research community through the specific projects, the involvement of the committee and engagement of PhD students across the partnership. In addition, capacity building will take place in the form of workshops, network building and knowledge-sharing activities as well as individual coaching and training courses within the seven crosscutting activities. Capacity building activities will have multiple target groups, such as local authorities, citizens, stakeholders and companies. As such, the capacity building activities

also has a role in the knowledge transfer of the C2C CC project results, while at the same time being an integrated part of the project, ensuring that the local authorities improve their general ability to work holistically with climate change adaption in close collaboration with stakeholders, during and after the duration of the project. Tools for capacity building will be developed in corporation, and in some cases as an integrated part of the planned demonstration projects and model development activities.

## **6. Cross boundary innovation & business development**

Christoffer Buch-Larsen, M.Sc. Business developer, Central Denmark Region

Cross sectoral stakeholders in Denmark as well as in the rest of the world have proclaimed that Water is the new Wind. The investments in climate adaptation will be huge in the upcoming years and will be much larger than the investments in eg. wind energy. Therefor innovative solutions to water and climate challenges have a big potential for growth, job creation and exports in Denmark.

C2C CC approaches the CCA plans as a cross-boundary challenge where coordination, knowledge sharing and capacity-building are necessary for improved governance and development of tools and innovation. Through C2C CC the region has the potential and ambition to be the leading region in Denmark in relation to cross boundary and cross sectional innovative climate challenge solutions and best practise show cases.

The presentation will introduce how the project will increase the business opportunities for climate change and water related businesses in the Region. The clustering of businesses and the analysis for new opportunities will be the main focus and exemplified through actions.

The specific focus is enhancing innovation among water businesses in the region, through knowledge sharing, reference built up, and networking between water businesses, utilities and municipalities.

Specifically, companies like Dansand, Grundfos, Kamstrup, and NCC will be involved in relevant innovation projects and cooperation fora. Counselling of industries for EU funding and training of start-up companies on business development within ecosystem services is also part of the work.

Furthermore, CDR has years of experience within exporting water solutions to Asian countries through the Danish Water Technology Hub – Danish Water Technology House – which is placed in Singapore and helps Danish SME enter the south- east Asian markets.

The strengths are demonstrated in the Climatorium and Aquaglobe; two innovation hubs on freshwater and seawater, respectively, for business collaborations between commercial players, educational institutions, water utilities and authorities, with possibilities for test facilities, shared office spaces and seminars to promote and generate innovation through business environment.

## 5.11 Exploring urban adaptation practice: a focus on co-production and multi-level governance

*Jeremy Carter, University of Manchester and Filip Lefebvre, Vito*

### Participation and co-production

#### Governance

1. Co-production panel (Angela Connelly, University of Manchester; Alberto Terenzi, ICLEI; Maddalen Mendizabal, Tecnalia)
  2. Multi-level governance panel (Koen Sips, POINT Consulting Group & Cycloop network; Resi Pansaerts, Province of Antwerp; Efrén Feliu, Tecnalia R&I; Griet Verstraeten, Flemish Environment Department; Ingrid Coninx, Wageningen Environmental Research)
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**Keywords:** co-production, collaboration, citizen participation, multi-level governance, science-policy interface, financing, European cities.

This session is focused around two panel discussions on topics that are central to the development of urban climate change adaptation and resilience responses. They are co-production and multi-level governance.

#### Co-production panel summary

Co-production and associated terms linked to collaborative working are increasingly discussed from the perspective of climate change adaptation and resilience. The notion that the researchers, policy makers and practitioners should collaborate more closely is also a now central feature of research funding programmes such as Europe's Horizon 2020 initiative. This is for good reason given the scope and complexity of the adaptation and resilience agendas. Further, municipalities are facing significant resource challenges especially when they are required, sometimes statutorily, to produce adaptation strategies and deliver related actions. Bringing together the public and private sector with scientific researchers is therefore imperative in order to progress climate change adaptation and resilience building in this challenging context. Yet, the process of collaboration and the co-production of outputs can face difficulties. This panel aims to provide insight into the practice of co-production in order to help advance this agenda. There is a need to go beyond a general understanding of co-production into learning from specific examples and experiences.

#### Multi-level governance panel summary

Flanders, the northern part of Belgium, is a low-lying area that is susceptible to climate change impacts due to sea level rise, more frequent heat waves, drought and flooding because of increased winter precipitation and more intense rainfall in summer. As Flanders is characterized by a high degree of entanglement of the built environment, transport, industry, agricultural land activities and nature areas, harmful impacts can be expected. Adaptation is challenging, in particular for small and medium sized towns and cities that often lack the staff, funding and expertise to take adaptation measures. Multi-level collaboration is considered within this panel as a way to support local authorities in developing adaptation strategies and action plans.

#### Significance to adaptation practice, policy and/or business

Co-production approaches can support urban decision makers looking to develop adaptation and resilience responses under conditions of high uncertainty and knowledge gaps. The co-production panel, drawing on experience of co-producing adaptation and resilience outputs, will help to raise awareness of this topic and build capacity of policy makers, practitioners and researchers to engage in related exercises. The multi-level governance panel will focus on climate adaptation in small and medium sized cities. In Europe, almost 72% of the population lives in towns/communes smaller than 100.000 inhabitants (ESPON 1.4.1 "The Role of Small and



Medium-Sized Towns (SMESTO)”, Final Report available online), hence a very significant target group for higher-level authorities to take into account in the development of policies, supporting data sets and tools.

#### **Details of the two panel sessions:**

##### **1. Co-production panel details**

A brief introduction to the panel discussion will be provided by Jeremy Carter, who will act as chair. This will outline goals of this panel discussion, which arose from collaborations within the Horizon 2020 RESIN (Climate Resilient Cities and Infrastructures) project. The goals centre on building awareness and understanding of co-production approaches in urban climate change adaptation and resilience practice, and sharing transferable learning to advance this agenda. Short interventions from each of the panel members on the theme of co-production and collaboration in climate change adaptation and resilience. Details of the panel members, and the topic that they will speak to, are provided below. The panel will close with a discussion on challenges and opportunities to developing collaborative approaches in the field of urban climate change adaptation and resilience. Questions and contributions from the audience will be encouraged.

#### **Working together: science-policy collaborations on urban climate change adaptation and resilience.**

Angela Connelly, University of Manchester

Angela will provide an introduction to co-production, and the role and relevance of co-production approaches within climate change adaptation and resilience activities. This will help to provide a framework and context for the remainder of the panel discussion, which will focus on co-production in practice.

#### **Co-creating decision support tools with cities: innovative approaches and experiences.**

Alberto Terenzi, ICLEI - Local Governments for Sustainability

Alberto will focus on the innovative methodologies used in the framework of EU-funded research projects that ICLEI is engaged in. Within these projects, co-production can help ensure that research results are not only innovative and scientifically sound, but that they are also tailored to support European policy-making activities on urban climate adaptation and resilience.

#### **Stronger together: collaborating on climate change adaptation and resilience in Greater Manchester.**

Panel member TBC

This element of the discussion will focus on the challenges and opportunities of joint knowledge production on climate adaptation through the lens of Greater Manchester’s historic and ongoing relationships between academics and public authorities. The evolution of this process will be considered against the backdrop of multi-scale governance on climate change, as well as changing and increasingly devolving legislative and economic frameworks. A further objective is to highlight the impact of this collaborative working on climate change adaptation strategy and activity in Greater Manchester.

#### **Stimulating innovative climate adaptation mainstreaming through research-policy cooperation in Bilbao.**

Maddalen Mendizabal (Tecnalia)

Research and innovation initiatives have been a catalyst for the consideration of climate adaptation and resilience in Bilbao’s city policies. Relevant ongoing work will be highlighted, including the development of the Zorrotzaurre peninsula regeneration plan, and Bilbao’s General Master Plan update and revision. Both of these examples illustrate how the climate perspective is progressively acknowledged and is increasingly influencing decision making, and how the interaction between science and policy is a crucial factor for encouraging innovation.

## **Adaptation to Climate Change and Resilience in Paris: analysis of two urban planning projects.**

Panel member TBC

EIVP (Engineering School of the City of Paris) and the City of Paris have been working together for a number of years on various challenges and issues (energy, climate, resilience, urban planning, etc.). This presentation focuses on how they are collaborating via the Horizon 2020 RESIN project in order to support resilience building and climate change adaptation within the design and operation of the city of Paris and its infrastructure systems.

### **2. Multi-level governance panel details**

This session will be organized as a lively panel discussion. After a short context-setting introduction by the chair, Filip Lefebvre, the panel members will be asked to the stage for a discussion session. Each panel member will shortly introduce the organization to which it belongs or the organization it represents. Details of the panel members, and the specific issues that they will cover, are provided below. The discussion will then focus on three issues that are experienced by these local authorities, and experiences from Flanders will be shared on how to deal with these issues via a multi-level governance approach. The three issues are:

- Information sharing: what kind of data is managed at which level; what is the role of climate service and science and citizen participation?
- Governance and decision making: how to maintain autonomy in a multi-level context; how to create a climate adaptation community connecting everybody to increase collaboration: how to foster information sharing and mutual learning?
- Financing: How can climate adaptation be financed; connection with other policy themes.

#### **Koen Sips (POINT Consulting Group & Cycloop network) representing city of Leuven**

The city of Leuven (100.000 inhabitants) is a typical medium-sized city with an ambitious climate mitigation policy ambition (carbon-neutral in 2030, <http://www.leuvenklimaatneutraal.be/>) that has recently also engaged itself to make Leuven more resilient against climate change impacts by entering the Mayors Adapt initiative.

#### **Rési Pansaerts (province of Antwerp) representing province of Antwerp**

The province of Antwerp signed the Mayors Adapt initiative and is busy finalizing its first climate adaptation action plan. Therefore, a study was commissioned to analyse the climate risks on the level of the Antwerp province, focusing on risks that are the responsibility of the province such as water, environment, nature and spatial planning. The province is also working on how to support the communes and towns in its territory on this agenda. Finance and funding are relevant for climate action. While many funds are available, it is not easy for a small town to get access to it. The provincial level can play a role in supporting municipalities to gather funding for climate related policy activities.

#### **Griet Verstraeten (Flemish Environment Department) representing the Flemish regional level**

At the regional level, the Environment administration, unit Climate Adaptation, has applied a user requirement analysis to investigate the needs of the cities and communes to initiate and implement local climate adaptation policies and action plans. Based on this analysis, a knowledge information platform focusing on adaptation measures, adaptation examples and implementation finance knowledge is currently being developed. At the same time, the Flemish Environment Agency is taking action to provide a clear picture and evaluation of observed and projected climate change impacts. The 2015 Climate Report contains very detailed information on the different aspects. Finally, the Flemish Environment Agency is working on a climate adaptation portal showing geographical information on climate risks and vulnerabilities at the local scale. This will be also be integrated in the overall knowledge information platform.

**Efrén Feliu (Tecnalia), expert Basque Country multi-level adaptation case**

The Basque Country in Spain has a long trajectory in environment and sustainable development policies, anchored in multilevel public decision making, which includes climate action, mainly from the mitigation angle until now. The recent update of the Basque Climate Strategy (Klima 2050) covers adaptation objectives and action lines again with a multilevel and multisectoral perspective. The existing structures to manage knowledge development and information sharing, financial capacities and governance in regional spatial planning, urban development and local sustainability, will serve as framework to channel and deploy mainstreamed climate action for advancing towards a “climate proof” territory, towns and cities.

**Ingrid Coninx (Wageningen Environmental Research), expert Dutch multi-level adaptation case.**

The Netherlands is a country that is particularly vulnerable to climate change risks such as sea level rise and flooding from extreme weather events. In 2007 a large national Knowledge Platform was set up to assist national and local administrations (Knowledge for Climate). The Netherlands wishes to fulfil a frontrunner role and strives for a coherent European climate adaptation policy. Wageningen Environmental Research is part of the European Topic Centre on Climate Change impacts, vulnerability and Adaptation (ETC/CCA) and contributes to mainstreaming climate adaptation and cross-cutting activities in the Netherlands. Relevant experiences linked to multilevel governance will be discussed.

## 12.5 Using nature-based solutions to manage flood risk – challenges, tools and experience

*Stéphanie IJff, Deltares*

### Ecosystem services and NBS

#### Flooding

1. Guidance for successful implementation of nature-based climate adaptation (Stéphanie IJff, Deltares)
2. The UK Working With Natural Processes (WWNP) approach (Mark Ross, Environment Agency, England)
3. Case study: Medmerry coastal realignment scheme (Wendy Brooks, Environment Agency, England)
4. Case study: Calderdale Flood Action Plan (Helen Batt, Environment Agency, England)
5. Interactive discussion: sharing experiences (Stephanie Janssen, Deltares)

**Keywords (max 8):** adaptation, working with nature, water management, flood risk management

Due to large flood events, climate change and increasing pressure on land use, there is a need to find more sustainable, effective and multifunctional adaptation measures. Through working with natural processes instead of against them, it is possible to implement sustainable solutions that does not only require less maintenance than traditional 'grey' measures but also provides different (ecosystem) services at the same time.

In this interactive session, Deltares (NL) and the Environment Agency (England) invite you to explore how working with nature can successfully be implemented to deal with a range of water management challenges in the face of climate change. This session will present the theory and tools that can be used, and the realities of doing so on the ground via the case studies. Questions that will be posed include:

- 'How does the implementation of nature-based solutions differ from traditional grey infrastructure for flood risk management?', and
- 'What do we know and what do we not know about the effectiveness of the 'working with nature' approach?'

Participants are encouraged to share their own experiences and views on these questions and challenges. In this session we hope to inspire participants on how they could work with their flood risk management issues by using natural processes, improving stakeholder interaction in decision-making and involving the local community.

### Significance to adaptation practice, policy and/or business

This session is targeted at practitioners, policy makers, NGOs, scientists and consultants that deal with, or are interested in adaptive flood risk management, especially using natural processes. In this session, the participants will have the opportunity to share experiences to identify and solve challenges in adaptive water management.

### 1. Guidance for successful implementation of nature-based flood risk management

Stéphanie IJff, Deltares

Worldwide, floods are the most frequent of all natural disasters. Until recently, most flood risk management responses have focused on using 'hard' engineering solutions or 'grey' infrastructure, such as dams, levees and channels to reduce flood risk. Recently, so called 'nature-based solutions' (NBS) or 'ecosystem-based adaptation' (EBA) are increasingly being implemented as a sustainable alternative for flood risk reduction measures. Moreover, they combine different functions such as nature development and recreation. There is a growing momentum and interest from all stakeholders, such as local communities, donors, policy and decision makers.

Successful implementation of such interventions is not straightforward, however. It requires specific knowledge of the physical system, socio-economic context and institutional interactions. In this presentation we will emphasise the steps that are needed for the assessment, design, implementation, and monitoring and evaluation of nature-based solutions for flood risk management. It follows the general cycle of a flood risk management project and provides more information on specific aspects that need further attention when implementing nature-based solution, such as the use of ecosystem restoration techniques or adaptive management.

The growing interest in this topic is also shown by the large number of online platforms and guidelines that are being developed to support successful and large-scale implementation of NBS for flood risk reduction worldwide. Examples are the Building with Nature guideline by Ecoshape and the PEDRR network, but also new initiatives of online platforms and technical design guidelines that are being developed. In this presentation, we will show how these initiatives link together and in which of the implementation steps they can aid local and regional resource managers, flood risk professionals, funders and others involved in project development.

## **2. Working with natural processes – a Directory of evidence and mapping toolbox**

Mark Ross, Environment Agency, England

A Working with Natural Processes (WWNP) approach to reduce flood risk involves taking action to manage fluvial and coastal flood and coastal erosion risk by protecting, restoring and emulating the natural regulating functions of catchments and coasts. Interest in this greener approach to engineering has soared in recent years following a spate of significant flooding events across the UK. WWNP can not only further help to reduce the risk of flooding to people and property but also achieve win-wins for the environment and society.

To date, the application of this innovative component of the flood risk management toolbox has yet to become fully mainstream. This lack of widespread acceptance is due to a number of reasons, including: definitive scientific evidence to support the implementation of the full spectrum of catchment and coastal WWNP measures is still being developed; the formal quantification of the ecosystems services being provided by these types of measures is still in its infancy, and the range of tools currently available to help interested parties to make strong business cases for funding these types of schemes is limited.

This presentation will showcase some early outcomes from a suite of projects we are managing to develop the evidence base, and subsequently, the technical guidance and tools needed by FERCM authorities to help them make the case for WWNP.

We will look in detail at the Draft WWNP Evidence Directory - a resource, derived from a comprehensive literature review, that will describe 'what we know' and 'what we don't know' about the effectiveness of different WWNP measures. This includes 65 detailed case studies that describe the practical implementation of these measures across a range of catchment and coastal situations and Ecosystem Service summaries for all WWNP interventions.

We will also discuss the development of a new national WWNP mapping toolbox, which is designed to help practitioners identify key locations within a catchment where the implementation of WWNP measures could be most effective. This will be supplemented by some guidance on modelling NFM interventions.

Finally, we will describe the work we are doing with the DEFRA funded NFM pilots on monitoring and evaluation, using these live projects to fill the R&D gaps identified in the Evidence Directory through the development of monitoring and evaluation plans.

### **3. Medmerry coastal realignment scheme - designing sustainable ecosystems that integrate human society and natural environment**

Wendy Brooks Flood Risk Management Strategy and Investment Manager, Environment Agency, England

Worldwide, sea levels are rising, intensifying flood risk and leading to coastal habitat loss. Ecosystem-based coastal defences can provide part of a solution. Managed realignment, the planned process of realigning river, estuary or coastal defences, can be used to combat coastal flooding through the cost-effective creation of wetland habitat and the removal of seawalls. There are over 100 examples of this approach in Northern Europe and Medmerry, on the Solent, is the largest scale implementation to date.

This session will detail competing challenges and the community-based approach taken to address the immediate and long-term flood management challenge in this locality including the interplay and cooperative partnership between flood risk management authority and the local community interests and actions. The final scheme delivers multiple benefits for people and wildlife conservation.

Flooding from the sea and local streams had been a problem in the Solent for many years, prompting concerned local residents to act. In 2001, residents organised an international meeting to help local communities understand the issues and to set out the options and implications to be considered and developed. This resulted in formation of the Manhood Peninsula Partnership (MPP), a forum for local people and statutory bodies to discuss how best to address flood risk in this section of the Solent.

In 2007, an English Environment Agency public consultation for the 'Pagham to East Head Coastal Defence Strategy' recommended a managed realignment project at Medmerry, a coastal site at the tip of the Manhood peninsula where new defences would be built inland from the existing coastline. As this option was not well initially received by the majority of local people, the Environment Agency worked with a large group of concerned local people to form the Medmerry Stakeholder Advisory Group (MStAG), a group of self - elected representatives from among the wider group created to represent local views, interact with the project team and report back to the community.

In 2008, land was purchased for the realignment. Construction began in October 2011 and was completed in late 2013. The scheme cost £28 million. It has created over 300ha of inland marshland and has reduced the flood risk for 350 homes, water purification facilities, tourism facilities and a main road serving 5,000 people. The site is now managed by the Royal Society for the Protection of Birds and has successfully withstood intense storms and minimised flood damage since construction.

### **4. Calderdale Flood Action Plan – a community driven approach to catchment flood management and climate change adaptation**

Helen Batt, Calderdale Catchment Director, Environment Agency, England

In December 2015, as a result of Storm Eva, over 9,000 households and businesses across the north of England (north and west Yorkshire) were affected by flooding. One location in particular, the Calder Valley was significantly impacted. Over 2000 homes, more than 1600 businesses, schools, power, transport and water infrastructure installations flooded. The Calder Valley has a strong social, industrial and economic connection with the many watercourses and river that flow through the valley, draining the moors above. This has and does bring significant flood risk, with flooding events recorded as far back as 1615. These risks will increase as the climate changes. Following the December floods, the Government provided an additional £35 million for flood management but also asked the Environment Agency to work with partners and communities to develop a Flood Action Plan for Calderdale. This action plan covers the whole river catchment in the Metropolitan Borough of Calderdale.

Bringing community organisations together was tackled through effective community engagement from the start. Examples include the Environment Agency working closely with existing community based organisations such as the Calder Catchment Flood Studies Network and the scientific initiative, SlowtheFlow: Calderdale. These groups are made up of mostly local people and volunteers who give up their time to undertake work to secure a future for all those who live, work and visit the area. They are investigating why and how the Calder Valley floods and identifying locations where natural flood management can help to slow the flow of water down the hillsides into the River Calder. Many of the natural flood management projects, particularly tree planting were originally put forward by, and will be undertaken by Treesponsibility, a local climate change organisation whose aim is to educate people about the need for action on climate change and how this can improve the local environment, as well as reduce flood risk.

The political climate directly after the December flooding enabled the key stakeholders to come together and consider Flood risk management at a catchment level and work effectively with organisations across organisational boundaries. However as the recovery phase draws to a close there is a challenge to keep this collaborative working in place. This is being tackled at the strategic level – looking forward to how future policy and support the catchment approach and at a tactical level, establishing and maintaining a dialogue with individual landowners in the catchment. The remaining challenge, how to develop a truly collaborative and long term plan, still stands. The Calderdale action plan provides the foundations, but it will take strong leadership to bring together the relevant sectors for the long term.

## **5. Interactive discussion: sharing experiences**

Led by Stephanie Janssen, Deltares

## 1.5 Providing a fit-for-purpose climate service for Europe: users' and purveyors' perspectives

*Maria Noguer, Institute for Environmental Analytics (SECTEUR coordinator) and Francesca Larosa*

### Climate services

1. **Setting the scene:** Climate services in Europe
    - 1.1 The Copernicus Climate Change Service (Carlo Buontempo, ECMWF)
    - 1.2 A European Roadmap for Climate Services (Roger Street, UKCIP)
    - 1.3 User requirements, barriers and opportunities: Introduction and scope
      - Maria Noguer, Institute for Environmental Analytics (SECTEUR coordinator),
      - Thanh-Tâm Lê, Climate-KIC (MARCO coordinator),
      - Adriaan Perrels, Finnish Meteorological Institute (EU-MACS coordinator)
  2. **Interactive session:** Use of climate information, long-term engagement and best practice from climate service purveyors and users. Focussing on 6 industrial sectors: Agriculture and Forestry (Wageningen University & Research), Health (ISGlobal); Insurance (BSC); Infrastructure (Tecnalia); Tourism (Tec Conseil); Coast (CMCC)
    - 2.1 Sector user specific information – developing an ongoing engagement with users
    - 2.2 Market analysis and prospects – developing innovative ideas
  - 3 **What's next:** Conclusions and feedback
- 

**Joint initiative of the: SECTEUR<sup>3</sup>, MARCO<sup>4</sup> and EUMACS<sup>5</sup> consortiums in collaboration with the PLACARD<sup>6</sup> project**

**Keywords:** Copernicus Climate Change services, user requirements, adaptation, decision-making, market with climate services, demand driven service

Have you got the climate information you need to make evidence-based adaptation decisions? Is that information in the right format or at the correct scales or is it available at all? What does the market for climate services look like? What are the main drivers and barriers for its growth? And how do we unleash the innovation potential for climate services in Europe?

This session gives participants a unique opportunity to share experiences in using climate information and the challenges of marketing climate services within Europe. We will give the first take of the answers and start the conversation. The session explores two key European initiatives, the European Roadmap for Climate Services and the Copernicus Climate Change Service (C3S), together with three programmes aiming to investigate the European market for climate services: its opportunities, barriers, user requirements and gaps. The session will seek to inspire through positive examples of effective users' co-development, marketing and business strategies, and nurturing policy environments. It will invite you to participate in the dialogue about how we can boost the

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<sup>3</sup> **SECTEUR** – Sector Engagement for the Copernicus Climate Change Service: Translating European Requirements, C3S 2016-2017 <http://climate.copernicus.eu/secteur>

<sup>4</sup> **MARCO** - Market research for a Climate services Observatory, H2020, 2016-2018 <http://www.marco-h2020.eu/>

<sup>5</sup> **EUMACS** - European Market for Climate Services, H2020, 2016-2018 <http://eu-macs.eu>

<sup>6</sup> **PLACARD** - Platform for Climate Adaptation and Risk reduction, H2020, 2015-2020, <http://www.placard-network.eu/>



provision of tailor-made climate services. We will also explore how best to communicate and maintain a long-term user engagement for a fit-for-purpose climate service.

Climate variability and change represents a sizeable economic, social and environmental risk in Europe and globally. Climate services are essential for catalysing economic and societal transformations that reduce these risks, improve societal resilience, and unlock Europe's innovation potential, competitiveness and economic growth. However recent analysis into the market with climate services in Europe (Brasseur and Gallardo, 2016; EC, 2015) revealed their relatively modest uptake for policy and decision making, despite the recognised economic and social value harnessed by climate services (WMO, 2015). Much climate information is available, but how can this data flow be managed, turned into useful information and made accessible to those who need it, such as researchers, knowledge purveyors, and decision-makers?

This session is ideal for participants from different industrial sectors interested in using climate information to support/facilitate their decisions or to support or enrich their own services. For example, industry representatives from tourism, insurance, agriculture, infrastructure, health care and coastal protection; as well as policy-makers and consultancies that use climate information to inform their clients.

### **Significance to adaptation practice, policy and/or business**

Climate information is crucial to adequately deal with risks and opportunities in numerous sectors notably exposed to climate change and weather extremes. This session will gather experiences from past and ongoing projects including the C3S Sectoral Information Systems, Climate KIC and Horizon2020, as well as provide examples on best practice from both providers and users of climate services. The session will be organised around the preliminary findings from:

- the market analysis of the European market for climate services conducted by the MARCO and EUMACS projects.
- the user requirements and existing gaps for climate information identified by SECTEUR, on behalf of the Copernicus Climate Change Service.

The session will enable the exchange of ideas on these findings and provide additional information that will help to improve climate service in Europe. Ultimately, end-users will have access to the information they need to support better decision-making and to help identify robust and resilient options for adapting to climate change.

The session will start with the state of climate services in Europe: an introduction to the Climate Services Roadmap and the provision of climate change services through Copernicus, the European Commission's Earth observation and monitoring programme. It will follow with a series of short presentations on the findings of three projects summarising the European market for climate services, opportunities, barriers, user requirements and gaps. We will then explore the marketability and user requirements of six sectoral services: Agriculture & Forestry, Coastal areas, Health, Infrastructure, Insurance and Tourism. Finally we will have an interactive session of knowledge sharing and exchange with participants with examples of best practice from climate services purveyors and users. Participants will have the opportunity to discuss how existing climate information could be improved to better fit your organisational needs. At the same time, the session provides a forum for continual engagement for future developments of the Copernicus Climate Change Service.

## **1. Setting the scene – Climate services in Europe**

### **1.1 The Copernicus Climate Change Service**

Carlo Buontempo, European Centre for Medium-range Weather Forecast, ECMWF

The European Union (EU) made substantial investments in frontline systems enabling modern meteorological services under the Copernicus Earth observation programme (previously Global Monitoring for Environment and Security, GMES) (EC, 2014f), as a contribution to the Europe 2020 strategy for smart, sustainable and inclusive growth (EC, 2010a). Copernicus Climate Change Service (C3S) is one out of six services of Copernicus service

component, designed to deliver knowledge to support adaptation and mitigation policies. C3S aims to provide information that will help societal and business sectors improve decision-making and planning regarding climate mitigation and adaptation.

### **1.2. A European Roadmap for Climate Services**

Roger Street, UK Climate Impacts Programme, University of Oxford and JPI Climate

In 2014 the European Commission (EC) mandated an ad-hoc expert group with the task of proposing a research and innovation agenda on climate services. The ensuing Roadmap for climate services (EC, 2015) was endorsed by the Commission as a significant contribution to its own plans for investment in research and innovation to facilitate the development of a market for climate services that provides social and economic benefits across Europe (Street, 2015). This presentation will reflect on how the Roadmap facilitates the move from academia to support the growth of a European market for climate services.

### **1.3. Introduction and scope of the session**

Maria Noguer, Institute for Environmental Analytics (SECTEUR coordinator)

Thanh-Tâm Lê, Climate-KIC (MARCO coordinator)

Adriaan Perrels, Finnish Meteorological Institute (EU-MACS coordinator)

**2. Interactive session:** Use of climate information, long-term engagement and best practice from climate service purveyors and users - towards a more systemic approach to risk management, leading to climate-smart decisions at various levels for a range of end-users.

#### **2.1. Sector user specific information**

What are the key climate information required by these different sectors? Are users familiar with climate information? Do they know where to search and how to judge alternative providers? What types of users can be distinguished? How do sectors use the available information to make decisions? What do they need that is not provided already? We will address these questions for a number of sectors including Agriculture & Forestry, Coastal areas, Health, Infrastructure, Insurance, Tourism.

#### **2.2. Market analysis and prospects**

What does the market for climate services look like, now and in – say – 7 years? What are the main drivers and barriers for its growth? And how do we unleash the innovation potential for climate services in Europe? We will give a first take on the answers and encourage debate among the representatives from academia, practitioners, business and policy makers. The discussion will be inspired by pitch presentations staging experienced purveyors of climate services.

Participants will:

- Share knowledge on the climate information your organisation use, how it is used and why.
- Discuss how existing climate information could be improved to better fit your organisation's needs.
- Debate what would you need to be able to use climate information If not already using it.
- Confer on the main climate information gaps within your sector.
- Explore best ways to establish a two-way-communication to maintain a long-term engagement for future development of the Copernicus climate change service.
- Gain new insights regarding the current variety and future potential in supply and use of climate services

### **3. What's next: Conclusions and feedback**

## 6.10 Horses for courses: adaptation pathways for different contexts

*James Butler, CSIRO*

### Pathways and transformation

1. Pathways of adaptation to high-end sea level rise for five coastal archetypes (Sally Brown, University of Southampton)
  2. Transformative adaptation pathways for natural resource management under climate change (Russell Wise, CSIRO)
  3. Livelihood adaptation pathways: using scenarios to design climate compatible development in Indonesia and Papua New Guinea (James Butler, CSIRO)
  4. Three Horizons pathways approach: Shaping emerging storylines in community resilience and adaptation (Ioan Fazey, University of Dundee)
  5. Tailoring adaptation pathways to support adaptive delta management in Bangladesh (Marjolijn Haasnoot, Deltares)
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**Keywords:** Adaptation pathways, development, uncertainty, decision-making, stakeholder capacity, planning

Following broad terms such as ‘sustainability’ and ‘resilience’, the concept of ‘adaptation pathways’ is becoming a lingua franca amongst scientists, practitioners and policy-makers addressing climate and global change.

Fundamentally the idea refers to decision-making processes and tools which aim to assist decision-makers to account for future uncertainty while making decisions today, but facing imperfect information and competing stakeholder objectives. As such, it directly addresses the problem of mainstreaming climate uncertainty into development decisions and investments over time. However, there are already a wide variety of interpretations of the concept, as researchers and practitioners adapt it to tackle a range of problems and decision-making contexts. This session seeks to explore researchers’ and practitioners’ experiences of applying adaptation pathways in a range of problem domains, from sea level rise and coastal infrastructure in Europe, to conservation planning in Australia, and rural community development planning in Indonesia, Papua New Guinea and Bangladesh. Presenters will explore their interpretations of adaptation pathways, and the tools and techniques they applied to support decision-making. Through a concluding panel and audience discussion, the convenors will attempt to distil key binding principles of adaptation pathways, and rectify possible mis-understandings that could cause confusion and even mal-adaptive practice. The session will be targeted at the science-policy-practice nexus, since the concept is intended to support stakeholders’ decision-making processes. It will be convened by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), from Australia, Deltares, from The Netherlands, and the RISES-AM (Responses to Coastal Climate Change: Innovative Strategies for high End Scenarios -Adaptation and Mitigation) project. It is intended that participants will contribute to a review paper on the application and interpretation of adaptation pathways, based on the presentations and discussion.

### Significance to adaptation practice, policy and/or business

Because adaptation pathways explicitly seek to support decision-makers to make ‘better’ decisions under conditions of future uncertainty, the session is directly relevant to adaptation practice and policy. It is also relevant to businesses who must increasingly make investment decisions which apply risk assessments based on current imperfect information. We envisage that the session will draw on practitioners’ interpretations and experiences of applying adaptation pathways thinking in their own policy, business and civil society roles.

### 1. Pathways of adaptation to high-end sea level rise for five coastal archetypes

Sally Brown, University of Southampton

Even under stringent climate change mitigation measures, sea-levels will continue to rise, posing long-term threats and making adaptation essential for coastal regions. However, adaptation infrastructure is expensive and

has long implementation time and design-life. These factors, together with the uncertainty around the magnitude and rate of sea-level rise, place adaptation decisions in a context of deep uncertainty. Exploring adaptation pathways can support decision-making in optimizing the timing of adaptation, and in avoiding adverse path-dependency. To date adaptation pathways applications are limited in coastal areas, possibly due to the lack of familiarity of practitioners with the key concepts upon which pathways are based. To close this application gap and to enable far-sighted adaptation action, we provide a basis for generating specific adaptation pathways in coastal systems by presenting generic adaptation pathways maps for different coastal archetypes. Among the many types of coastal zones, five archetypes types are identified which are particularly at risk by high-end sea level rise and for each of them the possible adaptation pathways were mapped. These archetypes are: 1) Urbanized coastlines with dunes or beaches; 2) Open coast with agriculture; 3) Urbanized low-lying deltas; 4) Rural low-lying deltas; and 5) Urbanized low-lying estuaries with agriculture. For each coastal archetype, we identify specific adaptation measures and describe conditions that will negate the effectiveness of these measures (so-called adaptation tipping points). Based on this, pathways are drawn by exploring various actions after each tipping point taking into account high-end sea level rise. When generating the pathways other considerations such as, the risk of overinvestment, the time needed for implementation or lack of social support, are included. Although for specific adaptation planning location-specific pathways are needed, the generic adaptation pathways can enable a quick-start for coastal planners as it will mainly be the tipping point conditions that need to be changed for this.

## **2. Transformative adaptation pathways for natural resource management under climate change**

Russell Wise, CSIRO

Current and future projections of CO<sub>2</sub> emissions confirm we are on a trajectory to 3°C warming. Recent experiences of natural and socio-economic systems' capacity to adapt being overwhelmed indicate climate risks at lower increases in global average temperatures and atmospheric CO<sub>2</sub> levels are larger than previously understood. Noteworthy examples of this include unprecedented bleaching of the Great Barrier Reef, irreversible habitat losses from extreme fires in Tasmania, and coastal erosion and inundation events exacerbating conflicts and trade-offs between private property owners and ecosystems. Consequently, the climate compatibility of societal and individual goals, and associated allocations of resources, need to be critically reassessed. There are substantial barriers to doing this, however, including: goal ambiguity under uncertain and transformative change; incumbent players resisting changes that might leave them worse off; and limited agency of decision makers to challenge and shift their regulatory, cultural or organisational environments. Tackling these barriers requires a strategic, long-term, and adaptive approach; and adaptation pathways are in principle well suited to this. However, in situations of transformational change, the 'adaptation pathways' approach needs to not only support decision makers sequence known adaptation options based on assessments of their performance under uncertain climate change, it also needs to account for the possibilities that: prevailing objectives will not be appropriate under climate-change; many climate-compatible options may not be currently legitimate, viable or legal; or existing decision makers' effectiveness will be compromised as climate changes unevenly impact across jurisdictions and time. Adaptation pathways approaches, therefore, will need to inform the design and implementation of adaptive strategies for changing the societal systems of rules, values and knowledge that currently constrain the agency and options available to decision makers to deal with transformational change. A 'transformative adaptation pathways' approach therefore might involve participatory visioning processes to catalyse acknowledgement amongst stakeholders of the need for transformation; building understanding of the dynamics and interdependencies between ecosystems and human wellbeing under climate change; processes for eliciting or activating societal and individual values for ecosystem changes; and undertaking potentially contested processes to reform natural resource management objectives and regulations informed by improved understanding of ecosystem dynamics and societal values under climate change. Recent experiences in adaptation pathways approaches to enabling transformation will be presented along with emerging principles and guidelines.

### **3. Livelihood adaptation pathways: using scenarios to design climate compatible development in Indonesia and Papua New Guinea**

James Butler, CSIRO

Few studies have examined how to mainstream future climate change uncertainty into decision-making for poverty alleviation in developing countries. With potentially drastic climate change emerging later this century, there is an imperative to develop planning tools which can enable vulnerable rural communities to proactively build adaptive capacity and 'leap-frog' the Sustainable Development Goals (SDGs). Using examples from Indonesia and Papua New Guinea, we present a novel participatory approach, 'livelihood adaptation pathways', to achieve this. We applied scenario planning to operationalise four adaptation pathways principles: 1) consideration of climate change as a component of multi-scale social-ecological systems; 2) recognition of stakeholders' competing values, goals and knowledge through co-learning; 3) coordination of responses across multiple decision-making levels; and 4) identification of strategies which are 'no regrets', incremental (tackling proximate drivers of community vulnerability) and transformative (tackling systemic drivers). Workshops with stakeholders from different administrative levels identified drivers of change, an aspirational vision and explorative scenarios for livelihoods in 2090, and utilised normative back-casting to design no regrets adaptation strategies needed to achieve the vision. The resulting 'tapestry' of strategies were predominately incremental, and targeted conventional development needs. Few directly addressed current or possible future climate change impacts. A minority were transformative, and higher level stakeholders identified proportionately more transformative strategies than local level stakeholders. While the vast majority of strategies were no regrets, some were potentially mal-adaptive, particularly for coastal areas and infrastructure. There were few examples of transformative innovations that could generate a step-change in linked human and environmental outcomes, hence leap-frogging the SDGs. We conclude that while effective at integrating future uncertainties into community development planning, our approach should place greater emphasis on analysing and addressing systemic drivers through extended learning cycles.

### **4. Three Horizons pathways approach: Shaping emerging storylines in community resilience**

Ioan Fazey, University of Dundee

In a world with a changing climate significant societal change is inevitable. This will be either through the rapid and significant transformative changes that will be necessary to keep the world within globally agreed goals of 1.5°C or through future re-organisation of society due to the forced changes from increasing climate impacts. This raises a critical challenge for humanity: how can we help accelerate desirable and transformative change? Pathways approaches are useful in this regard for helping visioning but their impact may be limited unless they are embedded in wider processes of engagement and action. In this presentation we explain how a pathways approach, called Three Horizons, was used as part of a process of community engagement in Scotland aimed at enhancing resilience to climate change. Three Horizons can be used to shape dialogue about how to alter patterns and pathways of change. It includes a simple framework that helps groups navigate the challenge of the need to simultaneously create visions while also situating those visions in relation to the present. Three Horizons was used within a wider set of actions conducted separately in three different communities in the Scottish Borders, with each community having different contexts and needs (urban regeneration, commuter town and rural development). In the presentation we explain the approach to the project and how Three Horizons was applied differently in each of the communities. We also report on analysis of how different storylines of change emerged in each community for the project as a whole, including the contribution of the Three Horizons pathways approach in this process. The work highlights how pathways approaches are themselves embedded in wider trajectories of change. It also explains how application of a pathways lens (a hindsight tool, in this case used to understand the storylines that emerged over time) can illuminate the relative value and contribution of a pathways approach (a futures oriented tool, involving application of Three Horizons) compared to other factors in influencing change. Finally, the work also shows that while pathways approaches are important, there is a need to

go beyond approaches that identify problems and solutions, towards being more directly part of practices for change.

## **5. Tailoring adaptation pathways to support adaptive delta management in Bangladesh**

Marjolijn Haasnoot, Deltares

In the face of uncertain environmental and socio-economic developments, policymakers and analysts are urged to develop adaptive plans to ensure long-term sustainable socio-economic and environmental development. An adaptive plan consists of short-term actions to make the necessary preparations and long-term options to adapt to uncertain changing conditions, if necessary. The Dynamic Adaptive Policy Pathways (DAPP) is an approach to develop such adaptive plans. The essence is the proactive planning for flexible adaptation over time, in response to how the future actually unfolds. The approach starts from the premise that policies/decisions have a design life and might fail as the operating conditions change. Once actions fail, additional or other actions are needed to achieve objectives, and a series of pathways emerge; at predetermined trigger points the course can change while still achieving the objectives. By exploring different pathways under multiple futures using an Integrated Assessment Metamodel or expert judgement, and considering path-dependency of actions, an adaptive plan can be designed. The plan is monitored for signals that indicate when the next step of a pathway should be implemented or whether reassessment of the plan is needed.

The adaptation pathways approach has found a fertile application domain in ‘adaptive delta management’ (ADM) in the Dutch Delta Programme, a nation-wide study to develop an adaptive Delta Plan to prepare the Netherlands for future climate and socio-economic change. Recently, the Bangladesh Government has formed a bilateral cooperation with the Netherlands to develop the Bangladesh Delta Plan 2100. Although the ADM approach is inspired by developments in the Netherlands, the application to Bangladesh has differences. While in the Netherlands the application focusses on: “How can the country be protected from adverse impacts resulting from uncertain changing conditions?”, in Bangladesh the application focusses on development goals and thus aims to answer the following question “How can we enable socio-economic development under uncertain changing conditions?”. The country’s first need is to strengthen economic development for example by enhancing water security. Such investments need to be stress-tested against possible futures to ensure that they are robust and/or flexible to perform well or adapt if needed.

This presentation introduces the concept of pathways to support planned adaptation under uncertainty and illustrates differences to tailor the application to support the Bangladesh Delta Plan.

## Thursday 8 June 2017 AM1 (09:00-10:45)

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## 1.4 Out of sight, out of mind? Understanding, and responding to, climate change impacts in the marine environment

*Paul Buckley, Cefas and Phil Williamson, University of East Anglia & NERC*

### Climate services

#### Coastal

1. The EU Copernicus Marine Environmental Monitoring Service (CMEMS) and its use to monitor and manage the marine environment (Rosa Barciela, Met Office)
  2. Ocean acidification: impacts on, and adaptation by, organisms, ecosystems and society (Phil Williamson, University of East Anglia & NERC)
  3. 10 years of the UK Marine Climate Change Impacts Partnership (MCCIP): Building a community view to inform policy, practitioners and the public (Paul Buckley, Cefas)
  4. Cumulative impacts in marine areas under changing conditions: assessing climate change and adaptation scenarios (Anna Sperotto, Ca Foscari University)
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**Keywords:** Maritime industry, ocean acidification, ecosystem services, climate services, MCCIP, partnership working, best practice, marine conservation

The marine environment plays a fundamental role in supporting life on earth by regulating our climate. Our oceans act as a vast reservoir, storing heat and moderating the amount greenhouse gases in the atmosphere, lessening the effects of climate change we feel on land. Whilst the oceans are helping to 'buffer' some of the effects of climate change, changes in the heat and carbon content of the ocean could have serious consequences for marine ecosystems and human societies. As the oceans absorb more heat and carbon (leading to ocean acidification), marine life is put under stress, with the potential to affect entire marine ecosystems. For human society, basic physical changes in the marine environment, expressed through warming seas, melting sea ice, rising sea levels, changes in ocean chemistry and storms and waves, as well as changing rainfall patterns, and seasonal heat distribution on adjacent land masses, could have important consequences. These include impacts on coastal and marine infrastructure as well as food security (both from the sea and crops on land...through impacts on weather systems), global trade routes, coastal communities and human health. Impacts of global climate change could be amplified if the buffering effect of the ocean is reduced in the future.

Whilst scientific understanding of these impacts has been developing rapidly over the past decade, recognition of marine climate change as an important issue has been relatively slow to get off the ground. Early IPCC reports barely mentioned the potential impacts of marine climate change and European and National level reports on climate change have taken time to fully recognize potential impacts on marine ecosystems and wider society. Furthermore, recent European polling studies show that marine climate change issues such as ocean acidification are often seen as 'psychologically distant' and not relevant to people's everyday lives.

This session will explore some of the unique challenges we face in synthesizing evidence for marine climate change in European seas, and making findings relevant to end users. We will look at the risks posed to marine ecosystems and society from a key marine issue, ocean acidification, and its relevance to society; introduce

climate services available to help support European-level decision making in the context of changing marine environmental conditions; and report on the experiences of the UK marine climate change impacts partnership (MCCIP), to provide a national case study on lessons learnt in communicating marine climate change impacts, and applying this knowledge to build resilience in industry and support marine managers.

### **Significance to adaptation practice, policy and/or business**

The session will highlight key marine climate impacts, and challenges around packaging and communicating this information in a form that is of value to end users. It will showcase new marine climate services relevant to supporting decision making across Europe, explore adaptation challenges on a fundamental marine issue, ocean acidification, and highlighting best practice approaches in communicating marine climate change issues. Future challenges, and potential ways forward around gathering, disseminating and applying marine climate change evidence of past, present and future change to underpin decision making, will be explored by the presenting authors.

## **1. The EU Copernicus Marine Environmental Monitoring Service (CMEMS) and its use to monitor and manage the marine environment**

Rosa Barciela, Met Office

To manage and sustainably exploit the resources of the marine environment requires the balancing of many demands. Accurate assessments of the current state of the seas, and forecasts of how it will evolve, play a critical role in ensuring that marine operations can be carried out safely and productively, while minimising undesirable environmental impacts. The EU's Copernicus Marine Environmental Monitoring Service (CMEMS) was established in 2015, following an 8-year development phase, to provide state of the art assessments of the marine environment, in near real time, with free and open access to users.

The concept of CMEMS is to provide a range of generic products based on satellite and in situ observations, as well as model-based products which synthesise all the available observations, filling data gaps to produce spatially and temporally complete estimates of the ocean state. The CMEMS products are freely available to users, either directly or through 'intermediate users' such as consultancies who process and interpret the CMEMS products to tailor them to individual end user needs.

CMEMS operates three 'Thematic Assembly Centres' which collate and serve different types of observational product, and seven regional 'Marine Forecasting Centres' which provide near real time analyses and 5-day forecasts of the ocean state (based on assimilation of available observations into state of the art ocean models), as well as delayed-mode 'reanalyses' which provide consistent estimates of the evolving ocean state over recent decades. Both physical and biogeochemical variables are provided.

This presentation will describe the elements of the CMEMS products, outline access to them, and show some examples of their application to inform marine decision making in areas such as pollution management, fisheries operations and planning, and environmental quality compliance in the European seas.

## **2. Ocean acidification: impacts on, and adaptation by, organisms, ecosystems and society**

Philip Williamson, NERC and University of East Anglia

Ocean acidification is a relatively recently recognised phenomenon and its study has grown exponentially over the last 10 years. Research has benefitted from EU-funded projects (EPOCA and MedSeA), and strong linkage between national programmes in the UK, Germany and USA, as well as with the wider international effort. Initially, most studies were short-term, on single species with single stressors. The UK Ocean Acidification (UKOA) research programme, and others, expanded the scope of research, to include temperature interactions, whole-community experimental treatments, observations of natural coastal variability in seawater pH, studies at natural CO<sub>2</sub> vents and high-resolution regional modelling of future ocean acidification impacts. Ocean acidification has



the potential for widespread and significant effects on marine ecosystems that will also impact human society. It is therefore not surprising that there has also been strong policy contributions by ocean acidification researchers at the national and international level, including engagement with the Intergovernmental Panel on Climate Change, the UN Sustainable Development Goals, the Convention on Biological Diversity and the UN Framework Convention on Climate Change – recognising that ocean acidification and climate change share a common driver, increasing atmospheric CO<sub>2</sub>. Ocean acidification must be part of the debate on emissions reduction and adaptation as the Paris Agreement is implemented. In particular, it brings additional arguments for encouraging governments and industry to reduce CO<sub>2</sub> emissions, since that action will reduce the impact of both climate change and ocean acidification. There is therefore need to promote the inclusion of mitigation of, and adaptation to, the impacts of ocean acidification in policy relevant documents, regulation and funding instruments and platforms. Key priorities for future research relate to the genetically-based adaptive capacity of organisms and ecosystems, as well as the behavioural adaptation of human society, considering ocean acidification in a multiple stressor context. Issues relating to sensitivity, resilience and potential adaptation strategies will be discussed in the context of multi-stressor interactions, global socio-economic consequences, and the design of cost-effective monitoring programmes to aid future planning and adaptation.

### **3. 10 years of the UK Marine Climate Change Impacts Partnership (MCCIP): Building a community view to inform policy, practitioners and the public**

Paul Buckley, Cefas & MCCIP

The United Kingdom is a maritime nation, with many 1000s of miles of coastline, a marine EEZ far larger than its land area and a whole expanse of Atlantic Ocean on its doorstep. With all this water, and shoreline, around the UK, it is hardly surprising that marine climate change is having wide ranging impacts. Changes in sea temperature and ocean chemistry are affecting marine and coastal ecosystems, with implications for marine conservation and commercial fisheries, whilst rising sea levels and changing wave and wind climate have the potential to affect maritime and coastal industries and coastal communities, as well as international trade.

Just 10 years ago, very little effort was being made communicate marine climate change, both at the national and international level. In 2005, the UK Marine Climate Change Impacts Partnership (MCCIP) was set up to act as a neutral clearing house for scientific evidence on marine climate change impacts, providing a community view on the state of the science which could be rapidly transferred to decision makers. Here we report on the challenges faced in bringing together and communicating the scientific evidence base on marine climate change, how the MCCIP model has evolved, and learnings and recommendations on how marine climate change could be better communicated in the future to inform policy, practitioners and the public.

This presentation will also discuss our efforts to use the evidence base we have been building for the past decade to inform adaptation through MCCIP Climate Smart Working (CSW). Through MCCIP CSW, we have engaged directly with marine trade associations and industry practitioners to identify risks and opportunities and provide advice and support on adaptation responses. Most recently we have been working with the conservation community, developing coastal and offshore cases studies around building resilience for marine protected areas.

Learnings from our impacts and adaptation work are highly relevant to wider international, and terrestrial, communities and similar initiatives are being rolled out elsewhere.

### **4. Cumulative impacts in marine areas under changing conditions: assessing climate change and adaptation scenarios**

Anna Sperotto, University Ca' Foscari Venice & Fondazione Centro Euro-mediterraneo sui Cambiamenti Climatici (CMCC)

Anthropogenic and environmental pressures on coastal and marine ecosystems are increasing in number and intensity as result of political, economic and societal developments. Climate change is likely to further exacerbate

the stress experienced by marine systems, triggering alteration on biological, chemical and physical processes (e.g. sea surface temperature increase, nutrient cycling, acidification) and interfering with human activities and the economic uses of the sea (e.g. shipping traffic, aquaculture, ports' activities, fisheries).

As results, the adaption of marine areas to climate change necessarily calls for a more holistic approach addressing several sets of interactions between social, economic and ecological components, taking place at different temporal and spatial scales. Improving the capacity to model the cumulative effects induced by multiple and interactive stressors, in decisional contexts where data are limited and uncertain, is therefore essential to address a sustainable marine planning and to boost inter sectorial management strategies.

Moving beyond the traditional cumulative impacts assessment methodologies, a multi-risk approach, integrating different metrics and scenarios of climate, ocean, bio-geochemical and anthropogenic pressures (e.g. temperature variation, shipping traffic, aquaculture, ports activities, nutrients input) in an interactive impacts perspective, was developed and tested in the Adriatic sea case study. Its operative steps (i.e. multi-hazard, exposure, vulnerability, risk and cumulative impact assessment), were implemented through integrated tools and methods (i.e. GIS-based maps, Multi Criteria Decision Analysis) including the application of Bayesian Belief Networks (BBNs) to evaluate the likelihood of cumulative impacts under multiple model-based management scenarios. Applied together, these tools act as a decision support system, allowing the identification of marine areas and targets (e.g. seagrasses, maërl and coral beds and marine protected areas) where management actions and adaptation strategies would be best targeted.

The developed multi-risk framework aspires to be an operational tool to support marine planners and decision makers developing and implementing robust and adaptive measures able to deal with risks and uncertainties arising from incomplete knowledge about the ecosystem and the future natural and human-made pressures.

## 12.4 Adapting nature conservation strategies to climate change: how can science inform this process?

*Jeff Price, Tyndall Climate Change Centre*

### Ecosystem services and NBS

1. Biodiversity impacts, adaptation options and effort requirements from 1.5°C to 6°C - refugia and tipping points (Jeff Price, Tyndall Climate Change Centre)
  2. Mediterranean Habitat loss under future climate conditions – Adaptation options for Natura 2000 protected area sites (Achille Mauri, European Commission, DG JRC)
  3. The role of science in developing climate change adaptation of biodiversity and ecosystems in England (Mike Morecroft, Natural England)
  4. Peatlands fit for the future: improving the UK evidence base for peatland condition to target management for adaption and mitigation (Janet Moxley, Centre for Ecology & Hydrology)
  5. Can we save the Montados? A modelling approach for testing the effectiveness of management options under different climate change scenarios (Tiago Capela Lourenco, Faculty Of Sciences - University Of Lisbon)
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**Keywords:** Biodiversity, ecosystems, conservation, practitioners, adaptation, management, extreme weather events, vulnerability

In our changing climate, nature conservation strategies need to be adapted to take into account climate change, for example by facilitating natural adaptation processes within ecosystems, or by enhancing natural resilience to climate variability and change. This session highlights how a scientific approach can be used to help design effective, climate resilient conservation strategies at global, national and local scales. Examples are taken from a range of ecosystems, and a wide variety of complementary approaches are discussed. These include the design of protected area networks; the assessment of the current vulnerability of ecosystems to climate variability and change; and conservation management plans. Some sessions are purely scientific whilst others report on the actual experience of incorporating the science into conservation practice and the lessons learnt from this.

### Significance to adaptation practice, policy and/or business

This session provides several practical examples indicating how science can better inform conservation management practise to make it more resilient to climate change, and/or to facilitate natural adaptation processes in ecosystems. It also covers some of the lessons learnt from attempts to put this science into practice. It will be of interest to business, government and non-governmental organisations seeking to conserve biodiversity in the future, irrespective of the scale at which they are working.

### 1. Biodiversity impacts, adaptation options and effort requirements from 1.5°C to 6°C - refugia and tipping points.

Jeff Price, Tyndall Climate Change Centre

Helix is an EU funded project looking at the potential impacts of climate change and potential adaptation options for global warming levels ranging from 1.5° - 6°C. This presentation presents an overview of some of the results from our Helix funded work on global biodiversity. The Wallace Initiative has developed models examining the potential impacts of climate change on 80,000 terrestrial plants, birds, mammals, reptiles and amphibians at a global spatial resolution of ~20 km, for 21 climate models, under several potential dispersal scenarios. The goal of the Wallace Initiative is to identify the refugia (i.e., areas remaining climatically suitable for >75% of the species studied), species range shifts and climate migratory pathways for a wide range of species. These data can be used to look at the design/robustness of protected area systems, to look at the potential changes in ecosystem services to local communities, and to design proactive sustainable development for biodiversity, food security, water

security and bioenergy at differing levels of climate change. While the impacts on biodiversity are as might be expected under 6°C of warming, there are still some areas that might be seen as partial refugia, at least for some taxa. However, there are sizeable differences in the potential adaptation effort required to maintain biodiversity in some parts of the world even between 1.5° C and 2°C (especially in the tropics). As the temperature increases the number of potential refugia decreases (tipping points in many temperate areas) and adaptation options quickly shift from Business-as-Usual natural resource management to the need to potentially facilitate change. Overall, across the five taxa, plants appeared to benefit the most and reptiles the least from holding the temperature rise to 1.5°C rather than 2°C. Regionally, Coastal East Africa appeared to benefit the most (average benefit of 22%) in the priority place area requiring reduced adaptation to climate change to maintain current biodiversity under these models. The African Rift Lakes and the Orinoco River (South America) region were second (21%) followed by Madagascar and the Namib-Karoo of Africa (20%). The degree to which dispersal (and corridors) can benefit biodiversity depends on how the 1.5°C target is achieved, especially which types of mitigation (e.g., biofuels), are used. While corridors and dispersal are often put forward as natural adaptation to climate change, barriers to movement in the form of competing land-uses, cities, and roads may limit movement as an adaptation option.

## **2. Mediterranean Habitat loss under future climate conditions – Adaptation options for Natura 2000 protected area sites.**

Achille Mauri, EC Joint Research Centre.

Euro-Mediterranean ecosystems are widely recognized as a global hotspot of biodiversity, hosting nearly 25,000 plant species (of which 13,000 are endemic), and representing one of the main reservoirs of plant diversity in the world. For these reasons, Euro-Mediterranean ecosystems are considered a primary target for biodiversity conservation also in light of the services they provide to humans. Nevertheless, anthropogenic climate change is a serious threat for biodiversity conservation in this region. Indeed, the combined effect of the contraction of the Mediterranean climate domain and the expansion of the arid climate domain will lead to substantial habitat loss, which in turn may aggravate the impacts on communities of plant and animal species. In this study we assess Mediterranean habitat loss under scenarios of climate change and propose a series of adaptation options for Natura 2000 protected area sites. We first computed changes in the Mediterranean and arid climate domains (according to the Köppen-Geiger classification) between the historical reference climate centred on the 1990s and two future periods centred on the 2030s and 2080s, under RCP4.5 and RCP8.5 scenarios. We used 11 high resolution (0.11°) regional climate model (RCM) simulations from the WCRP Coordinated Regional Downscaling Experiment (CORDEX). The simulations were previously corrected for bias by Dosio (2016). Results of this study identified Natura 2000 sites that will be affected by Mediterranean habitat loss. Our results indicate that by the end of the century the Euro-Mediterranean domain is projected to lose an area equivalent to the size of Greece and Portugal combined. The loss is entirely due to shifts of the arid domain, which is projected to double in size. The shrinking of the current Euro-Mediterranean domain is projected to affect an important proportion of the Mediterranean Natura 2000 sites. Options for adaptation are modelled looking at facilitating the mobility of vagile species and reconnecting stable Mediterranean habitats and Natura 2000 sites through maintenance or development of corridors and stepping stones, creation of new protected areas, and actions promoting appropriate management of the wider landscape. The proposed options take into consideration investments in Green Infrastructure and the creation of a denser network of interconnected protected areas in critical zones.

## **3. The role of science in developing climate change adaptation of biodiversity and ecosystems in England.**

Mike Morecroft, Natural England.

The vulnerability of biodiversity and ecosystems to climate change has been well documented, with emerging impacts being clearly identifiable and projections of future changes available for many systems. The need for adaptation to climate change has long been recognised in nature conservation; however, the integration of adaptation into practice has been slow and remains incomplete. One reason for this is that the effectiveness of

some of the potential adaptation options has not been tested so the evidence base is not available to justify changes in management. There has also been a tendency to identify general principles for adaptation rather than specific approaches for specific circumstances. Conservation is always context specific and general principles need to be developed into specific actions. The same is true of environmental management to provide ecosystems services for people, including ecosystem based adaptation such as flood risk management and local cooling. Natural England is the government conservation agency for England with a wide remit including advice to government and others, managing nature reserves, legal protection of species and habitats and running agri-environment schemes. Science underpins all aspects of this remit. Over the last 10 years we have led a research programme to test the effectiveness of different approaches to adaptation. This has allowed us to start identifying some of the most important aspects of climate change adaptation, for example providing rigorous evidence that larger blocks of habitat promote the resilience of species populations. We have also developed a range of mechanisms to support practitioners. The key elements are:

- Accessible information on climate change impacts
- Vulnerability assessment methodology and tools, including spatial datasets
- A climate change adaptation manual that provides detailed, habitat specific summaries of the evidence.
- Training and knowledge exchange.

Good feedback between policy, practice and science is essential. A critical element is building adaptation into the internal processes of the organisation, for example ensuring that it is built into management plans for nature reserves. This presentation will review the lessons learnt by Natural England and assess 1) what scientific evidence is most useful to support adaptation, 2) recent advances that can help to transform conservation and land management practice, 3) the limits of science and the importance of organisational and human factors.

#### **4. Peatlands fit for the future: improving the UK evidence base for peatland condition to target management for adaption and mitigation.**

Janet Moxley, Centre for Ecology and Hydrology

Peatland is an important global carbon store, locking away as much as 500 billion tonnes of carbon. The UK has large areas of peatland, providing ecosystem services for biodiversity and water and carbon storage, but around 80% of these peatlands have been eroded, modified or destroyed through anthropogenic pressures. Peat erosion reduces water quality and can increase flood risk and degraded peatlands are also a source of greenhouse gases (GHGs). The restoration of the UK's damaged peatlands has been prioritised as a method of mitigating climate change through reduced or avoided GHG emissions. Peatlands whose full hydrological function has been maintained or restored may be better able to cope with extreme weather events, storing rainwater, and smoothing river flow levels. This can be particularly valuable for down-river communities adjacent to uplands. An understanding of the current condition of peatlands is necessary in order to assess their vulnerability to changing climate, as drying and warming is likely to lead to the further release of carbon, potentially initiating a positive feedback loop. Here we present the methodology, challenges and results of a two year project, funded by the Department of Energy and Climate Change (now DBEIS) which has produced new mapping of the extent and current condition of UK peatlands. These new peat condition maps represent significant progress in filling a key knowledge gap (as identified by the IUCN Peatland Programme). The maps will enable optimised targeting of peatland restoration and rewetting projects to locations where they will have the greatest impact (either in mitigation or adaptation terms). There is also the potential to use the new maps in conjunction with climate change projection mapping to assess the areas of peatland most vulnerable to future climate change.

#### **5. Can we save the Montados? A modelling approach for testing the effectiveness of management options under different climate change scenarios.**

Tiago Capela Lourenco, University Of Lisbon

Montados are unique oak-grassland agroforestry systems with a prominent environmental, social and economic role. These oak savanna systems were created and maintained by active forest and pasture management, and provide many important ecosystem goods including cork and forage for livestock. However, this Mediterranean ecosystem is undergoing an unprecedented rate of change due to a variety of factors, including: i) unsustainable increases in livestock numbers leading to extremely low tree regeneration; ii) changing land use patterns coupled to socioeconomic and demographic changes; iii) changing practices in the livestock and wine industries (where cork is used as bottle stoppers); and iv) increasing drought frequency and intensity due to climate change.

To explore the impact of these growing pressures and to test the effectiveness of different management options, we used a stochastic forest landscape model (LandClim) designed to simulate long-term forest dynamics and the impact of climate, disturbances (i.e. fire), forest and pasture management on the provisioning of ecosystem goods and services. We simulated a cork oak (*Quercus suber*) montado near Lisbon, Portugal, to quantify the impacts of changing management and climate.

Our results indicate that present day grazing pressure is unsustainable in the long term, as there was a drop in cork-oak regeneration and cork production even without climate change (CC). In most of the CC scenarios, there was a strong reduction in cork production up to 50% by 2050 and up to 100% by 2100. Forage production was also extremely reduced in all scenarios due to increasing droughts. Our results also indicate that the use of active management measures such as the reduction of grazing pressure to historical levels, can counteract the effects of CC in the milder scenarios (RCP 4.5). However under high end scenarios (RCP 8.5), Montado systems are at a serious risk of collapse.

Considering that cork trees take many years to grow and reach harvestable sizes, urgent action is needed to preserve this important ecosystem. European Union agricultural policies fluctuate and are often inconsistent, and do not currently provide adequate measures for sustaining Montado industries and landscapes. Montados provide a great opportunity to promote sustainable development, mitigation and adaptation goals and EU and national policies as well as mechanisms such as the voluntary markets of ecosystem services should be aligned to promote their long-term sustainability. These should favour practices that increase oak regeneration, maintain uneven size classes of trees, and decrease land use intensity, particularly grazing pressure.

## 1.8 Understanding, Analysing and Adapting to Climate Change Impacts on the Historic Environment

*Mairi Davies, Ewan Hislop, Historic Environment Scotland and Carsten Hermann*

### Climate services

1. Assessment of climate change impacts on historic sites in the care of Historic Environment Scotland: Development an assessment method using a risks and vulnerabilities matrix (Mairi Davies, Historic Environment Scotland)
  2. Community engagement for archaeological recording in the context of climate change (Tom Dawson)
  3. Adapting a historic town to climate change in Norway: The Aurland pilot project (Marte Boro)
  4. Adapting a UNESCO World Heritage Site to climate change through community engagement: Challenges and opportunities. (Adam Wilkinson)
  5. 'Hindsight is a wonderful thing'. Lessons in future mitigation and adaptation from the historic environment. (Hannah Fluck, English Heritage)
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**Keywords:** environmental impacts; climate change adaptation measures; historic environment; conservation; cultural heritage; built environment; risk assessment

The historic environment sustains our tourism industry, supports local communities and shapes people's cultural identities and understanding. Climate change impacts today are already damaging and destroying historic places – from designated monuments and traditional buildings to archaeological remains and cultural landscapes. A finite resource, the historic environment needs to be adapted urgently to mitigate the physical impacts of climate change.

In this session, the wide range of climate change impacts on the historic environment will be discussed, together with options for their assessment, monitoring and mitigation and how this can inform conservation-minded adaptation planning and governmental policy. The papers in this session will focus on site assessment methods, policy implications and evaluation procedures for adaptation measures. Assessment of site-related risks and vulnerability are becoming more commonplace but are still rarely utilised in conservation planning.

The link to practical implementation will be a key element for this session: The discussion will focus on how relevant cultural and environmental data (namely information about heritage and climate change) is used in adaptation activities by different stakeholders and how this different stakeholder communicated with each other. Stakeholders will include local authorities, government departments, funders, site owners, operators and users, businesses and community groups as well as researchers and consultants.

The session will bring together foremost researchers and policymakers to enable discussion on how current research can inform policy development and identify knowledge gaps to establish future research needs.

### Significance to adaptation practice, policy and/or business

The session will demonstrate how assessments and subsequent adaptation of our historic places can be achieved, gathering and using increased quantities of data on the historic environment and advanced assessment methods and analysis techniques and by learning from practical applications of adaption measures in Scotland and beyond. The session will be significant to those involved in managing historic places and to businesses planning, implementing and/or evaluating adaptation measures in practice, as well as to policy makers at local, regional and national levels.

## **1. Assessment of climate change impacts on historic sites in the care of Historic Environment Scotland: Development an assessment method using a risks and vulnerabilities matrix**

Mairi Davies, Historic Environment Scotland

As a large public body, Historic Environment Scotland (HES) has duties under Part 4 of the Climate Change (Scotland) Act 2009 that require it to contribute to climate change mitigation and adaptation, and to act sustainably. Ministers have identified HES as a 'Major Player' because it has a larger influence/impact on climate change than other public bodies. A Climate Change Action Plan for Historic Scotland 2012-2017 sets out how HES will fulfil its duties under the Act. The UK Climate Change Risk Assessment 2012 identified a range of risks and opportunities that climate change may present. Many of these have the potential to impact on the historic environment. HES is key to the delivery of *Climate Ready Scotland: Scottish Climate Change Adaptation Programme*, which tasks it with the following:

- quantifying heritage assets affected by climate change using GIS
- developing a methodology for assessing climate change risk to historic sites
- creating a risk register for the 'Properties in Care' that are managed by HES (to assist with management planning and resource allocation).

In response, HES has undertaken a research project in partnership with the British Geological Survey (BGS) and Scottish Environment Protection Agency (SEPA) that sets out to identify the threats associated with climate change (such as slope instability and flooding) that have the potential to impact on the HES Estate. The results are assisting HES in preparing a risk register for the properties across the HES Estate and in shaping and prioritising on-going conservation and maintenance programmes. The research will also inform the development of a methodology for the broader historic environment.

## **2. Community engagement for archaeological recording in the context of climate change**

Tom Dawson, University of St. Andrews

Scotland's coastline is one of the longest in Europe. The mainland and hundreds of offshore islands have attracted people since Scotland was first settled, as shown by thousands of archaeological and heritage sites. Many contain evidence of past environmental change, demonstrating how people adapted to climate change in the past. Unfortunately, coastal areas are also highly dynamic, and the combination of wind and sea can cause flooding, storm damage and erosion, leading to many metres of land being lost in single events.

Natural processes are putting thousands of coastal sites at risk of destruction, and climate change will likely increase that threat. In order to understand the size and significance of the cultural heritage resource of the coast, Historic Environment Scotland started a programme of rapid coastal surveys in the mid-1990s, documenting all heritage sites together with information on coastal vulnerability.

Many of these surveys were managed by the SCAPE Trust and the University of St Andrews, and they subsequently analysed the results in order to create a prioritised list of sites requiring action. The analysis showed that there had been significant changes within the dynamic coastal zone since the first surveys were undertaken, and records needed to be updated. This led to the initiation of the Scotland's Coastal Heritage at Risk Project (SCHARP), which adopted a citizen science approach to updating information.

The entire coastal heritage database was made accessible through a website and mobile app, and sessions were held around the coast to train volunteers in monitoring and recording coastal sites. Volunteers sent in photographs and completed simple, multiple choice forms. The updated records were verified and then appended to the database, and the information was shared with local and national heritage agencies.



SCHARP also recognised that collecting data alone does not save sites, and projects at locally-valued sites, nominated by the communities themselves, were established. These have brought local volunteers together with heritage professionals to undertake a range of activities which have rescued information from threatened sites. Work has included excavations, creating videos, relocating structures, digital surveys and interpretation projects. The activities have demonstrated that partnership working involving national and local heritage agencies, professionals, academic institutions and local communities can help to provide a framework for dealing with a global problem which is likely to become more acute in the future. This paper will share methodologies and experiences from SCHARP.

### **3. Adapting a historic town to climate change in Norway: The Aurland pilot project**

Marte Boro, Riksantikvaren

Riksantikvaren, the Directorate for Cultural Heritage Research of the Government of Norway, has initiated the Aurland pilot project to develop the following expertise: knowledge about climate change impacts on cultural heritage and environment; working methods for assessing risk for injuries and measures to reduce damage; and good management and preparedness at the various administrative levels.

Based in Aurland Municipality, in coastal southwestern Norway, the project has been conducted to gain experience and knowledge in how municipalities, regional cultural heritage and national cultural heritage authorities should develop its heritage management in times of a changing climate. The project is a collaboration between Aurland Municipality, Sogn og Fjordane county, the County Governor of Sogn og Fjordane, Norwegian Water Resources and Energy Directorate and Norwegian Institute for Cultural Heritage Research.

The primary tasks of the project have been:

- Assess what is the expected climate changes or events related to this municipality
- Consider how best to categorize cultural heritage and communities in the municipality, held up against climate change and damaging threats.
- Conduct ROS analysis of a selection of cultural heritage.
- Assess current measures to reduce the risk of injury
- Assess extraordinary measures - preparedness at events, major initiatives for extra sensitive cultural monuments and sites.
- Assess the need for better emergency preparedness - cooperation - both concrete for cultural heritage, but also as part of the county and municipal emergency work
- Evaluate and propose further work in the heritage sector

Development of working methods has been part of the project work.

### **4. Adapting a UNESCO World Heritage Site to climate change through community engagement: Challenges and opportunities.**

Adam Wilkinson, Edinburgh World Heritage

Each World Heritage site has its own unique characteristics and therefore it has a unique to its character problems and solutions. Edinburgh World Heritage Site, has one of the largest residential areas within the world heritage site and each day sees 22,000 residents & 73,250 workers. That does not include the 2,298,100 of tourists that visit the city during the Fringe Festival in August and all year round visitors. The climate change projections for Edinburgh identified that the city has experienced 5% increase in heavy rainfall and on average 6mm more rain per month [1961-1990 baseline]. As such, the likelihood of increased vulnerability of key heritage assets to damage is rising. While many of Edinburgh's historic buildings have experienced and withstood climatic changes in the past, it is a challenge to ensure that they continue to do so in the future. Potential risks of increased stone erosion and accelerated biological growth can compromise on architectural integrity of the

building stock. By its nature, adaptation is about trial and error, using emerging knowledge, understanding creativity and judgement based on experience. Empowering communities and providing them with knowledge about the adaptation options will be imperative for preserving the outstanding universal values of the Edinburgh World Heritage site.

In this talk we would showcase our community based work on how we engage residents' associations in helping us increasing the adaptive capacity of the buildings that they occupy. We will present the main results of the climate change impacts assessment of the EWH site and solutions proposed by the heritage architects that could be implemented on the wider city scale. The talk will be aimed at introducing EWH's Maintenance and Energy Efficiency Cooperatives scheme that empowers residents and gives them tools to carry out maintenance at their own merit. Furthermore, talk will discuss the case studies of our successful work already carried out such as the Lister Housing Cooperative.

**5. 'Hindsight is a wonderful thing': Lessons in future mitigation and adaptation from the historic environment**  
Hannah Fluck, Robyn Pender, and Jenifer White, English Heritage

The daily bread-and-butter of professionals involved in the conservation of the historic environment is looking back into the far past, and projecting its lessons into the far future. To ensure that we successfully prolong the lifespan of our buildings, designed landscapes, and archaeology, we have to be pragmatic: determining what has worked – and failed – in the past, and how the lessons we learn might guide us to make better decisions.

For this reason Historic England has been closely involved in climate-change issues for some 15 years. We see understanding the environment of the past, and how people adapted to that environment, as critical to planning for the environment to come. We believe we have a very important role to play in climate change adaptation, since our horizons are much longer than the 30 or 50 years adopted by most adaptation plans. Indeed, it is routine for us to think in terms of centuries, or even millennia.

Moreover, we have found that examples from the historic environment are an excellent way of communicating all aspects of climate change: its underlying causes, its implications for the way we live, and the options for mitigation and adaptation.

To do this, we use tools and mindsets that could be of great practical help to the wider world, which is struggling to find meaningful actions that would limit climate change, and deliver adaptations to it that will be successful in themselves and not risk unintended consequences.

This presentation will paint a picture of these tools and how they can be applied, with some engaging illustrations from our built heritage, our green heritage and our historic places of exactly what we mean by "learning from the past to inform the future".

## 7.1 Climate adaptation and sustainability. Part I: Approaches to integrate the SDGs into climate adaptation

*Laszlo Pinter, Central European University*

### Climate justice

1. Climate change and the Sustainable Development Goals: A Whole-Systems Approach (Henrik Carlsen, Stockholm Environment Institute)
  2. SDGs and climate change threat: impact assessment and adaptation strategies (Lorenza Campagnolo, Fondazione Eni Enrico Mattei)
  3. Informing critical risks 'beyond adaptation'- the Loss and Damage space (Reinhard Mechler, IIASA)
  4. An economic and development evaluation of a global adaptation and climate fiscal risk management pool (Junko Mochizuki, IIASA)
  5. Defining transformative climate science in the context of high-end scenarios. (J. David Tabara, Autonomous University of Barcelona)
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**Keywords:** SDGs, goals, targets, risk, loss and damage, transformation

Agenda 2030 and the sustainable development goals (SDGs) represent the global communities to date most ambitious and comprehensive effort to recognize and systematically respond to the interlocking sustainability challenges facing the planet and human societies. Climate change is but one of the many challenges calling for adaptation and transformative change in how we do science, policy and business, with its pervasive causes and impacts, but it both determines and is influenced by the context of most development efforts.

The session will review new research focused on exploring the interface between climate change adaptation and the SDGs, empirically tracking how SDG targets and climate change interact using Cross-Impact Balance methods in the specific context of Sweden (Carlsen and Weitz). Given its broad interlinkages, climate change will affect the ability of countries to meet SDGs. This, and the impacts of necessary but often costly adaptation measures on achieving SDG targets has been studied using recursive-dynamic Computable General Equilibrium (CGE) models, with results presented for 28 indicators, 16SDGs and 45 countries (Campagnolo and Delpiazzo).

Based on empirical evidence it is recognized that successful adaptation will be beyond the capacity of countries to adapt to dangerous climate change. Damage and loss resulting from climate change that is beyond adaptation will also affect the ability of countries to meet other goals. In order to advance science and global dialogue, the risk and policy space for damage and loss will be discussed, along the lines of assessing climate-related risk including adaptation deficits; the relevance of risk preference and coping; and the distributive and compensatory justice aspects of climate justice (Mechler and Schinko). Results of a multi-model approach to study the implications of creating a global climate risk and adaptation pooling fund will be presented, including implications for adaptation, climate risk management, mitigation and development (Schinko et al.).

Creating the knowledge necessary for diagnosing, understanding and developing innovative solutions for a world with wide-ranging development goals but potentially extreme climate change will challenge society and institutions well beyond business and usual. The last presentation will discuss the need for and outlines of transformative climate science in search of solutions that point beyond climate change to integratively tackling increasingly unsustainable global trends (Tabara et al.).

### Significance to adaptation practice, policy and/or business

The session will help situate adaptation science, policy, practice and business in the broader context of the SDGs and also provide language, concepts and examples for showing how adaptation contributes to and depend on

achieving the SDGs. The session will introduce and demonstrate the use of specific analytic tools and models that help this analysis. Going beyond standard adaptation approaches, the risk and policy implications of loss and damage will be discussed, including the conditions for a global climate risk and adaptation pooling fund. A contribution calling for transformative climate science particularly under the conditions of extreme climate change will help view and position adaptation as critical for successfully tackling climate and broader development challenges.

## **1. Climate change and the Sustainable Development Goals: A Whole-Systems Approach**

Henrik Carlsen, Stockholm Environment Institute

Climate change is intrinsically entangled with the UN 2030 Agenda for sustainable development. For example, the Paris Agreement explicitly recognizes a potential trade-off between emission of greenhouse gases and food production ('...low greenhouse gas emissions development, in a manner that does not threaten food production...') and Agenda 2030 dedicates one goal specifically to climate (SDG 13: "Climate Action"). However, the interactions between climate change and the Agenda 2030 go far beyond goal no. 13. In fact, climate change has a potential impact on most of the 17 SDGs. It is also true that many of the SDGs are related to mitigation efforts as well as being highly relevant for the development of coping capacity. This paper presents a methodology for systemic analysis of the SDGs in order to enhance our understanding of the interactions between climate change and the UN's sustainability agenda.

Making trade-offs and striking balances between competing interests are natural and integral parts of any political process, but the universal and integrated Agenda 2030 poses a challenge to many government administrations when they now move to implementation. In the UN rhetoric, the Agenda is "indivisible": the 17 goals and associated targets depend and build on each other and countries should implement the agenda as a whole. However, most public administrations are not effectively organized to deal with multi-sectoral, multi-scale, multi-actor, transdisciplinary and intergenerational issues.

Exactly how targets affect each other is an empirical question to which the answer will be different in different countries. It depends, for example, on the natural resource base (such as land or water availability), governance arrangements, what technologies are used and political ideas of future pathways for sustainable development. In this paper we therefore focus on a specific policy context (Sweden) and present a method for systemic analysis of the SDGs and their relation to climate change. We utilize Cross-Impact Balance (CIB; Weimer-Jehle 2006), a semi-quantitative method for systematic analysis of qualitative expert insights, in order to identify combinations of trends in SDGs (and associated targets) that reinforce each other. Such combinations are said to be self-consistent. Combining qualitative expert assessment of how targets interact (pair-wise) with a quantitative method that help to analyse the underlying network that link them all together, we identify consistency and contradiction between targets across the whole SDG framework including climate change.

## **2. SDGs and climate change threat: impact assessment and adaptation strategies**

Lorenza Campagnolo, Fondazione Eni Enrico Mattei (FEEM)

In September 2015, the adoption of the Sustainable Development Goals (SDGs) by the United Nations defined broad and ambitious development targets for both developed and developing countries encompassing all sustainability dimensions (economic, social, and environmental) and designing the pathway towards an inclusive green growth.

Climate change will pose serious risks for human and natural systems, hindering the already arduous way toward SDGs. Moreover, climate change impacts will not be evenly distributed within regions and across regions, poor people and developing countries will likely be affected more than the others by global warming side-effects due to their higher vulnerability and the lack of resources to invest in precautionary adaptation measures.

It is essential to quantify the heterogeneity of climate change impacts across regions not only taking into account its economic costs, but also a broader set of indicators, ranging from poverty and malnutrition prevalence to healthy life expectancy. Quantifying impacts is the prerequisite for mobilising funds for adaptation and better direct them to the more impacted areas.

This presentation will offer an ex-ante assessment of climate change impacts on the global pathway towards achieving SDGs, and will highlight the contribution of adaptation measures in keeping on track of 2030 targets. In any case, adaptation measures are costly and could have detrimental side-effects especially in developing countries which are trying to translate their economic growth into higher well-being. Therefore, we will evaluate the benefits of an international adaptation fund directing support to the most vulnerable regions.

Our analysis relies on a recursive-dynamic Computable General Equilibrium (CGE) model developed and enriched with indicators representative of each SDGs. CGE models have a flexible structure, and can capture trade-offs and higher-order implications across sectors and countries that follow a shock or a policy. These models are suited to assess the performance of economic and some environmental indicators; in order to consider some key social indicators, ICES was further developed relying on the empirical literature and directly estimating the relations between indicators and endogenous variables of the model.

Our framework considers 28 indicators covering 16 SDGs. The analysis has world coverage, but we aggregate the result in 45 countries /macro-regions. The baseline scenario reproduces a Shared Socio-economic Pathways 5 (SSP5) and it is used as a benchmark to assess the impact of climate change related shocks on agricultural sector.

### **3. Informing critical risks 'beyond adaptation'- the Loss and Damage space**

Reinhard Mechler, IIASA

The issue of 'dangerous' climate change has been fundamental for the international climate negotiations, informing the adoption of the 2 °C and 1.5 °C goals. The question of how to adapt and manage dangerous climate change as being experienced and perceived by developing countries and communities has been one of the most contentious questions in international climate negotiations. The Paris Agreement included ground-breaking text on the need for a mechanism to help identify risks beyond adaptation and support the victims of climate-related loss and damage—but how exactly it will work remains unclear. A number of promising avenues for taking the debate further have been preliminarily identified such as focussing on climate risk management and current international efforts for promoting disaster risk management. There have been a few studies reporting on empirical assessments. Overall, there is a need to solidly define the grounds for Loss and Damage (e.g., compared to adaptation), develop key principles to build on, as well as further generate evidence regarding risk "beyond adaptation"

We build on three lines of analysis or building blocks arising from discussions among researchers and negotiators in order to identify the risk and policy space for Loss and Damage. These include: Assessing climate-related risk comprehensively including any adaptation deficits; the relevance of risk preference and coping; and establishing a role for climate justice in terms of distributive and compensatory justice. We integrate these building block into a framework for identifying risks beyond adaptation, and define the policy space for loss and damage as composed of two sets of options where developed and developing countries could agree on international support and action in addition to support on adaptation or disaster risk management.

The first set of options refers to support for curative measures, which deal with unavoided and unavoidable risks. For example, given increasing sea levels induced by climate change, there is need to upgrade infrastructure and coastal protection; melting glaciers increase the risk of glacial lake outbursts, for which additional protection efforts are required. At high levels of warming, impacts become unavoidable, and people may be forced to migrate, for which international legal protection is essential. The second set of options refer to the concept of transformative risk management—that means building resilience against climate-related impacts while also

realizing that people and communities will need support to learn new skills and develop new livelihoods, or even voluntarily migrate to new homes to cope with the impacts of climate change. We support our argumentation with analytical insight referring to salient examples and discuss the implications for science and policy.

#### **4. An economic and development evaluation of a global adaptation and climate fiscal risk management pool**

Junko Mochizuki, IIASA

While rough estimates of annual funding needs for a global risk pool to absorb high level fiscal stress from extreme event risks exist, the development benefits, fiscal and macroeconomic consequences of managing such a global risk pooling fund has not been sufficiently investigated. Moreover, to what extent such funding needs may evolve due to future socio-economic developments and climate change remains unclear.

Funding needs for pro-active adaptation planning for slow-onset events have been estimated on a regional and global level (e.g. UNEP, 2014), as well as macroeconomic impacts of adaptation strategies. However, the integrated assessment of co-operative risk management of extreme events with simultaneous adaptation planning for slow-onset events has not been undertaken so far.

Based on these existing gaps in research, we study the potential economic and development consequences of different climate risk management funding options. We focus on extreme event risk management (flood and drought risk) and slow-onset sea level rise, and the corresponding pro-active adaptation needs. By joining forces between the sectoral CATastrophe SIMulation (CATSIM) model, focusing on extreme events, and the macro-economic models, WITCH and GEM-E3, we will build on the strengths of each modelling approach. This multi-models exercise serves as a case in point to explore the potential synergies and trade-offs that may exist between climate change adaptation and climate risk management, mitigation, and development.

In particular, we present the following results:

- Assessment of adaptation needs against risks from extreme events by looking into actual probabilistic loss distributions in the present and future (up to 2050).
- Generic stylized portfolios of risk management and adaptation for tackling frequent events through risk prevention (e.g., design standards for flood prevention structures), and rarer events through risk financing (compensation and insurance).
- Assessment of adaptation needs against risks from slow onset sea level rise, based on a two-step approach: The first step assesses the pure cost of inaction. The second step estimates the economic implications of an optimal level of protection scenario (based on bottom-up model input).
- Estimates for the wider (macro-)economic, (sectoral) spillover effects of adapting to climate change and managing extreme event risks with particular focus on the synergies with international risk transfer schemes.
- Effects on the development and climate change mitigation agenda by considering different adaptation funding burden sharing regimes (e.g. risk-based or emission based) and economic instruments (e.g. taxes vs. subsidy cuts).

#### **5. Defining transformative climate science in the context of high-end scenarios.**

J. David Tabara, Autonomous University of Barcelona

Conventional solutions and science approaches will not be enough to cope with the challenges posed by climate High-End Scenarios (HES) if major disruptions in social-ecological systems are to be avoided. However, a systematic understanding of the meaning and implications of transformation both for science and policy –and societal innovations at large– under the new climatic conditions is still lacking. To support this aim, we define transformative climate science as the open-ended process of producing, structuring and applying solutions–

oriented knowledge to fast-link adaptation and mitigation strategies to sustainable development. In addition, we also use 12 key dimensions to support the design of transformative social-climate research programmers from a complexity-based perspective. In this paper, we make the case for that transformation does not depend on mitigation or adaptation policies and actions. However, it is a necessary dimension to support the kind of profound institutional reconfigurations required to deal with the ultimate causes of the current climate crisis – mostly the growing unsustainability of the present global systems trends. The meaning of transformative climate solutions is discussed, together with further research questions –and limitations- of this new science-policy approach.

## 10.4 Adaptation of crop and livestock production to climate change and mitigation policies in a +1.5 K world

*Martin Köchy, Thünen Institute*

### Agriculture & forestry

1. Introduction: European agriculture in 2050 – MACSUR assessments of synergies and tradeoffs among adaptation and mitigation needs (Martin Köchy, Thünen Institute)
  2. Impact of Climate Change on the milk production of dairy cows in the United Kingdom (Nándor Fodor, University of Leeds)
  3. Climate and animal monitoring for adapted smart dairy barns (Severino Pinto, Leibniz Institute for Agricultural Engineering and Bioeconomy)
  4. Modelling GHG mitigation co-benefits and trade-offs after implementing adaptation measures to adapt from heat stress in dairy farms (Elena Galán, BC3. Basque Centre for Climate Change)
  5. Adaptation to climate change at farm level – integrating crop production and economy in a meta-model (Shailesh Shrestha, SRUC)
  6. Integrated modelling to quantify impacts of +1.5°C and uncertain precipitation sums on Austrian agriculture (Martin Schönhart, University of Natural Resources and Life Sciences, Vienna)
  7. Towards evidence-based and sustainable adaptation action plans for European farms (Nicolas Metayer, Solagro)
  8. EU and global climate mitigation policies – open discussion (Sonia Schimmelpfennig, Thünen Institute of Rural Studies)
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**Keywords:** agriculture, dairy production, smart barns, farm economy, integrated models, case studies

When global efforts to curb emissions of greenhouse gasses (GHGs) are successful, the average temperature increase will be limited to below +2 K. Even though this is a low-end scenario, changes in temperature and precipitation will have a strong impact on agricultural crop and livestock production. At the same time, the need for food production and demand for resources for a bio-economy are increasing. The MACSUR knowledge hub is an interdisciplinary network of researchers collaborating with stakeholders along the agri-food chain for providing assessments of impacts of changes in environmental, policy and socio-economic drivers on agriculture through the application of its combined expertise. Collaborating in MACSUR has improved the comparability and hence appropriate selection of models on soil, crop, livestock, and socio-economic-related topics, improved the linking of models for comprehensive assessments at regional level, and built up a network of regional case studies with European coverage.

Presentations by MACSUR-related projects in this session show impacts of climate change on agriculture in several regions across Europe and identify tradeoffs or synergies among adaptation, mitigation and other SDG-related goals and potential consequences of decisions to solve these tradeoffs. An open discussion including the audience at the end of the session will identify likely scenarios of regulations to achieve mitigation of GHG emissions and carbon storage to which European agriculture may have to adapt in a +1.5 K future.

### Significance to adaptation practice, policy and/or business

An assessment of the effect of the projected changes in climate on crop and dairy production will enable the food industry to identify the need for adaptation strategies. Along with other impact studies, these results help inform policymakers on the relative risk to the agricultural industry, and hence where intervention will be required to support the industry. The session provides a forum for discussing mitigation scenarios with industry and policymakers for integration in future assessments.



## **1. Introduction: European agriculture in 2050 – MACSUR assessments of synergies and tradeoffs among adaptation and mitigation needs.**

Martin Köchy, Thünen Institute, Germany

We will present an overview of adaptation needs based on MACSUR case studies and indicate tradeoffs with EU and national regulations. Efforts in MACSUR within the next years will focus on assessing mitigation strategies in line with GHG reduction targets for a +1.5 K world.

## **2. Impact of Climate Change on the milk production of dairy cows in the United Kingdom**

Nándor Fodor<sup>1</sup>, Andreas Foskolos<sup>2</sup>, Kairsty Topp<sup>3</sup>, Christine Foyer<sup>4</sup>

<sup>1</sup>University of Leeds, UK; <sup>2</sup>Aberystwyth University, UK; <sup>3</sup>SRUC, UK; <sup>4</sup>University of Leeds, UK

The impact of climate change on the dairy cows' milk production in the UK has been investigated using a gridded modelling approach. Five milk loss calculation methods based on the Temperature Humidity Index (THI), which accounts for the impact of heat stress, and eleven climate projections (UKCP09) with 25 km spatial resolution and covering the 1950-2100 period have been used in the study. Three of the investigated methods were using daily meteorological data. The two other methods use finer temporal resolution input data. The expected value of the heat stress has been characterised by the mean of the milk loss values calculated by using every climate projection × milk loss method combinations. The number of days when dairy cows are projected to be affected by heat stress will increase sharply as we approach the end of the century: e.g. In Southern-England, the number of days of heat stress increases from an annual average of 10 (baseline: 1990s) to over 40 per year. The associated milk loss will rise from a 30 kg/cow/yr up to 200 kg/cow/yr. By the end of the century, dairy cattle in large portions of Scotland and Northern Ireland will experience the same level of heat stress as cattle in Southern-England today. The number of days when daily step methods result in no milk loss while sub-daily time step methods result in non-zero milk loss shows monotonously increasing trend throughout the century. Consequently, simple methods that use only daily average temperature and relative humidity values may underestimate the impact of heat stress in the future. The projected milk loss figures show a high degree of uncertainty because of two major factors. The largest portion of uncertainty comes from the differences between the methods of calculating milk loss, while the other major factor is the climate projections. While the modelling the impact of certain mitigation or adaptation options is a great challenge, those options range from providing shelters for the cows to shifting the calving periods so that the dry period coincides with the days most affected by heat stress. Transgenic techniques can be applied to farmed animals to improve their growth, fitness and efficiency of production.

## **3. Climate and animal monitoring for adapted smart dairy barns**

Severino Pinto, Leibniz Institute for Agricultural Engineering and Bioeconomy (ATB), Potsdam, Germany

Large-scale dairy farming in Europe is of great economic relevance and a hot topic in public discussions related to animal welfare and pollutant emissions. Cattle are frequently housed in naturally ventilated buildings. Hence, they are particularly vulnerable to climate extremes and increased variability as projected in climate change scenarios. The microclimate in the barn has an impact on the animals' physiology and, hence, their greenhouse gas emission rates and net production of a farm. Microclimatic conditions (i.e., temperature, humidity and wind speed) vary across the animal occupied zone and there is a wide spread in the animal-individual response to heat stress.

In the OptiBarn project we monitor the microclimate and the physiological and behavioural response of the animals in selected pilot farms. This data is combined with lab experiments and modelling at different temporal and spatial scales to improve the assessment of heat stress risk and the adaptation of dairy buildings to future climate conditions.

We found that for climate monitoring in the barn wind speed and relative humidity must be measured in several parts of the barn due to their inhomogeneous distribution. Orthogonal inflows can cause a jet effect.

For monitoring animal responses to indoor climate, body temperature and respiration rate turned out to be particularly fast indicators for the animal-individual stress. The actual thresholds for heat stress, however, depend on various animal-specific parameters (e.g. age and milk yield of the cow). In addition, activity and body posture of the cows must be taken into consideration: Lying cows, for example, tend to have higher respiration frequencies than standing cows.

The suitability of selected reference points for climate monitoring in naturally ventilated barns and sensors for the animal-individual heat stress response will be discussed in the context of smart barns in this contribution. These smart barns permit to improve the microclimatic conditions much more efficient, and thus, may reduce the required total energy and water consumption. In addition, there is some indication that optimising the barn's microclimate can minimise GHG emissions (e.g., of methane). In this sense, the development of smart barns can be understood also as a mitigation measure.

#### **4. Modelling GHG mitigation co-benefits and trade-offs after implementing adaptation measures to adapt from heat stress in dairy farms**

Elena Galán, BC3. Basque Centre for Climate Change, Spain

Strategies to successfully tackle climate change in dairy farming systems vary according to agroclimatic conditions and choices at different levels of the farm management. In this study, using a whole-farm model coupled to an LCA approach, we compare the scope of different management practices applied in different agroclimatic conditions, including changes to increase the barn ventilation rate, calving seasonality or grazing period for example, on GHG and N emissions at the farm and across the whole production of 1 L of milk. We also assessed the effect on farm economics and other environmental impacts, trying to provide a holistic assessment of different adaptation measures introduced to alleviate dairy cows from suffering heat stress.

#### **5. Adaptation to climate change at farm level – integrating crop production and economy in a meta-model**

Shailesh Shrestha, Vera Eory, Kairsty Topp, SRUC (Scotland's Rural College), UK

We will present work on analysing the impacts of climate change on Scottish dairy farms by linking a crop/grass model (SPACSYS) to an economic farm level model (ScotFarm). The linkage will be achieved by using a statistical emulator which will enable the economic model to run different scenarios in a much faster way. The work will also identify the optimal farm adaptations under the climate change scenarios.

#### **6. Integrated modelling to quantify impacts of +1.5°C and uncertain precipitation sums on Austrian agriculture**

Martin Schönhart, Erwin Schmid, University of Natural Resources and Life Sciences, Vienna, Austria

Austrian agriculture will likely face a +1.5°C warming until the mid of this century, but changes of precipitation sums are rather uncertain. We present an integrated modelling framework (IMF) combining a bio-physical crop model and a bottom-up economic land use model to quantify climate change impacts until 2040. The IMF takes autonomous adaptation by farmers into account. Mitigation is considered by calculating changes in soil organic carbon levels and green-house-gas emissions. We apply the IMF to climate change scenarios that represent contrasting patterns in precipitation sums. Results reveal a large heterogeneity in climate vulnerability among Austrian regions, which is driven by a large climate gradient and heterogeneous bio-physical production conditions. Climate change induces autonomous adaptation of crop species, soil management (e.g. tillage), irrigation, or fertilization levels in the IMF. Livestock adaptation includes herd size and feeding diets. Crop choices are driven by their relative yield levels and rotation system. Adaptation of management result from changing ratios between yield impacts and production costs. Agricultural adaptation impacts the environmental status of soils, water, air, and regional landscapes.

## **7. Towards evidence-based and sustainable adaptation action plans for European farms**

Nicolas Metayer, Solagro, France

In a context of ever-increasing evidence of climate change, European farmers are interested in assessing the vulnerability of their farms and considering options to increase their resilience. Abundant literature, numerous models and various large-scale evaluations about the long terms impacts of climate change on European agriculture exist. Meanwhile, very little has been done, so far, to help farmers tailor farmscale measures to adapt to a changing climate.

The Life AgriAdapt project, bringing together four partner organizations from France, Spain, Germany and Estonia, aims at bridging some of this gap. The idea is to turn an abstract concept (climate change) into tangible facts that can be observed at farm level. Our presentation will include:

- a demonstration of our new software tool (which will be released next Spring 2017), aimed at conducting farm-level climate vulnerability assessments throughout Europe. Based on our experience with designing software tools to support the development of on-farm action plans (CarbonCalculator, AgriClimateChangeTool, ClimAgri®, Dia'terre®...), this new instrument will, once fed with key farm data, identify a farm's strengths and weaknesses in the face of climate change. The assessment then provides a reliable basis on which farmers can build action plans to best respond to the specific challenges they face.
- a presentation of the methodology developed to implement this tool on 120 farms throughout Europe and evaluate the efficiency of the corresponding action plans. The criteria used for the choice of these 120 farms will be key to guaranteeing the EU-wide relevance of the project results.
- an invitation to conference participants to join one of the projects stakeholders advisory boards to contribute to the effort and share ownership of the results.

AgriAdapt (2016 – 2019) is co-funded by the Life Programme of the European Commission. The overall objective of this project is to demonstrate that 3 of the most important farming systems in the EU (livestock, arable and permanent crops) will be more climate-resilient by implementing feasible measures which have also positive environmental crosscutting benefits (including climate change mitigation).

Project partners: Fundacion Global Nature (Spain), Solagro (France), Bodensee Stiftung (Germany), EMU (Estonia).

## **8. EU and global climate mitigation policies – open discussion**

Sonia Schimmelpfennig, Thünen Institute of Rural Studies, Braunschweig, Germany

Limiting climate change to less than a 2 K increase in temperature requires strong actions in the agricultural sector, which is causing 10% of the total GHG emissions in Europe (EUROSTAT). Other major sources are households, manufacturing, energy-related uses, transport and storage and other economic activities. Main agricultural sources of GHGs are soils, ruminants and manure. Land use and land use change are other sources of GHGs partly included in the Kyoto protocol but not in the EU climate policy. EU policies are likely to aim at lowering emissions, which might be achieved by lower production or technological improvements. After a short introduction to EU and global mitigation policies, session participants are invited to identify likely mitigation regulations that must be considered in assessments of future European agriculture.

## 5.6 Integrated research methods for co-creating adaptation solutions

*Katharina Hölscher, Drift and Simona Pedde, Wageningen UR*

### Participation and co-production

1. Knowledge co-production in European cooperation projects: evidence from a comparative study (Joanne Vinke-de Kruijf, University of Osnabrück)
  2. Adaptation pathways – can they achieve stakeholders' Visions for Europe under high end scenarios? (Ian Holman, Cranfield University)
  3. Qualitative and quantitative approaches to support adaptation decision making under uncertainty. Application in Cauvery River Basin in Karnataka (Suraje Dessai, University of Leeds)
  4. Climate Change Impacts and Local Adaptation Efforts in Louisiana, USA (Jeannette Dubinin, Director of Coastal Program, CPEX)
  5. Panel (Calum Brown, University Of Edinburgh; Stefan Haenen, Prospex; Ruth Monfries, ClimateXChange; Marta Olazabal, Basque Centre for Climate Change)
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**Keywords:** interdisciplinary, transdisciplinary, research methods, knowledge co-creation

*'All religions, arts and sciences are branches of the same tree'*

*Albert Einstein*

Adaptation is complex because of synergies and trade-offs across socio-economic sectors and abilities to adapt vary across populations and regions. Interdisciplinary and transdisciplinary research approaches (hereinafter 'integrated research') are emerging to address complexity in problem definitions and solutions for adaptation. Integrated research aims to generate systemic understanding of problems and solutions related to adaptation.

However, in reality scientific communities deal with different foci, for example ranging from local problems and vulnerabilities to large-scale modelling. Additionally, knowledge co-production between scientists and stakeholders is constrained by different priorities and responsibilities.

This session takes stock of and reflects on the state-of-the-art interdisciplinary and transdisciplinary research methods and their application on real-world climate adaptation responses. The session combines presentations on the applications of different methods and a panel discussion between researchers and practitioners, who have experience with such research and its practical relevance to reflect on the suitability and challenges of inter- and transdisciplinary for the development of climate adaptation solutions in different contexts.

### Significance to adaptation practice, policy and/or business

The session combines presentations on interdisciplinary and transdisciplinary research with a panel discussion between researchers and stakeholders who have experience with such research and its practical relevance.

This generates insights about how current research co-creates integrated knowledge about problems and solutions to adaptation and what opportunities and challenges are.

### 1. Knowledge co-production in European cooperation projects: evidence from a comparative study

Joanne Vinke-de Kruijf, University of Osnabrück

This contribution examines the co-production of knowledge in European cooperation projects that focus on climate change adaptation. Knowledge co-production occurs when a plurality of knowledge sources and types are brought together in a collaborative process to generate knowledge that is ready for action. European cooperation projects are likely to provide the 'ideal' circumstances for the transfer and co-production of knowledge. In these projects, cooperation and implementation processes go hand in hand with mutual learning and knowledge

transfer. As they are implemented by a heterogeneous group of actors (e.g. local, regional or national authorities, businesses, universities or research organizations) they are likely to bring together a plurality of knowledge sources and knowledge types. Through these joint projects, organizations or regions are expected to, for example, develop concerted strategies or jointly identify solutions to common or similar problems. Yet, participants tend to learn from each other but often fail to learn with each other. Hence, they miss out on opportunities for knowledge co-production. Against this background, we critically analyse the degree to which knowledge co-production occurs as well as the conditions under which this occurs in European cooperation projects. In doing so, we assess knowledge co-production as a process of three successive stages: exchange, transfer and co-production. Exchange applies when participants just provide information to other participants. Transfer occurs when participants discuss existing knowledge to understand and assess the applicability of this knowledge in their own context. Co-production applies to projects in which participants jointly create new knowledge that preferably can be applied to different contexts. By comparing evidence from ten completed projects (INTERREG4 and FP7), we examine what partner-specific and process-specific conditions are necessary or sufficient for knowledge co-production to occur and reflect on the feasibility of co-producing knowledge in European cooperation projects.

## **2. Adaptation pathways – can they achieve stakeholders’ Visions for Europe under high end scenarios?**

Ian Holman, Cranfield University

1. High end scenarios, both climate change and socioeconomic change, are likely to lead to major potential impacts on human and environmental systems. Consequently, a broad range of adaptation and mitigation responses have been proposed to address these challenges. However, the ability to project the efficacy of these options into societal outcomes is compromised by uncertainty in a number of factors:
2. the desired goal or end-point of such responses i.e. what specifically is society / business / government aiming to achieve?
3. the limitations imposed by future societal conditions i.e. how much and what type of responses can actually be carried out?
4. the timing of responses i.e. when do responses need to be carried out?
5. the synergies and trade-offs between different response.

In this presentation, we demonstrate how each of these limitations have been addressed within the IMPRESSIONS project to inform adaptation planning within Europe. Firstly, a set of goals identified by a broad range of European stakeholders were unified within a common Vision for 2100, which were subsequently modified and confirmed by the same stakeholders within a participatory workshop setting. The Vision statements on environment, economy, food/water/energy, health and well-being, resilience and equity were then converted into quantifiable statements by expert assessment. Secondly, the magnitude of adaptation responses were limited according to scenario-specific temporal trends in social, human, manufactured and financial capital within European Shared Socio-economic Pathways (SSPs). Finally, a regional multi-sectoral time-dependent modelling system (the IMPRESSIONS regional Integrated Assessment Model or rIAM) was used to explore the effects of adaptation timing on the exceedance of critical thresholds within a range of contrasting European SSPs associated with food, water resources, biodiversity, flooding and social/human/manufactured capitals. The effectiveness of adaptation to achieve elements of the scenario-independent Vision is shown to be scenario-specific and to be influenced by important synergies and trade-offs associated with cross-sectoral interactions and mitigation. Finally, we will discuss the implications of the findings for the need for transformative solutions.

### **3. Qualitative and quantitative approaches to support adaptation decision making under uncertainty.**

#### **Application in Cauvery River Basin in Karnataka**

Suraje Dessai, University of Leeds

Deep uncertainty in future climate change and socio-economic conditions necessitates the use of assess-risk-of-policy approaches over predict-then-act approaches for adaptation decision making. Robust Decision Making (RDM) or Decision Making Under Uncertainty (DMUU) approaches embody this principle and help evaluate the ability of adaptation options to satisfy stakeholder preferences under wide-ranging future conditions.

We simultaneously apply two RDM approaches; qualitative and quantitative, in the Cauvery River Basin in Karnataka (population ~23 million), India. The study aims to (a) determine robust water resources adaptation options for 2050s and (b) compare the usefulness of a qualitative stakeholder-driven approach with a quantitative modelling approach.

We combine climate narratives and socio-economic narratives to develop a large set of future scenarios. Climate narratives are developed using structured expert elicitation with a group of climate experts in the Indian Summer Monsoon. Socio-economic narratives are developed to reflect potential future urban and agricultural water demand. In the qualitative RDM approach a stakeholder workshop helped elicit key vulnerabilities, water resources adaptation options and performance criteria for evaluating options. In the following workshop, stakeholders elicited adaptation pathways by sequencing options till 2050. In the quantitative RDM approach, a Water Evaluation And Planning (WEAP) model is forced by quantitative data coherent with the climatic and socio-economic narratives to develop plausible scenarios of future water availability and demand. Individual adaptation options and adaptation pathways are applied across scenarios to assess their robustness.

In this predominantly agricultural basin, we find that options which address agricultural water demand, such as micro-irrigation and agricultural water pricing reduce the pressure on water resources. Urban water demand options are also important for rapidly expanding cities; Bangalore and Mysore. Agricultural water demand options demonstrate ability to satisfy legal in stream flow requirements for downstream riparian states across a larger range of scenarios, indicating robustness. Conversely, large scale infrastructural projects demonstrate lack of robustness, illustrating lock-in effects and potential maladaptation. Adaptation pathways demonstrate differential value across scenarios, depending on timing and sequencing of options, thus illustrating the need to design them carefully.

The qualitative approach is relatively resource-light and facilitates stakeholder interaction, while the quantitative approach is useful to demonstrate the scale of climate change impact and effect of options. We find that iteratively combining these approaches can suitably support adaptation decision making under uncertainty.

### **4. Climate Change Impacts and Local Adaptation Efforts in Louisiana, USA**

Jeannette Dubinin, Director of Coastal Program, Center for Planning Excellence

In 2005, Hurricanes Katrina and Rita exposed Louisiana's coastal decline and increased vulnerability to storm surge, flood risk, and rising sea levels. Until then, community planning and development in the state had been largely unguided and uncoordinated. The combination of poor planning and the decades long erosion of natural coastal defenses increased a very real but unacknowledged, or simply ignored, vulnerability. The response was the creation of the Coastal Protection and Restoration Authority and a comprehensive master plan to restore the coast and protect people and the economy. The plan focuses on structural (levees and floodwalls) and restoration (barrier islands, coastal wetlands) measures, but these can take years to construct and only provide protection for limited geographies when completed. CPEX, recognizing that time is of the essence for protecting communities across the entire Louisiana coast, has focused on incorporating nonstructural (green infrastructure, stormwater management, elevating structures) elements into the risk reduction toolbox of local communities. CPEX has taken a three-pronged approach: 1. Research and identify the needs and efforts of Louisiana's coastal communities to

reduce flood risk and provide the findings to state-level decision makers for policy and program development, 2. Advocate for a strong nonstructural component to be included in the Coastal Master Plan (which is updated every 5 years), and 3. Develop tools and guidelines for implementing nonstructural elements at the local level. CPEX will present an overview of climate change impacts in coastal Louisiana, CPEX's research with impacted local jurisdictions as published in *The View from the Coast*, and the tools and models for flood risk reduction CPEX developed to assist local jurisdictions with adapting to climate change and mitigating local flood risk.

## 4.3 Tracking Adaptation to Climate Change at Multiple Levels: International, National and Urban

*Robbert Biesbroek, Wageningen UR and Marta Olazabal and Elisa Sainz de Murieta*

### Monitoring and evaluation

#### Governance

1. Framework for tracking adaptation to climate change (Robbert Biesbroek, Wageningen UR)
  2. Assessing Stakeholder Needs for Adaptation Monitoring and Evaluation (Frances Wang, Adaptation Tracking Collaborative)
  3. Indicators for symbolic and substantive policy making for climate change adaptation (Andrew Tanabe, Adaptation Tracking Collaborative)
  4. A policy instruments approach to conceptualizing adaptation policy in comparative studies (Alexandra Lesnikowski, McGill University)
  5. On the credibility of current local climate adaptation plans (Marta Olazabal, Basque Centre for Climate Change)
  6. Understanding risks in the light of uncertainty: Low-probability, high-impact coastal events in cities (Elisa Sainz de Murieta, Basque Centre for Climate Change)
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**Keywords:** Climate Change Adaptation, Adaptation Policy, Adaptation metrics, Adaptation Tracking, International, National, Governance, Urban Areas.

Over the year's adaptation action has been reported at different administrative levels and contexts. With momentum coming out of the Paris Agreement, the need to understand the current state of adaptation and measure progress and effectiveness of adaptation policy is critical for accountability of climate investments and policy orientated learning. With a proliferation of adaptation tracking research a focus on the central challenges of the field is needed.

The objective of this session is to examine and critically discuss the various methods and concepts and their applications for tracking adaptation to climate change. Adaptation measures and policies are designed and evaluated at many levels including international, national, urban and project level. Crucial questions include:

- What are the benefits and limitations of aggregate versus discrete metrics for the various levels of adaptation?
- What are the needs of different stakeholders in measuring adaptation?
- What could be a meaningful baseline for tracking?
- How are adaptation metrics linked to the SDGs?
- What are key lessons learned for tracking adaptation and what are remaining challenges?

This session aims to bring scientists together to discuss ways forward in adaptation tracking under the cross-cutting theme of evidence for action.

The target audience is scientists with different backgrounds, but discussions are highly relevant to policy makers (to monitor and evaluate adaptation), businesses (private adaptation data, investments and finance), and stakeholders such as international organizations, NGOs or other groups related to accountability and transparency issues. We expect the session to: 1) deliver a future outlook and research agenda, 2) give practical examples of best practices, and 3) provide some convergence in the rapidly expanding discussions surrounding adaptation tracking.



This session will serve as a forum for scientists to come together to discuss the current state of adaptation tracking, elaborate on current challenges and set future goals. It is essential to understand whether policies and investments made in adaptation are working toward coherent progress, reducing vulnerabilities on the ground, and enabling learning, accountability, transparency and proper allocation of resources. In order to track adaptations it is critical to develop standards, methodologies, indicators and baselines for assessing progress. Multiple types of adaptation tracking are required and the potential benefits of adaptation tracking are far reaching.

## **1. Framework for tracking adaptation to climate change**

Robbert Biesbroek, Wageningen UR

Tracking climate change adaptation has gained considerable political and scholarly interest after the adoption of the Paris Agreement (2015) in which the UN Adaptation Committee was requested to propose methods for global adaptation stocktake, develop modalities, and review progress under the agreement. The need for Adaptation Metrics is highlighted in the UN Sustainable Development Goals (SDG13) where sets of indicators are proposed to measure progress achieving sustainability. Within the EU, the Adaptation Scoreboard is an example of sets of procedural indicators to assess and measure progress on adaptation policy across a variety of contexts and regions and to stimulate policy orientated learning. Various countries globally have started to explore ways to track their national adaptation efforts, most noticeably by developing Monitoring Reporting and Evaluation systems. Leading international financial institutes such as the World Bank and European Investment Bank, as well as a pallet of insurance companies are exploring ways to measure adaptation performance of their (project) investment decisions. Many NGO's and other organisations are calling for metrics to create transparent accountability structures for measuring progress and distributing climate finance for those that need it most. The preparatory climate change conference "Adaptation Metrics" for COP22 (27 sept 2016), showed that despite several promising attempts, limited comprehensive frameworks currently exist.

In response, this presentation builds on and synthesizes more than 5 year of experience in tracking adaptation research. The framework presented in this paper adopts a proximity-to-target approach to assess the progress countries, regions, cities or projects have made from their baseline to achieve their adaptation targets, reduce their climate risks, and take advantage of opportunities. By connecting climate risk profiles with adaptation policies, inferences can be made about whether or not progress can be attributed to substantive policy making or other factors (e.g. economic crisis). It allows, for example, to assess whether or not policy targets need to be intensified when climate risks change. The paper proposes a set of indicators for both the climate risk profiles as well as adaptation policy.

The paper uses illustrative examples from the National Communications and (I)NDCs countries to illustrate the value of the framework for tracking adaptation at national level. We argue that the framework and underlying methodological approach is flexible in design and can be diffused across different levels and contexts.

## **2. Assessing Stakeholder Needs for Adaptation Monitoring and Evaluation**

Frances Wang, ATC, TRAC3

In contrast to the well-developed measurement tools for mitigation, the absence of approaches for monitoring and evaluating (M&E) adaptation progress has been recognised by the UNFCCC Adaptation Committee as well as stakeholders from governments, the private sector, and civil society. Adaptation Tracking (AT) seeks to address this gap through systematically identifying, characterising, evaluating, monitoring, and comparing adaptation over time.

With significant development in both adaptation theory and practice, the next critical step is to connect the two components for effective adaptation actions. Namely, utilising stakeholder perceptions, concerns, attitudes, and information needs in climate resilience to inform adaptation planning, implementation, and M&E. This

understanding also translates to the design of the Adaptation Tracking framework, with methodologies supported by robust theoretical grounds while serving practical purposes and accessible to different stakeholders.

To inform such work, the Adaptation Tracking Collaborative (ATC) conducted an international needs assessment involving over 200 organisations. The goal is to 1) identify key information needs and gaps in current adaptation M&E; 2) analyse general trends in adaptation demands by different types of stakeholders; 3) in particular to the private sector, identify needs and gaps for M&E metrics in relation to public policy and the creation of an enabling environment for adaptation actions; 4) create a stakeholder map to identify influencers and enablers; 5) determine ways in which adaptation tracking can assist stakeholders to improve environmental policy decision-making.

This study involves stakeholders from governments, international organisations, civil society and boundary organisations, research and academia, as well as the private sector. A large portion of the research is completed through desk research, sampling published documents online. Given the significant information gap in private sector adaptation actions, semi-structured interview is the preferred methodology when engaging private sector stakeholders, completed in partnership from the ND-GAIN.

### **3. Indicators for symbolic and substantive policy making for climate change adaptation**

Andrew Tanabe, ATC, TRAC3

A major conceptual challenge to tracking climate adaptation policy is parsing substantive and symbolic policies. First generation adaptation tracking literature has focused largely on comparative studies of regions and countries engaged in adaptation policy making. Dupuis and Biesbroek (2013) argue that these early studies offer influential benchmarks and elaborate examples of adaptation policy that can stimulate other countries to develop similar policies, but they fall short of producing a powerful comparative lens to provide meaningful comparisons and evaluation and could hamper transitional learning and policy transfer.

To begin to remedy the situation, we created a preliminary framework and set of indicators to allow for more refined measurement of substantive vs. symbolic adaptation policy. The framework and indicators were created through a systematic review of existing literature on symbolic policy making. In order to develop the framework and set of indicators, the public policy literature was examined to identify, collect and synthesize the ways in which symbolic policy making is conceptualized and operationalized in the public policy literature. Symbolic policy mechanisms and indicators are outlined and the value of symbolic policy making in the context of climate adaptation tracking is discussed.

### **4. A policy instruments approach to conceptualizing adaptation policy in comparative studies**

Alexandra Lesnikowski, McGill University, ATC, TRAC3

The emergence of adaptation tracking as a distinct methodological family within the adaptation scholarship mirrors a rapidly growing interest in comparative approaches to studying dynamics underlying adaptation governance processes. Cross-sectional comparative studies are particularly useful for examining the drivers of policy adoption, including how structural, institutional, and political factors matter for policy selection and implementation. Larger cross-sectional studies are therefore invaluable for explaining variation in adaptation policy outcomes across contexts.

The question of how to define and measure complex policy phenomena like adaptation is a major challenge for designing robust large-n comparative studies. To date the majority of these studies use the existence of an adaptation plan or strategy as a proxy for the existence of adaptation policy, but we know this to be problematic for three reasons: 1) governments may be adapting even without the presence of a plan, 2) the existence of a plan does not necessarily guarantee its implementation, and 3) there is a broad range of quality in these plans that is not accounted for in this basic proxy. Some studies have sought to develop adaptation policy typologies

that capture the range of discrete policies, programmes, and initiatives observed at various levels of government, however there is as yet no consensus on how to design and operationalize these typologies systematically.

This presentation will argue for the need to better conceptualize adaptation policy in large-n comparative studies using a policy instruments approach to measuring adaptation implementation. This approach is framed as an entry-point for establishing a more structured understanding of the complex nature of adaptation policy processes, and so enabling more robust comparison across contexts. The usefulness of such an approach will be demonstrated using results from a study on institutional drivers of adaptation implementation in 150 cities from high-income countries. The study of local adaptation implementation presents a particularly interesting opportunity to operationalize a policy instruments approach because of the direct role that cities play in adaptation-relevant policy and service delivery for land use, building, urban design, and infrastructure maintenance. The application of a policy instruments approach provides a stronger conceptual foundation from which to define the dependent variable in comparative adaptation studies, and so supports more robust hypothesis-testing about the drivers of adaptation policy implementation.

## **5. On the credibility of current local climate adaptation plans**

Marta Olazabal, Basque Centre for Climate Change (BC3)

Local climate adaptation planning is relatively new. The earliest local adaptation plans began emerging about ten years ago and are an increasingly important component of the international urban policy agenda. Because these plans by nature involve long-term objectives, some of the main questions raised in current adaptation tracking research studies are whether and how they will be implemented and what is required for these plans to successfully achieve their objectives? There is no consensus on how to define “successful adaptation” and there are multiple, sometimes competing, interpretations of success.

We present a metrics-based approach for assessing the credibility of local adaptation planning, understood as the likelihood that these plans will be successfully implemented and sustained in the long-term. Credibility is a critical issue in climate policy. In the international mitigation policy context, credibility has been defined as “the likelihood that policymakers will keep promises to implement their pledges” and is argued to be essential to generate the necessary flows of climate finance from private and public sectors. Past performance with respect to similar policies, the quality of plans, the assignment of responsibilities and commitment of resources for their implementation, among others are central issues. Here we develop a Credibility Index to compare the likely efficacy of recently approved local climate adaptation plans for dealing with current and future climate impacts. We develop a conceptual model of what credibility means in climate adaptation planning and discuss a selection of metrics for assessing policy and economic credibility (in relation to, for example, the extent of a plan, budget, and assignment of responsibilities), scientific credibility (in relation to, for example, knowledge generated and used, monitoring and learning processes) and legitimacy (in relation to, for example, transparency, participation, equity and justice). We develop a pilot testing and discuss results and the adequacy of these metrics for assessing credibility of climate adaptation policies.

## **6. Understanding risks in the light of uncertainty: Low-probability, high-impact coastal events in cities**

Elisa Sainz de Murieta, Basque Centre for Climate Change (BC3) and Grantham Research Institute, London School of Economics (LSE)

Adaptation tracking needs metrics that can show how adaptation initiatives are performing on the ground and how they will perform in the future. The approach developed in this study can be used as a damage-based metric to support adaptation policy and its tracking in coastal cities affected by extreme coastal events. A quantification of present and future expected damages due to extreme coastal events can be crucial for adequate decision making on adaptation to climate change in coastal areas around the globe. However, assessing future impacts needs to deal with a major issue: uncertainty, referred to the intensity, frequency and timing of extreme events.

When uncertainty has to be accounted for, the traditional approach of estimating mean annual losses presents some major limitations. Here we propose a sophisticated methodology to incorporate the role of uncertainty in future impacts. A stochastic model is first used to estimate the probability distribution of future relative sea-level rise under three regionalised scenarios (RCP2.6, 4.5 and 8.5) for 124 major coastal cities. Additionally, we present two risk-modelling variables that can be a very useful to guide progressive adaptation strategies for cities, i.e. to help implement adaptation gradually in the light of new information. Based on these two risk-measures we estimate optimal adaptation needs and timing according to a range of acceptable risk levels that can be tailored for each city. This is something new in the field of economics of adaptation and offers a much broader picture of the challenges related to dealing with climate impacts. It can be applied to assess not only adaptation needs and timing, but also to evaluate and keep track of the implementation in each city.

## **7. How Well Are We Adapting? Designing a framework and implementation process for monitoring climate change adaptation across local governments in Australia**

Susie Moloney, Centre for Urban Research, RMIT University, Melbourne, Australia

Local governments are at the forefront of responding to climate change in developing risk assessments and mitigation and adaptation strategies. In the Australian context, local government plans and strategies are emerging, however the extent to which municipalities are planning effectively for climate change and whether they are delivering on outcomes is difficult to assess. While there are a number of frameworks for monitoring and evaluating climate change adaptation and urban resilience, very few have been implemented at the local scale. This paper will present a case study from a group of councils in metropolitan Melbourne who have collaborated to develop a framework to track how well they are adapting to climate change. The project process, framework design, indicators and pilot implementation phase will be outlined including an analysis of the challenges and issues that emerged in developing and implementing an approach to monitoring and evaluation. We seek to contribute to the gap in knowledge around ‘doing adaptation’ in particular how we can monitor and evaluation progress. In the post Paris climate policy context, much more attention is needed on how we can better understand the “actual experience of adaptation” which broadly asks “are we adapting”? (Ford and King 2015, p.506) and in the case of the particular Australian case study presented in this paper, the focus is on how can we assess ‘How Well Are We Adapting?’ and ‘How can we assist councils to track their progress and improve decision making?’. We will also present the findings from our analysis of existing practice around monitoring and evaluation (M&E) for climate change adaptation along with outcomes from a series of workshops with WAGA (Western Alliance for Greenhouse Action) councils and other stakeholders on how to effectively develop and embed M&E as part of the adaptation process.

## 6.4 Adaptation in practice: Case studies of flooding

*Sally Brown, University of Southampton*

### Flooding

1. A critical analysis of barriers and enablers of climate change adaptation: flood risk in the city of Leeds, UK (Jouni Paavola, University of Leeds)
  2. Insights into flood-coping appraisals of Protection Motivation Theory: Empirical evidence from Germany and France (Jonas Laudan, University of Potsdam)
  3. Costing climate change impacts and adaptation in Ireland with a specific focus on local businesses and the insurance industry (Swenja Surminski, London School Of Economics)
  4. Impacts and adaptation needs for coastal flooding: Global implications of coastal subsidence (Robert Nicholls, University of Southampton)
  5. Sea level rises on Ho Chi Minh City: impacts and adaptation (Paolo Scussolini, Institute for Environmental Studies (IVM))
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**Keywords:** flooding, social vulnerability, risk, management, socio-economic, drivers of change, response, development

Summary of session: Flooding occurs from multiple sources, and adaptation is essential where there is risk to infrastructure or human life. Understanding the causes of flooding is also important, so that appropriate adaptation can occur. This session considers case studies and practices from around the world in adapting to different sources of flooding. Firstly, it will question, what are the drivers to flooding. Flooding occurs from multiple drivers, and often extreme conditions. The presentations will question why flooding has occurred or is at risk of occurring, and whether this has changed over time to height flood risk. This includes discussion of the atmospheric and terrestrial drivers of change. It also considers social and engineered changes that result in an increase in flood risk. Secondly, the session will discuss the potential impacts of flooding through case study analysis from global to local scales. It will discuss risk, vulnerability, exposure and impacts, and the knock-on consequences of flooding for the local and wider regions. Physical and social risks and vulnerability will be discussed. Thirdly, the presentations will focus on adaptation. Adaptation is a broad umbrella term for a need for change. This may be social or policy change, and influencing behaviours or preparedness, a physical change to engineering or economic changes influencing cost-benefit of schemes. The presentations will discuss the different types of adaptation related to their case studies, and the factors that allow or not allow adaptation to occur. Future research will also be highlighted.

### Significance to adaptation practice, policy and/or business

Our session is relevant to managers who need to adapt to multiple changes on different temporal and spatial scales. It provides examples of the challenges in successfully adapting to changes, from a number of environments around the world, from social, physical and economic perspectives. It also provides guidance on how society or businesses could be more prepared for flooding. This highlights key policy challenges, will raise awareness by the sharing of experiences in adapting in order to reduce flood risk.

### 1. A critical analysis of barriers and enablers of climate change adaptation: flood risk in the city of Leeds, UK.

Jouni Paavola, University of Leeds

Recent research on the barriers and drivers of climate change adaptation suggests that although comprehensive inventories of factors hindering and enabling adaptation are produced, discussed and empirically tested by scientists, few insights have been presented to date on the temporal dynamics of adaptation barriers, their causes and the interdependencies between different driving and hindering forces. The literature has also

suggested that actor-centred and comparative research could promote a better understanding of how to overcome adaptation impediments (Eisenack et al. 2014). This paper seeks to contribute in this regard by examining and comparing the factors determining successful climate change adaptation to flood risk in the city of Leeds, UK. The paper explores the barriers to and enablers of adaptation by using a methodological framework drawing from the work of Lehmann et al. (2015). The main aim of the analysis is to better understand the underlying dynamics that influence adaptation success across Europe. We first examine the historical frequency and impacts of flooding to assess the hypothesis of an increasing flood risk and frequency. We then apply three climatic and socioeconomic future scenarios (determined in the EU FP7 research project BASE, which aims to support action for sustainable climate change adaptation in Europe) to Leeds. Data for the Leeds case study was collected through informal interviews, document analysis, a key stakeholder workshop and graphical representations of the scenarios. For the barriers and drivers part data was classified according to key driving and hindering factors, e.g. such as knowledge, actors, resources, measure type and regulatory framework, and underwent rigorous analysis relating single factors to the properties of the case studies and to each other. The preliminary results indicate that the relevance of the various driving and hindering factors discussed in the wider literature varies substantially depending on context and perceptions of climate change adaptation. Likewise, the strength and nature of the links between different key factors has an important impact on creating virtuous or vicious circles of adaptation action. Strategies combining different factors to prevent various types of deadlock and crises of confidence have been identified. Our findings do not only provide important insights for the design of adaptation strategies in cities and their implementation at different spatio-political levels, but also provides ground for further research related to the causes of barriers of adaptation, their dynamics and strategies to overcome them.

## **2. Insights into flood-coping appraisals of Protection Motivation Theory: Empirical evidence from Germany and France.**

Jonas Laudan, University of Potsdam, Germany.

Integrated risk management concepts increasingly gain importance as a comprehensive approach to reduce impacts of natural hazards by also including the contribution of vulnerable individuals. Insights into individual decision making processes are given by the Protection Motivation Theory (PMT), which has become a popular theory to explain risk-reducing behaviour of individuals against natural hazards in recent years. PMT captures two main cognitive processes that individuals undergo when faced with a threat, namely threat appraisal and coping appraisal. The latter describes the evaluation of possible response measures that reduce or avert the perceived threat. Related literature and the PMT framework revealed that the coping appraisal component stands out as a good predictor of protective or non-protective behaviour, yet little is known about the factors that influence coping appraisals of individuals with regard to natural hazards, and floods in particular. Further, it is unknown to which degree similar types or groups of coping appraisals exist among flood-prone residents from different states. A better understanding of these factors can be beneficial for developing effective risk communication and coping strategies which also target individual needs. This study presents the results of two surveys among more than 1600 flood-prone households in Germany and France, covering a wide range of environmental and intrapersonal variables. Four hypotheses on factors related to flood-coping appraisals were tested using multiple regression models and Principle Component Analysis (PCA). In addition, a group comparison was carried out to identify patterns of similarity within and between German and French households regarding their coping appraisal attitudes towards specific protection measures. The results show that similar patterns and groups occur within Germany and France for the adaptation measures “structural measures” and “non-structural measures”, also the variables influencing these patterns are equal. A good risk- and coping information is positively related to groups which show high coping appraisals. We also find that socio-economic characteristics alone are not sufficient as explaining factors for coping appraisals. Particularly, observational learning from the social environment, such as friends and neighbours, is positively related to flood coping appraisals. This suggests that social norms and networks play an important role in flood-preparedness decisions. Given the strong positive influence of the social

environment on flood-coping appraisals in Germany, future research should investigate how risk communication can be enhanced by making use of the observed social norms and network effects.

### **3. Costing climate change impacts and adaptation in Ireland – the impact on small businesses and insurance**

Swenja Surminski, London School Of Economics

Increased risk of flooding has been identified as one of the main threats to Ireland from climate change (see e.g. EPA's 2012 State of the Environment report). More generally, the need for adaptation strategies has been recognised in recent European and Irish policy documents (e.g. the EU's White Paper on Adapting to Climate Change, 2009; the EU Adaptation Strategy, 2013; and Ireland's National Climate Change Adaptation Framework, 2012). To manage flood risk effectively, and adapt efficiently to changing risk profiles as a result of climate change, more needs to be known about the economic costs of flooding and its wider impacts on economic activities in the short, medium and long term. Recent research projects have identified the likely future impacts of climate change in Ireland in terms of physical changes in temperature, precipitation and sea level rise. However, there remains an outstanding gap in the information available to policymakers in terms of the economic costs of climate impacts in Ireland in the absence of adaptation.

This presentation highlights the initial findings from a project commissioned by Ireland's Environmental Protection Agency (EPA) to develop a framework for costing the impact of flood risk on the Irish economy and assessing the options for managing it, with a specific focus on local businesses and the insurance industry. Our project aims to bridge the gap from vulnerability and impact assessments to the formulation of evidence-based local adaptation plans. Our empirical research will go beyond estimates of direct losses and also account for the value of disruptions to businesses, households and the wider economy from flooding.

### **4. Impacts and adaptation needs for coastal flooding: Global implications of coastal subsidence.**

Prof Robert Nicholls, University of Southampton, UK.

It is widely recognised in multiple studies that climate-induced sea-level rise is raising extreme water levels around the world's coast and this will accelerate in the coming decades. In turn, this will lead to an increase in coastal flood risk, unless there is corresponding adaptation. In addition to this effect there are also important geological effects that are causing relative sea-level rise such as tectonics, neotectonics, and glacial-isostatic adjustment (GIA). As global models are available, GIA is often considered in global analyses, but other sources of land elevation change are ignored, and implicitly this is seen as a local problem.

One of the biggest sources of geologically-induced sea-level rise is human-induced subsidence due to groundwater pumping and drainage of organic soils, compounded by the exclusion of sedimentation. These effects are especially marked in many of the world's populous deltas, while the effects are even larger in many coastal cities on deltas. A number of such cities have subsided several metres over large areas during the 20th Century. Well known examples include Tokyo, Shanghai and Bangkok, with Jakarta currently subsiding at alarming rates. Further human-induced subsidence is emerging as an issue in other expanding coastal cities.

Using the available global estimates of such subsidence, the Dynamic Interactive Vulnerability Assessment (DIVA) model is used to assess the current and potential role of human-induced subsidence in enhancing coastal flooding in comparison to climate-induced effects. This builds on earlier analyses of sea-level rise and adds this important additional factor. Climate change scenarios consistent with significant climate change and stringent climate mitigation are considered. The analysis considers indicators based on coastal risk (exposed population and expected annual damage) as well as potential mitigation (source control) and adaptation approaches and costs to counter the predicted flooding. Preliminary results demonstrate that this subsidence is globally significant and is likely to remain an important issue through the 21st Century. Hence the relative role of subsidence will be evaluated in relation to climate-induced sea-level rise, including the wider implications for adaptation, development and attaining the SDGs.

## 5. Sea level rises on Ho Chi Minh City: impacts and adaptation

Paolo Scussolini, Institute for Environmental Studies (IVM)

One of the most critical impacts of future climatic and socioeconomic change is that on the flooding suffered by delta megacities in the tropics. Here we analyze the case of Ho Chi Minh City, Vietnam, to quantify the present and future challenges to livelihoods and safety posed by floods due to storm surges and sea level rise until the end of the century. For this, we set up a model cascade that incorporates climate and socioeconomic projections into hydraulic, impact and risk modeling. We find that flood damage is already very substantial, and impacts on people (including potential casualties) and the economy may grow by up to ca. 50% and 300%, for a moderate and a high-end emission climate scenario, respectively. Next, we explore the possibilities of adaptation, and simulate the outcome of the measures: building dikes, elevating land, retrofitting buildings, and changing land use. Elevating the areas at highest risk seems to bring about the highest benefits, while combinations of some of the considered measures yield the best outcome in a cost-benefit analysis. Lastly, we sketched possible narratives of Ho Chi Minh City adaptation policy for the decades to come, applying the concept of adaptation pathways, to illustrate how the results of our simulation can assist policy-making and strategic thinking.



## 9.1 Urban development toward sustainability and resilience: from mega-city to dwelling

*Jill Jaeger*

### Urban, energy & infrastructure

1. Climate planning in Italian cities: State-of-the-art, barriers, opportunities and future perspectives. (Filomena Pietrapertosa, National Research Council of Italy (CNR-IMAA))
  2. Developing Low Carbon Cities into Planners' and Decision Makers' Agenda: An Urban Climate Change Adaptation Solutions, Quezon City, Philippines (Tabassam Raza, Philippine School of Business Administration)
  3. Enabling Opportunity Spaces for Transformation towards Sustainability in Global Megacities: Comparative evidence from Shanghai and Istanbul (Diana Mangalagiu, University of Oxford)
  4. Operationalizing Urban Resilience: Living with Water in Rotterdam (Liliane Geerling, Texas State University)
  5. Developing a Tool for Rapid Overheating Risk Assessment of New Apartment Buildings in London (Andrea Botti, University of Surrey / PRP Architects)
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**Keywords:** Urban planning; Adaptation; sustainability; Resilience; Low Carbon; Action Plans; Heat island.

Within the theme “urban, energy and infrastructure” this session will concentrate on the city scale development of climate policies. This session is well positioned in the science/practice interface at the urban scale.

Cities cover less than 2 per cent of the earth's surface, represents 50% of the population, consume 78 per cent of the world's energy and produce more than 60% of all carbon dioxide emissions. Cities are heavily vulnerable to global climate change and are encountering specific problems related to urban climatology (heat, flooding). At the same time, there is a growing importance of cities across the globe in term of decision making related to climate change. Cities are important entities to foster the green economy and conceive policies toward sustainability and resilience. Cities can be a better spatial unit to decide such activities in a more responsive way to urgent problems. Cities can also learn from each other (replication of decisions) how to conquer barriers and promote new policies.

### Significance to adaptation practice, policy and/or business

These presentations seek to raise awareness and improve engagement in designing urban infrastructure under changing climate. The studies are location specific however replication for other urban areas is presented to provide climate mitigation, adaptation and resilience solutions. We first analyse how cities have developed programs and started actions to mitigate and become more resilient to climate change under the influence of national and international stakeholders. Potential barriers to the development of climate plans are also studied as well as win-win strategies (green business model) and policy recommendations. Moreover at city level strong co-benefit exists between mitigation and adaptation to climate change and pollution, wellbeing and health.

These subject are treated in this session from mega-city level to dwelling scale as example of decision making to promote mostly adaptation, green development or strong resilience. Most of the presentations are geographically specific but all discussion and results can be transposed and/or adapted to other urban developments.

### 1. Climate planning in Italian cities: State-of-the-art, barriers, opportunities and future perspectives.

Filomena Pietrapertosa, National Research Council of Italy (CNR-IMAA)

Cities are places of high overall primary energy consumption, high GHG emissions [1] and high concentrations of people potentially affected by the adverse effects of climate change [2]. At the same time, cities are--because of the concentration of people--the ideal framework for implementing low-carbon policies [3] and adaptation

strategies through a strategic planning process shared with citizens and local stakeholders [4]. However, to do so cities require integrated solutions to master the challenge of climate change as leader in the transition towards a more sustainable future [5].

This study aims at understanding how Italian cities are tackling the climate change challenge. To this end, we analysed the mitigation and adaptation actions undertaken by a sample of 32 Italian cities which are included in the Eurostat Urban Audit (UA) database [6-7] investigating the influence of national and international climate urban network.

In Italy, a large number of cities have developed mitigation plans and carried out decarbonization strategies thanks to a strong background in energy planning and a virtuous circle triggered by the Covenant of Mayors (CoM) initiative [8]. Presently, 3166 Italian towns and cities have signed up to the CoM, 2977 have submitted their Sustainable Energy Action Plans (SEAPs) pledging itself to achieve GHG emission reductions of at least 20% by 2020.

On the adaptation side, Italian cities have started late due to the lack of a national adaptation strategy, which was only approved in June 2015 [9]. Until recently, in Italy, adaptation strategies have mainly been developed at provincial and regional level regarding sectoral issues (e.g. heat waves, hydrologic risk); but cities now try to catch up. A first boost was given by the Mayors Adapt initiative (launched in 2014) which collected adhesions from 53 Italian cities. In 2015, Mayors Adapt has merged with the CoM under the new integrated Covenant of Mayors for Climate & Energy (CoM\_CE), which adopts the EU 2030 objectives and an integrated approach to climate change mitigation and adaptation. In the first year of activity of the CoM\_CE, 74 Italian cities have already made a commitment to implement a Sustainable Energy and Climate Action Plan (SECAP).

Considering the high impact that CoM have had in Italy in these years, it is expected that the CoM\_CE could give a strong impetus to the integration of adaptation concepts in urban planning and become the flywheel to build resilient cities in Italy as in the rest of Europe.

## **2. Developing Low Carbon Cities into Planners' and Decision Makers' Agenda: An Urban Climate Change Adaptation Solutions, Quezon City, Philippines.**

Tabassam Raza, Philippine School of Business Administration

Cities in the Philippines are on their fastest pace towards urbanization. For example, Quezon City (QC) is developing aggressively. The effect of urbanization, i.e., the replacement of vegetation by buildings, has changed the microclimate, raising summer temperatures up to 7oC. Intense rainfall has resulted in cities flooding, causing both physical and psychological illnesses to those impacted. Cities have evidently become distorted from the natural environment being replaced by buildings, roads and other infrastructures. Such massive changes in the environment are obviously altering the ecology of cities. If we are to make the cities of the future more resilient and climate adaptive, we must learn how to minimize urbanization effects on the climate. We can do this through prevention of Urban Heat Islands (UHI), increasing runoff and flash flooding. Further, production of carbon dioxide needs to be prevented to decrease Greenhouse Gases (GHGs) emissions, air pollution and impact on biodiversity. In order to achieve the above adaptive solutions (objectives), this study developed Low Carbon Cities Development Framework (LCCDF) comprises of seven activities. The framework was developed using intensive internal, external and online desk researches as primary methodology to collect secondary data. Further, participatory process was also applied to collect pertinent data from QC Government key department heads through survey questionnaire and the overall workability of the Framework in terms of Suitability, Feasibility and Acceptability was tested. The Framework was then implemented in urban situation using QC as pilot to in developing Local Climate Change Action Plan. This presentation is limited to the provision of results generated after the implementation of limited activities of the Framework. Initially the City has developed an ordinance creating the Quezon City Green Transportation Office under the department of Public Functions, and Safety to

reduce the GHG emission. The resolution urging the local government of QC to consider using E-Jeepneys and E-Tricycles for various monitoring activating and other purposes was also developed. Further, the Primer on the Green City Building Program is in practice to eventually create resilient City. The full implementation framework is under way with a vision towards achieving a low carbon and sustainable City in the hope of becoming a model for other local government units to emulate. The LCCAP is expected to emphasize on extreme weather events and Urban Heat Island impact reduction Program Projects and Activities (PPAs) to be mainstream in the urban development and physical plans.

### **3. Enabling Opportunity Spaces for Transformation towards Sustainability in Global Megacities: Comparative evidence from Shanghai and Istanbul**

Diana Mangalagiu, University of Oxford

Transformation towards sustainability in growing megacities – cities with a population over ten million – promises high impact through mitigation and adaptation to anthropogenic climate change. Globally, cities are engines of economic growth and sources of innovations for technologies, finance, organizations, infrastructure, and institutions. Today, fast-evolving urban systems in megacities open up opportunity spaces for transformation – wherein public and private organizations’ strategic interests and business models synergize between climate actions and development needs. However, without understanding the existing and evolving enabling environment surrounding these emerging opportunity spaces, transformation, as an emergent open system phenomenon, may fail to achieve climate action and sustainable development goals.

Based on research in Shanghai and Istanbul, two representative megacities and economic centers of upper-mid-income countries located in East Asia and between West Asia and Europe, we identified two significant opportunity spaces for transformation. One was enabled by the disruptive business innovations of the sharing economy in Shanghai’s mobility sector and the other by the sustainable practices developed hand-in-hand with the intensification of Istanbul’s building sector in urban renewals. We investigated the multi-layered contexts underpinning the emerging opportunity spaces in these two megacities, and the various intertwining aspects of the enabling environment affecting their potential transformation towards sustainability in each system. Comparing the two cases, we find that, while deliberate and collective efforts are underway from multiple stakeholders within and beyond the two megacities, the enabling environments for transforming critical sectors toward sustainability, like building and transport, remain limited due to conflicting priorities and models of sustainability among key players, and divergent cultural-cognitive barriers among different groups of stakeholders. Our research suggests how opportunity spaces in the two sectors could be expanded and catalyzed through concerted deliberation and alignment with critical dimensions of the enabling environment for urban transformation.

### **4. Operationalizing Urban Resilience: Living with Water in Rotterdam**

Liliane Geerling, Texas State University

Delta cities must safeguard urban populations and infrastructure from the potentially devastating impacts of climate change and severe weather, such as storm surge, flooding, and sea level rise (Connecting Delta Cities Volume 3, 2013). Enhancing resilience in these cities at the mouths of river systems requires a delicate balance of facilitating commerce, minimizing flood risk, and maintaining and often improving quality of life (Fields et al 2016). While the broad outlines of resilient delta city planning have begun to emerge, detailed analysis of project and system impacts is still minimal.

This research examines the key elements of the Rotterdam water resilience system and seeks to quantify key technical impacts such as water storage and infiltration, and, more broadly, addresses how enhanced spatial resilience towards effects of climate change interacts with the overall resilience (social, ecological and economic) of local inhabitants. Nearly 80 percent of Rotterdam lies below sea level (some parts by up to more than 6 m). The

city and the surrounding region are protected from the sea by a complex and extensive system of dikes, closure dams and storm surge barriers, all part of the Dutch Delta Plan (regional and national systems). Rotterdam Climate Proof (RCP), was launched in 2008 and aims to ensure that Rotterdam is fully climate resilient by the year 2025. Since then many local climate adaptation measures have been implemented. Next to that in 2016 Rotterdam's first-ever comprehensive Resilience Strategy was launched. This strategy primary goal is to make resilience-thinking common practice in Rotterdam and part of its DNA in 2030.

The research uses a case study of three neighborhoods just around the center in the north of Rotterdam (Proveniersbuurt, Blijdorp and Agniesebuurt). These neighborhoods provide a representative cross-section of the Rotterdam water resilience system where instead of expanding and adding expensive sewage systems, sustainable solutions were and are still found in multiple use of (semi) public space, with the historic, city beautiful canal system as the base with the addition of innovative elements like the Benthemplein Water Square, a public plaza that doubles as a water retention and infiltration system, and a network of green streets with permeable pavement. Data on the water impacts of the system have been collected to show how the individual projects act together as a neighborhood wide system. These data are coupled with interviews of city and neighborhood stakeholders to examine the social resilience impacts of the water projects. Results of the analysis highlight the significance of the connection of individual projects in a larger water resilience system and the importance of planning the system for quality of life benefits for existing residents.

## **5. Developing a Tool for Rapid Overheating Risk Assessment of New Apartment Buildings in London.**

Andrea Botti, University of Surrey / PRP Architects

The need to adapt buildings for climate change is widely recognised as a key challenge. Tackling building overheating is one of the top priorities for action, as confirmed by the 2017 UK Climate Change Risk Assessment.

The most commonly adopted approach across the building industry for assessing the risk of overheating goes beyond Building Regulations requirements and it is based on the use of detailed Dynamic Thermal Simulation Modelling (DTSM) to quantify the risk against a combination of static and adaptive temperature thresholds.

This approach, however, presents two key limitations. Firstly, overheating assessments are often performed late in the design process, and so prevents or limits the opportunities for implementing effective passive strategies early enough to avoid or reduce the risk of overheating.

Secondly, detailed DTSM is a time-consuming and costly exercise. For new medium and large residential schemes, this means that assessments often need to have a limited scope and focus the 'worst-case scenarios', corresponding to a small percentage of the development. This limitation may be such that levels of risk which are lower than the worst-case but still worth considering could be under-estimated, which would lead to under-adaptation, i.e. adaptation measures being insufficient to mitigate the risk. It is also possible for the reverse to happen, with over-estimation of the risk leading to over-adaptation, i.e. the implementation of disproportionate measures.

The research presented here documents the creation of the 'tool' as a meta-model, built on a large set of parametric dynamic thermal simulations, capable of rapidly estimating the summer overheating risk for typical modern apartment buildings in London. Those have been found to be more the most vulnerable, due to their relatively small plan area and low ceiling heights, improving levels of thermal insulation and airtightness, high solar gains and insufficient ventilation.

Parameters related to building form (i.e. orientation, window-to-wall ratio etc.) are combined with different building fabric specifications and occupancy patterns, to generate combination of parameters capable of representing a high number of design variants.

The tool assesses the hourly resolution outputs of the parametric DTSM against standard industry criteria and metrics used by previous research. Furthermore, it compares the output of DTSM with that of the simplified, 'steady-state' Standard Assessment Procedure (SAP) methodology that fulfils Building Regulations requirements.

## 5.8 Adapting to droughts and water scarcity: Supporting decision making, identifying solutions and delivering evidence to inform adaptation and mitigation

*Len Shaffrey, University of Reading*

### Drought

1. Historic Droughts – Understanding past drought episodes to develop improved tools for the future (Simon Parry, CEH)
  2. IMPETUS - Improving predictions of drought To inform user decisions (Len Shaffrey, University of Reading)
  3. MaRIUS - Managing the risks, impacts and uncertainties of drought and water scarcity (Helen Gavin, ECI, University of Oxford)
  4. DRY - Drought risk and you (Lindsey McEwen, University of the West of England)
  5. The implications of drought for future woodland conservation management in the UK (Pam Berry, ECI, University of Oxford)
  6. Discussion (All)
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**Keywords:** Water, drought, climate risks, impacts, drivers, resilience, decision-making,

How can we adapt to future droughts and water scarcity? What can we learn from successful adaptation options that have been put in place across Europe? How can we support resilience and adaptation planning for stakeholders and communities?

Droughts and water scarcity pose a substantial threat to the environment, agriculture, infrastructure, society and culture, yet our ability to characterise and predict their occurrence, duration and intensity, as well as minimise their impacts, is often inadequate.

This session offers an opportunity for researchers and practitioners to have a two-way conversation and exchange of knowledge related to the management of droughts and water scarcity aiming for a more resilient society. The session will introduce the work undertaken by the UK Drought and Water Scarcity Programme. The Programme has been working with users for the last 2 years to support improved decision-making and the identification of solutions in relation to droughts and water scarcity by developing new research. The Programme is:

- Characterising the drivers and nature of droughts and water scarcity, including the environmental, social and cultural factors that influence their occurrence, severity and impact.
- Examining the multiple and inter-linked impacts of UK droughts and water scarcity on the environment, agriculture, infrastructure, society and culture and the trade-offs between them.
- Developing methods to support decision-making for drought and water scarcity planning and management and assessing opportunities through management (including community and public responses) to reduce their occurrence and severity.

This introduction will be followed by an open discussion session led by the Programme Coordination Team, inviting contributions from participants working on drought adaptation projects and applications. We aim to identify the commonalities and differences in approaches among different European countries when dealing with drought and water scarcity, and to share best practice and establish an open dialogue with other researchers and practitioners across Europe.

### **Significance to adaptation practice, policy and/or business**

Pressures on freshwater availability and security are increasing and pose challenges for water management. Over-abstraction to meet the needs of growing populations, agricultural and industrial use, and the effects of climate change are causing multiple challenges in water-stressed regions.

With shifting frequency and patterns of rainfall and increasing demand for water, the effects of water shortages are becoming increasingly critical for the environment, food production, industrial efficiency and households.

Our session addresses these challenges and aims to identify water adaptation practices adopted in Europe, share best practice and increase resilience to the effects of water shortages that climate change will bring.

### **1. Historic Droughts – Understanding past drought episodes to develop improved tools for the future**

Jamie Hannaford, CEH

Observational evidence from past drought episodes is crucial information for decision making, both in terms of long-term planning and for managing an emerging drought episode. Historic Droughts will deliver a new, interdisciplinary understanding of past droughts. A key output is the 'UK Drought Inventory' a multi-sectoral evidence base of past drought characteristics (from the late 1800s to present), their drivers, impacts and interactions between them. In addition to a wealth of new datasets, the Inventory will contain timelines of past drought occurrence from a range of sectoral perspectives (hydrometeorological, agricultural, water supply, regulation, and public and media discourse). This multi-sectoral perspective aims to foster a systems-based understanding of past droughts that will support improvements in the management and communication of droughts in future.

### **2. IMPETUS - Improving predictions of drought to inform user decisions**

Professor Len Shaffrey, University of Reading, UK

Forward planning is critical for managing the impacts of drought, since early warning enables stakeholders to curb demand and to effectively manage diminishing water resources. IMPETUS is an interdisciplinary project that aims to improve the forecasting of UK drought on monthly to decadal timescales to support improved decision-making processes. This is being achieved by improving meteorological, hydrological and water demand forecasts and how they are combined to produce drought forecasts. IMPETUS is working closely with stakeholders to better understand their needs for drought forecasts and to ensure that drought forecasts are relevant for decision-making.

### **3. MaRIUS - Managing the risks, impacts and uncertainties of drought and water scarcity**

Helen Gavin, ECI, University of Oxford

Management of droughts and water scarcity will in future be more explicitly risk based, incorporating authoritative analysis of the full range of drought impacts for people and the environment, and a systemic understanding of their interactions and uncertainties. MaRIUS will deliver new interdisciplinary and integrated understanding of the impacts of droughts and water scarcity at a range of spatial and temporal scales. A risk-based approach will enable the development of management measures whose costs and impacts are in proportion to the probability and consequences of water scarcity, informed by a mature understanding of perceptions of droughts from the perspectives of a range of communities and stakeholders. Improved understanding of associated uncertainties will provide the basis for identification of management responses that are robust to uncertainty and will help to make the case for adaptive management approaches informed by targeted data acquisition.

#### **4. DRY - Drought risk and you**

Professor Lindsey McEwen, University of the West of England Bristol

DRY is exploring science-narrative interaction and its potential in decision-making, governance and adaptation planning in drought and water scarcity. To achieve this, we are bringing together drought science and scenario-modelling (drought risk and water availability modelling/ecology – grassland response and crop experiments) with stakeholder engagement/narrative storytelling. While previous drought impact studies have often focused on using mathematical modelling, this project is very different, integrating arts, humanities and social science research methods, with hydrological, meteorological, agricultural and ecological science knowledge through multi-partner collaboration. All this is informing the development of a 'utility' (as both process and output) that integrates narrative methods/resources and drought science to assist multi-stakeholder decision-making at critical points for mitigation and management of drought, water scarcity and heatwaves but also more general water efficiency. This process also aims to empower new stakeholders to participate in governance

#### **5. The implications of drought for future woodland conservation management in the UK**

Pam Berry, ECI, University of Oxford

Many studies have investigated the potential impacts of projected climate changes on habitats and species, but most only use mean climate change, whereas extreme events are considered to have a disproportionate effect on biodiversity. For example, drought and water scarcity can have a number of ecological effects, including reducing productivity, which if prolonged can lead to death, as well as affecting the distribution of organisms, with consequences for the composition of habitats.

In this paper we provide (one of) the first assessments of the potential impacts of drought and water scarcity on woodlands in Great Britain. We use climate scenarios and a novel drought event set, generated in the Marius project and apply them to two modelling approaches: species distribution modelling (BIOMOD) and a dynamic global vegetation model (LPJ-GUESS). We use BIOMOD in order to project changes in the suitable climate space for a range of dominant, sensitive and woodland species of conservation importance. We utilise LPJ-GUESS to model possible tree mortality and thus assess the drought vulnerability of tree species. We will show the potential for climate to have differential impacts on tree species mortality and suitable climate space for a range of species, with consequent regional differences in woodland vulnerability to drought across Great Britain. The consequent effects for habitat structure, composition and functioning and conservation adaptation management will be discussed.

#### **6. Discussion**

All (contributions from participants welcome)

The aim of this open discussion is to share best practice and create a platform to exchange knowledge between researchers and practitioners to ultimately increase European resilience to water scarcity and drought events.



### 1.6 Information needs for planning adaptation at national and local level

*Roger Street, UKCIP (Facilitator), Manuela Di Mauro, UK Committee on Climate Change and Diana Reckien, University of Twente*

#### Climate services

1. European climate change, impact and vulnerability assessments (Hans-Martin Füßel, European Environment Agency)
  2. German climate change vulnerability assessment (Petra Mahrenholz, German Federal Environment Agency)
  3. National climate change impact indicators for Italy (Federica Flapp and Andrea Motroni, Regional Environmental Protection Agencies of Friuli Venezia Giulia and Sardinia)
  4. UK Climate Change Risk Assessment 2017 Evidence Report (Manuela Di Mauro, UK Committee on Climate Change)
  5. Urban adaptation to climate change in Europe 2016 — Transforming cities in a changing climate (André Jol, European Environment Agency)
  6. Second Assessment of Local Climate Plans in European Cities – State and progress of adaptation and mitigation planning across EU-28 urban areas (Diana Reckien, University of Twente)
  7. A focus on Local Climate Change Plans in German, Italian and UK cities (Monica Salvia, National Research Council of Italy (CNR-IMAA))
  8. Integrating adaptation and mitigation in Local Climate Change Action Plans (Stelios Grafakos, Erasmus University Rotterdam)
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**Keywords:** Adaptation, risks, impacts, vulnerability, adaptation and mitigation links, national adaptation plans, local climate plans

Governments across Europe are carrying out national assessments of climate change impacts, vulnerability and risks. These assessments are intended to be used by policy makers to develop adaptation strategies and plans at the national level, while they also inform urban decision makers preparing local adaptation (and mitigation) plans. The information feeding into these plans share common points as well as differences, particularly when looking across countries and planning cultures in Europe. The processes and methods used, the impact, vulnerability and risk metrics, and the formats of the information feeding into adaptation plans vary depending on factors such as the scale of the plan, the policy context, location-specific risks, as well as capabilities and availability of resources.

This session will explore the information used to feed into national and local adaptation plans, discussing whether the information produced at national and local level are fit-for-purpose and what are the main information needs. The discussion will cover key common points and differences across countries, as well as at the national versus the local scales. This will include discussing key barriers or information gaps, as well as the interlinkages with mitigation plans, i.e. potential gains or benefits from information provided or needed for mitigation plans. The panellists will introduce two pan-European studies on these topics as well as country-specific analyses carried out for the UK, Germany, and Italy.

#### Significance to adaptation practice, policy and/or business

This session aims to gather lessons and key elements that make climate change impact, vulnerability and risks assessments useful to feed into national and local adaptation plans.

This session will be of interest for policy makers involved in developing adaptation plans at national and urban level; as well as for experts and scientists producing climate change risk and vulnerability information to ensure that these are well tailored and practically usable by the policy makers.

### **1. European climate change, impact and vulnerability assessments**

Hans-Martin Füssel, European Environment Agency (EEA).

The EEA will discuss the European climate change, impact and vulnerability assessment to be published in late 2016. The report presents information on changes in the climate and its impacts on ecosystems, society and human health through about 40 indicators.

### **2. German climate change vulnerability assessment**

Petra Mahrenholz, Federal Environment Agency (UBA), Germany.

The UBA will discuss the German climate change vulnerability assessment published end of 2015. This was a collaborative effort involving 16 German agencies and different research institutes, coordinated by the Environment Agency. The results and conclusions of the vulnerability assessment were endorsed by all ministries and were used in the progress report of the German Adaptation Strategy to identify action needs as basis for the Federal Adaptation Action plan.

### **3. Climate change impact indicators and adaptation strategy for Italy**

Federica Flapp and Andrea Motroni, Regional Environmental Protection Agencies of Friuli Venezia Giulia and Sardinia

The Italian National Institute for Environmental Protection and Research (ISPRA) will discuss the climate change impact indicators being developed together with the Regional Environmental Protection Agencies at national level. The set of indicators has provided policy makers with a robust and comprehensive climate change monitoring framework. The Euro-Mediterranean Center on Climate Change (CMCC) will discuss the national and regional climate change impact and vulnerability assessments conducted for the Italian Climate Adaptation Strategy (2014) and Plan (2016).

### **4. UK Climate Change Risk Assessment Evidence Report**

Manuela Di Mauro, UK Committee on Climate Change.

The Adaptation Sub-Committee (ASC) of the UK Committee on Climate Change will discuss their recently-published UK Climate Change Risk Assessment Evidence Report. The ASC has worked with hundreds of academics and other experts to evaluate nearly sixty individual risks and opportunities. These risks were classified based on the urgency of the actions needed to tackle them, to fulfil the Government's need for identifying priority areas for action.

### **5. Urban adaptation to climate change in Europe 2016 — Transforming cities in a changing climate**

André Jol, European Environment Agency (EEA).

The second representative of the EEA will present the report "Urban adaptation to climate change in Europe 2016 — Transforming cities in a changing climate". Also this presentation will focus on the information needs of authorities, but this time the information needs to prepare local adaptation plans as noticed as part of the activities for this and in this report.

## **6. Second Assessment of Local Climate Plans in European Cities – State and progress of adaptation and mitigation planning across EU-28 urban areas**

Diana Reckien, University of Twente

Diana will present evidence from the Second Assessment of Local Climate Change Plans conducted on all Urban Audit (UA) Cities across the EU-28. The UA Cities are large- and medium-sized cities of regional representativeness and comprise more than 900 European cities in total. As part of the assessment researchers collect and analyse the cities' local adaptation and mitigation plans. This intervention will focus on the state and content of these plans as well as the information used to develop the plans: which information was derived from national assessments, which information was produced at local level and which information gaps were encountered.

## **7. A focus on Local Climate Change Plans in German, Italian and UK cities**

Monica Salvia, National Research Council of Italy (CNR-IMAA).

The intervention draws on the Second Assessment of Local Climate Change Plans presenting the evidence from adaptation plans at city level as developed in Germany, Italy and the UK. The presentation will discuss the different data and information that feed into these plans.

## **8. Integrating adaptation and mitigation in Local Climate Change Action Plans**

Stelios Grafakos, Erasmus University Rotterdam.

This final intervention will discuss the differences and similarities of information used to inform adaptation and mitigation planning. Starting from an assessment of mitigation and adaptation plans at urban level, the panellist will share conclusions on the interactions or disjoints among adaptation and mitigation plans.

## 2.10 Guidance for EU and national bodies in identifying options for innovative solutions to increase resilience

*Mário Pulquério, University Of Lisbon*

### DRR

1. The RESIN project (Resilient Cities and Infrastructures) (Peter Bosch, TNO)
  2. The EU-CIRCLE project for assessing the resiliency of critical infrastructures to climatic hazards (Athanasios Sfetsos, National Centre for Scientific Research “Demokritos”)
  3. The RESCCUE project (RESilience to cope with Climate Change in Urban arEas - a multisectorial approach focusing on water) (Marc Velasco, Suez Water Advanced Solutions – Aquatec)
  4. The BRIGAIID project (Bridging the Gap for Innovations in Disaster Resilience) (Marco Hartman, HKV Consultants, Business Director for BRIGAIID)
  5. Roundtable discussion (Mário Pulquério, University Of Lisbon)
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**Keywords:** Climate change Adaptation, Disaster Risk Reduction, standardization, methods and tools, guidance

Human systems are already suffering the effects of climate change and the increase of frequency and intensity of extreme weather and climate events, which will most likely further increase in the future. Especially in highly technological and dynamic systems such as cities and transport infrastructures, there is a demand for finding innovative solutions for increasing the resilience of such systems. Seen from the demand side, identifying appropriate and effective solutions will require the development of standardised methods to assess climate change impacts, vulnerabilities and risks, and tools that can support decision making tailored to different end-users for the development of adaptation and risk reduction plans and measures. From the supply side, ensuring that effective, market-driven climate adaptation solutions emerge will require tools to provide structural support to innovators developing these solutions. The development of such methods and tools requires an advance of the scientific knowledge in the areas of climate change adaptation and disaster risk reduction, in particular, on the use of the best and complementary knowledge produced by the two communities. Additionally, proper guidance on using the methods and tools is necessary, which needs to be easily available and transferable to similar situations. This is particular relevant for cities, where most of populations live, and critical infrastructures, from which populations are strongly dependent. Thus, this session will aim to:

- Share recent advances in the development of innovative methods and tools for the development of adaptation and risk reduction plans and measures, as well as for supporting the creation of more effective climate change solutions
- Discuss current research needs for further development of such methods
- Discuss which current methodological gaps exist to best support the development of adaptation and risk reduction plans and measures
- Discuss how best to provide guidance and make such methods become widely used by end-users
- Highlight these methodological developments on the basis of a selected number of innovations to reduce the risks of drought, flood and extreme weather

The discussion will be supported by presentations from four ongoing H2020 projects: PLACARD (Platform for Climate Adaptation and Risk Reduction), RESIN (Climate Resilient Cities and Infrastructures), EU-CIRCLE (A pan-European Framework for Strengthening Critical Infrastructure Resilience to Climate Change), RESCCUE (Resilience to Cope with Climate Change in Urban Areas) and BRIGAIID (Bridging the Gap for Innovations in Disaster Resilience). This will be followed by a round table discussion among presenting authors and the audience.

## **Significance to adaptation practice, policy and/or business**

The session will allow a close discussion between researchers, practitioners, decision-makers and the five ongoing projects on the current knowledge, methodological and technological needs for introducing new innovative solutions to increase cities and infrastructures' resilience. Additionally, the proposed discussion will aim to identify concrete suggestions and recommendations for the uptake for the proposed solutions by the related stakeholders.

## **Introducing the session**

Mário Pulquério, University of Lisbon

Recent international agreements, such as the Paris Agreement, Sendai Framework for DRR and the Sustainable Development Goals, require a mobilization by society to develop innovative solutions for their corresponding implementation. A strong collaboration and exchange of knowledge between complementary research, policy and practice communities is needed for the development and implementation of appropriate and effective solutions that can effectively increase the resilience of human systems. This is certainly true for the Climate Change Adaptation and Disaster Risk Reduction communities, which share very similar goals but still lack collaboration in many sectors. Each of these communities have developed their own methods and tools, but effective solutions require the integration of such methods and tools to better respond to the challenges imposed by climate change.

### **1. The RESIN project (Resilient Cities and Infrastructures)**

Peter Bosch, TNO

The RESIN (Resilient Cities and Infrastructures) project focuses on harmonising and standardising approaches for risk mapping in cities, for the selection of adaptation options and developing adaptation strategies. Based on a newly developed typology of European cities for the impacts of climate change, a standard approach to vulnerability and risk mapping is proposed. This effort is coordinated with ongoing work of the international standardisation bodies CEN and ISO. Similarly common units are introduced to communicate the effectiveness of adaptation options, to allow cities and infrastructure managers to make better choices among various adaptation options. The presentation will report on ongoing work with cities in Europe to outline how the information can best be structured in decision support systems and tools. Common to the development of various tools for cities and infrastructure managers is a co-creation process with the stakeholders to ensure applicability.

### **2. The EU-CIRCLE project for assessing the resiliency of critical infrastructures to climatic hazards**

Athanasios Sfetsos, National Centre for Scientific Research "Demokritos"

EU-CIRCLE aspires to generate a scientifically validated framework for assessing the resiliency of critical infrastructures to climatic hazards. In the project's perspective the resiliency encompasses the operation of the critical infrastructures in a holistic manner, which translates to the maximization of the business output under future climate conditions. The proposed framework builds upon a comprehensive assessment of multiple climate risks and related natural hazards, including those that are directly attributed to climate parameters, such as floods, forest fires, droughts. A main objective is to provide scientific evidence in better understanding how future climate regimes might affect the interconnected CI during their lifespan, assess and propose the most cost-effective adaptation measures to manage these changes. This requires a comprehensive identification and assessment of risks and uncertainties associated with climate change and an understanding at the strategic/policy level that promoting adaptation of current infrastructures may be a more advantageous policy than relying on rebuilding or redesigning infrastructure after a disaster has occurred.

These presentations will overview how the EU-CIRCLE project may be applied by the relevant stakeholder community to obtain responses for specific policy objective(s) and/or science question and/or a business decision. It will provide the consortium's overview and approach on how to set up a methodological framework for

anticipating climate change implications to the capacity and operations of the essential services of a country and thus determine appropriate adaptation measures to strengthen operational and societal resilience of the respective CI. Resilience, in the context of critical infrastructure, is defined as the ability of a facility or asset to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance due to climatic pressures.

### **3. The RESCCUE project (RESilience to cope with Climate Change in Urban arEas - a multisectorial approach focusing on water)**

Marc Velasco, Suez Water Advanced Solutions – Aquatec

We live in a world of cities. This is a trend that will continue to grow in the future. Today, 54 % of the world's population lives in urban areas, a proportion that is expected to increase to 66 % by 2050. Moreover, climate change will cause pressures and uncertainties that will pose challenges to urban living. This can affect basic urban services, such as water or energy supply, making the city capacity of continuously functioning critical. Managing urban areas has become one of the most important development challenges of the 21st century.

In this framework, RESilience to cope with Climate Change in Urban arEas - a multisectorial approach focusing on water (RESCCUE) aims to help cities around the world to become more resilient to physical, but also social and economic challenges. More precisely, RESCCUE will generate models and tools to bring this objective to practice and make possible to have these tools available to be deployed to different types of cities, with different climate change pressures. RESCCUE will also assist cities preparing their resilience plans by developing guidance materials and plan templates.

The multisectorial approach to the urban resilience concept that will be tackled in RESCCUE constitutes the major innovation of the project. The models and tools will be validated in three different cities, carefully selected by their representativeness of the European diversity in terms of climate type and city characteristics. In addition, resilience plans for each one of these cities will be created, building on what has been done in the past, and using all the lessons learnt, models and tools from RESCCUE. In addition, RESCCUE focuses on the water sector. This approach has been taken due to the importance of water related risks in the correct functioning of a city and the diversity and quantity of data that the water sector manages in its everyday activity.

The involvement of the RESCCUE research sites (Barcelona, Lisbon and Bristol) in the 100 Resilient Cities network together with the high institutional, urban services operators and resilience research centres engagement in the project, is precisely one of the strengths of RESCCUE. City managers cannot predict which disruptions will come next, but they can plan for them, learn from them, and ultimately make their cities more resilient places in which living is safer and easier. The implicit motivation is therefore make living better not only in times of emergency situations, but every single day.

### **4. The BRIGAID project (Bridging the Gap for Innovations in Disaster Resilience)**

Marco Hartman, Partner with HKV Consultants, Business Director for BRIGAID

IPCC reports conclude that Europe is particularly prone to river and coastal flooding, extreme droughts and water shortages and damages caused by extreme weather. Climate Change projections indicate that the impact of these events will increase.

Innovators come up with solutions and concepts aiming to mitigate the impact of these climate-related events. However, many of these solutions do not find their way to implementation. Either potential end-users are not aware of their existence, or they are reluctant to act as a launching customer. BRIGAID stands for Bridging the Gap for Innovations in Disaster Resilience. The project aims to bring innovators and end-users together by providing structural, ongoing support for innovations in climate adaptation.

To achieve that, BRIGAD develops an innovative mix of methods and tools that are projected to become a standard for climate adaptation innovations. This mix consists of three elements:

- 1) a framework that evaluates the effectiveness of innovations and outlines the organizational and governance elements required for their implementation. The framework assesses the market readiness of the innovation in terms of its:
  - a. Technical readiness: the performance and effectiveness of an innovation to reduce climate-related risks, as shown in field tests and operational environments.
  - b. Social readiness: the extent to which the innovation complies with public and private end users' priorities and needs.
  - c. Investment readiness: the potential of an innovation to develop a solid business case and attract investors.
- 2) a business development and financing model for climate adaptation innovations that aims at engaging the innovator into gaining a sharper insight of the needs of the potential end-user, as well as identifying appropriate funding sources for each individual case.
- 3) an online interactive innovation sharing platform that showcases innovations, and connects innovators, end-users, investors, and grants and fiscal incentives advisors throughout Europe.

During the implementation of the project, 75-100 promising innovations are assessed, the 35-50 most promising ones are improved, and lastly the top 20-30 innovations with the highest socio-technical and investment readiness are supported to access the market.

The project kicked off in May 2016. In the autumn of 2016 the first round of stocktaking innovations is being done, and some frontrunner innovations mitigating the impact of floods, droughts and extreme weather are selected. These frontrunners put our approach to the test. During the session at ECCA in June 2017 we will be able to share some first lessons learned.

## 6.1 Tools for economic analysis of adaptation options

*Marjolijn Haasnoot, Deltares*

### Economics and business

1. Toolbox for economic assessment of climate adaptation: developed by the ECONADAPT-project (Jenny Tröltzsch, Ecologic Institute)
  2. A Framework to allow comparison of adaptation options with adaptive capacity investments in a Flood Management context (Alistair Hunt, University of Bath)
  3. Quantifying Social Resilience and Evaluating Climate Change Adaptation Strategies (Leah Dundon, Vanderbilt University)
  4. An Investment Model for Ecosystem-based Climate Adaptation: Multi-functional Water Harvesting (Henry David Venema, International Institute For Sustainable Development)
  5. Real options and robust adaptive management: evaluating the impact of scientific and context uncertainty on local water management (Michael Green, Global Sustainability Institute)
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**Keywords:** cost, benefits, evaluation, risk, uncertainty, adaptive management, water management, decision making under uncertainty

Decision makers need to take informed decisions on long term costs and benefits of climate adaptation options. This session explores a number of innovative approaches for socio-economic evaluation adaptation options to support risk management and adaptive decision making. We will discuss how to address uncertainty and risk is addressed in an economic analysis. The 1<sup>st</sup> presentation introduces a toolbox that aims to inform the application of economic assessment tools to adaptation and show strengths and weaknesses of different methods and applications. The 2<sup>nd</sup> presentation acknowledges the importance of identifying costs and benefits of both climate and non-climate drivers and presents a framework to address this. The 3<sup>rd</sup> presentation addresses indirect effects of climate change and the importance of this for an assessment of social resilience of communities and shows how this can be included in evaluation of adaptation options for flood resilience. The 4<sup>th</sup> presentation acknowledges the importance of social values for evaluation of adaptation options and discusses how this can provide additional information to traditional economic evaluations for a case study on coastal flooding in Tasmania. In the 5<sup>th</sup> presentation real options is used as a method to develop robust and adaptive options under uncertainty using probabilistic climate projections. In the discussion, the question will be addressed to what extent the methods and tools described may be upscaled or transferred to other places and conditions.

### Significance to adaptation practice, policy and/or business

Economic analysis can provide valuable information for decision makers and stakeholders. It can inform about trade-offs between different indicators and cost-effectiveness of actions. This way it helps to identify and rank promising adaptation options. Dealing with risk and uncertainty in economic analysis is receiving increasing attention in research. This session explores novel methods and tools to support evaluation of actions on adaptation under uncertainty.

#### 1. Toolbox for Economic assessment of climate adaptation: developed by the ECONADAPT-project

Jenny Tröltzsch, Ecologic Institute

With climate change impacts increasing and becoming widespread, decision makers face the need to take informed decisions on the long-term costs and benefits of investing in different infrastructure project or policy programmes. The use of economic analysis can provide valuable information on the value, efficiency and feasibility of adaptation projects and strategies. There is wide recognition that economic analysis currently used in adaptation can provide valuable information for decision-makers and stakeholders by, e.g. bringing clarity on trade-offs associated with different development paths in the medium to long term; strengthening the capacity of



society to envision and plan strategically in face of high uncertainty and supporting the identification of robust solutions capable of high performance against a large number of futures; and Presenting a structured approach to design, implement and evaluate planned investments, projects and policies, and enable the comparison of wait-and-see strategies as opposed to immediate action.

Within the ECONADAPT-project a web-based toolbox for economic assessment of climate adaptation has been developed. The objectives of the project are to build the knowledge base on the economics of adaptation to climate change and to convert this into practical information for decision makers, in order to help support adaptation planning. The Toolbox has the aims to inform the application of economic assessment tools to adaptation. It provides in particular information on methodologies, data and evidence for practitioners with a more technical background. It targets interested economists and policy makers, some of whom may use or develop the methods further, others who may simply gather information on how to interpret results or methodological approaches.

We will describe a screening of different tools, portals and toolboxes related to adaptation decision making which was implemented as a pre-screening before developing the ECONADAPT toolbox. We analyzed about 20 different platforms which have as target group policy- and decision-makers on different governance levels. We did a structured analysis to compile key strengths and weaknesses of different applications. We describe the approach taken to develop the Web-Toolbox (including a Library with more than 700 documents), integrating stakeholders and the potential user group of the Web-Toolbox in the design and choice of content. We will present the general framework on economic assessment of adaptation in different adaptation contexts which structures the toolbox. We will conclude with Lessons Learned regarding the structure, the design of the toolbox, the stakeholder involvement process and the dissemination of such a tool.

## **2. A Framework to allow comparison of adaptation options with adaptive capacity investments in a Flood Management context**

Alistair Hunt, University Of Bath

To date, the literature on adaptation actions has primarily focused on sector-specific actions that directly target specific climate drivers. This is arguably due to the fact that local manifestations of specific climate risks and opportunities often require ad hoc, context specific adaptation actions (Adger and Brooks, 2004). However, another branch of possible adaptation actions, system-wide actions, is available to decision makers. System-wide actions look to build cross-sectoral resilience to climate drivers by changing the adaptive capacity of human and natural systems (IPCC, 2014). These actions are characterised by indirect benefits, which may be overlooked if they are not well defined. For example, improved weather forecasts do not reduce specific climate risks by themselves but the information they provide can be used to better inform decision makers about actions they should take in response to predicted climate risks. Therefore, decision makers need to account for the wider impact of system-wide actions in order to reliably compare them to sector-specific actions. A failure to account for benefits and costs associated with alternative actions can result in misallocation of resources and maladaptation (IPCC, 2014).

Moreover, system-wide actions may be better suited to achieve wider objectives than conventional adaptation options. The inherently broad nature of system-wide actions is likely to support non-climate, objectives, in addition to adaptation. For example, improved education in statistics helps individuals better understand climate change data, and so make better-informed decisions about adaptation, as well as other life decisions.

The benefits and costs relating to climate and non-climate drivers also often need to be formally distinguished in order to inform financial planning within both public and private organisations. By classifying benefits and costs relating to climate and non-climate drivers, the framework developed in this paper addresses these concerns. It can be used to differentiate between system-wide and sector-specific actions along two spectrums:

- The extent to which benefits from the adaptation action are directly or indirectly related to climate drivers; and,
- The extent to which non-climate drivers are targeted by the adaptation action.

We present a case study to show how an investment into development of new climate change scenarios can be evaluated in this framework. It shows how the indirect value of developing new scenarios can be realised through their influence on adaptive capacity – specifically, making better decisions about flood management in a river basin in Northern England. We indicate the potential for transferability to other decision contexts.

### **3. Quantifying Social Resilience and Evaluating Climate Change Adaptation Strategies**

Leah Dundon, Vanderbilt University

A primary focus of many activities associated with climate change adaptation has been the performance of vulnerability assessments to identify locations subject to high-risk from climate-induced events, followed by the development and evaluation of candidate adaptation strategies directed at reducing risk to an acceptable level. Accurate identification of high-risk locations and selection and implementation of cost-effective adaptation strategies rely heavily on the ability to estimate the consequential impacts imposed by an event on the area in question.

To date, impact measures have predominantly been associated with human casualties, asset damage and business disruption that occur during and in direct response to an event. Yet, it is generally accepted that substantial indirect impacts, particularly those associated with social systems, may persist for some time after an event and are often not well-captured by traditional assessments. *Social resilience*, the ability of communities to persist in the face of a disturbance and respond to improve outcomes, is a quality that substantively influences future system viability. Therefore, measuring social resilience is important to aid in the identification of long-term and indirect impacts of climate-induced events.

Much of the reason for not including social resilience in climate vulnerability assessments and evaluations of adaptation strategies stems from the difficulty in quantifying social resilience and its effects in a manner that can be applied in this context. This presentation will introduce a new approach to quantifying social resilience, one that leverages the availability of demographic and spatial analysis techniques, such that it can be incorporated into traditional climate vulnerability assessments and adaptation strategy evaluation methods. The method is subsequently applied in a case study of a 1,000-year flood event recently experienced in Nashville, Tennessee to illustrate its use in assessing social vulnerability and evaluating the ability of candidate adaptation strategies to improve future flood resilience.

### **4. An Investment Model for Ecosystem-based Climate Adaptation: Multi-functional Water Harvesting**

Henry David Venema, International Institute For Sustainable Development

The impacts of climate change – particularly more frequent and longer duration flood and drought episodes – pose an acute risk in the Prairie agro-ecological region of Canada (spanning the Provinces of Alberta, Saskatchewan and Manitoba). The Canadian Prairies are a globally significant food production region, producing 20% of the world's internationally-traded grains and oilseeds.

Water infrastructure has generally focussed on drainage and conventional flood risk management, with a high loss of ecosystem services and generally without consideration of drought resiliency. CMIP5 GCM ensemble modelling results for the Prairies reveal a much greater risk of high frequency cycling between flood and drought conditions – a risk that also characterizes the world’s other major dryland food production regions.

The investment logic for modern water infrastructure that provides flood and drought risk management and ecosystem services is developed based on ecological engineering principles. The key design elements are generalized LiDAR-based topographic and hydrodynamic analysis for watershed-based flood management, ecosystem-based retention storage and dynamic ecosystem service modelling including nutrient interception, biomass production and CO<sub>2</sub> credits. A high-performance computational platform allows stochastic reliability analysis of system performance using the CMIP5 ensemble for alternative investment horizons and emissions scenarios.

The computational platform allows parallelization and multi-watershed aggregation for the design of green bonds that support regional climate adaptation and synergies between adaptation and mitigation.

## **5. Real options and robust adaptive management: evaluating the impact of scientific and context uncertainty on local water management**

Michael Green, Global Sustainability Institute, Anglia Ruskin University

Climate projections are increasingly presented in terms of uncertainties and distributions rather than median or ‘most-likely’ values. The current UK set of national climate change projections, UKCP09, provides 10000 probabilistic and 11 spatially coherent projections for three different emission scenarios for various future time slices (e.g. 2010s, 2020s, 2030s etc.), whereas previous generations provided only a single ‘most-likely’ projection for each scenario. The move to probabilistic projections, whilst highlighting some of the uncertainty (though not all), complicates adaptation.

However, it is not clear beforehand whether or how it impacts real-world decisions, and hence its added value. The UK is currently in the process of developing the next generation of national climate change projections, UKCP18, which will directly supersede UKCP09. Like the previous iteration, this suite of projections will provide probabilistic projections of the future climate, whether stakeholders are sufficient prepared to utilise this information or how the extra information (and uncertainty) is best communicated and used to support decision making is unknown.

This paper presents the analysis of two real world case studies; (1) constructing an irrigation reservoir to combat water scarcity and (2) designing a sustainable urban drainage system to manage urban runoff in the 2050s, providing contrasting perspectives on decision making under uncertainty in the context of local water management. The impact of climate change uncertainty on real-world adaptation and infrastructure design is systematically assessed, using a combination of non-probabilistic methodologies and real-options analysis across several UK sites. A simple and rapidly methodology for decision making under uncertainty, combining a non-probabilistic decision criterion and real options analysis is developed and compared, which provides a more robust tool compared to current methods.

## 7.2 Climate adaptation and sustainability. Part II: Knowledge management and learning examples from around the world

*J. David Tàbara, Autonomous University of Barcelona and Global Climate Forum*

### Climate justice

1. CCA knowledge platforms. Some evidence on how they are being used; some feedback on what they should they aspire to. (Richard Taylor, Stockholm Environment Institute)
  2. Zaman Lebidi: improving the transmission and the use of climate information for adaptation to disasters in Burkina Faso (Florian Gallo, Met Office)
  3. Capacity building approaches to climate adaptation in African Rangelands: European institutional inputs and outcomes for livelihoods, wildlife and ecosystems. (Michael Thompson, Frankfurt Zoological Society)
  4. Scaling back adaptation and development in a future of mega events? The case of Cyclone Pam in Vanuatu (Johanna Nalau, Griffith University)
  5. The Adaptation-Gender-Migration nexus: insights from the Mahanadi delta, India (Giorgia Prati, University of Southampton)
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**Keywords:** knowledge management, adaptation, equity, DDR, climate conflicts

Development, to become sustainable, must integrate climate adaptation in all its complex policy, social, ethical and knowledge management dimensions. In this session we look at practical examples of how to integrate such dimensions from various perspectives as follows:

#### **Knowledge management and monitoring:**

A fair and inclusive management of knowledge is a prerequisite for the fair development of climate solutions. Richard Taylor first introduces practical insights about the ways professional Climate Adaptation Platforms are being used in knowledge brokering and bringing fairly together the views of multiple set of actors while providing a framework with a set of criteria to assess how they intend to deliver. Understanding the way knowledge and expertise travels or is deployed in different regions of the world is also crucial in integrated climate-sustainable development strategies. In this regard, Gallo et al. examine and share the lessons learned for climate information to become better usable and understood by farmers in countries such as Burkina Faso where most of the population depend on agriculture. While Thompson explores how different expertise networks interact (e.g. North-South, South-South) and become engaged with civil society movements or government institutions. This is done, among other ways, through international advisory programmes, development assistance, and civil sector peer support. The talk will also reflect on how these processes translate in practice based on examining a selection of rangeland sites in Kenya-Tanzania, Namibia and Botswana.

#### **Integrated strategies looking at equity-climate- sustainable development interlinkages**

The integration of Disaster Risk Reduction (DRR) and Climate Change Adaptation strategies has been recognized to create multiple positive synergies. This is particularly true when looking at the occurrence of extreme events and mega-disasters, such as the Vanuatu category 5 tropical cyclone Pam in 2015, a case which will be explained by Nalau et al. As pointed by these authors, such events raise questions about climate justice, limits to adaptation, and the durability of sustainable development processes and the need for discussing reciprocal resource support for comprehensive risk management and adaptation given the anthropogenic origin of such risks. Considering equity issues, being at the core of sustainable development, calls for the need to unveil the often neglected dimensions of the climate change-migration nexus. To this aim Prati, by focusing on the case of the Mahanadi delta in India, looks at the interlinkages between and across SDGs crosscutting themes such as equality, gender and migration and relates that to adaptation and adaptive capacity. This empirical study shows

how migration shapes power structures, accessibility to livelihood capitals and socio-cognitive factors with consequences on the adaptive capacity of the populations that remain behind in the sending areas.

### **Significance to adaptation practice, policy and/or business**

This session will shed light on how to support knowledge integration through new forms of platforms and enhance and monitor the integration of sustainability goals in climate adaptation strategies. Conclusions will be based on both on empirical and original reflections on how equity issues and knowledge management aspects need to be taken into account in practice.

#### **1. CCA knowledge platforms. Some evidence on how they are being used; some feedback on what they should they aspire to**

Richard Taylor, Stockholm Environment Institute

Professional climate change adaptation (CCA) knowledge platforms play an important role in bringing together information that goes beyond what organisational websites, businesses and the third sector each can individually offer. Collaborations among different actors have begotten CCA platforms that are as diverse as the principles that they are founded on.

This paper uses data from a post-conference survey to investigate what participants said they value in a CCA platform. The findings are then compared with a recent framework that proposes a set of criteria suggested as being important. The aim is to validate parts of the framework and to identify any potential shortcomings therein. The paper then looks at what 27 platforms deliver - or claim to deliver – in relation to these criteria. A detailed review was undertaken in mid-2016 using quantitative indicators for each criterion that informed a statistical analysis and data visualisation.

Finally, the same survey data – approximately 250 responses – are used to understand to what extent were participants using platforms, and which of the 27 platforms were people from different sectors and geographical regions using. We examine possible interesting correlations using statistical and visualisation techniques.

We aim to bring to the attention of practice, policy and/or business participants the role of knowledge platforms, and the emerging views on what criteria they aspire to. We want to highlight how other entities can benefit from platforms. We also want to show where platforms stand today - the CCA community provided a good appraisal of this in a survey – which together with our review allows us to point out the gaps. This would, we hope, provide practice, policy and business with some entry points on how they can benefit but also contribute.

#### **2. Zaman Lebidi: improving the transmission and the use of climate information for adaptation to disasters in Burkina Faso**

Florian Gallo, E. Henley, J. Strachan (Met Office)

Burkina Faso's economy largely relies on agriculture, the life of 80% of the population depending directly on it. Climate change and variability have and will have a strong impact on this activity. Farmers need to be able to understand and to use climate information, especially at seasonal timescales, in order to be able to adapt to interannual variability and extremes. One of the DFID-funded BRACED (Building Resilience and Adaptation to Climate Extremes and Disasters) projects, the Zaman Lebidi program aims to build the resilience of vulnerable communities in Burkina Faso to climate extremes and disasters. These include droughts, floods, extreme temperatures and extreme precipitation.

Zaman Lebidi is a consortium of ten partners, led by Christian Aid. Partners include NGOs covering resilience measures at local community level, but also the Met Office and Burkina Faso national meteorological service (DGM, Direction Générale de la Météorologie), providing weather and climate advice in order to improve access

to reliable, useful and usable information. We present here a number of activities that have been undertaken, in order to improve the quality of the information, its relevance and its dissemination, e.g.:

- developing and delivering a training course on forecast verification methods, in order to improve the quality and the reliability of the information that was generated.
- working with consortium partners and communities to examine whether climate information/services can be integrated with indigenous knowledge and oral history
- developing examples of post-event analysis case studies, looking at meteorological and user impacts of events and demonstrating the socio-economic benefit of DGM services
- developing and delivering community training in the use of climate information, by creating and broadcasting a radio show containing seasonal information

The design and the implementation of each of these activities are described and the results and lessons learned are shared. The issue of climate change and variability and the availability of reliable and usable climate information is a major challenge in developing countries and we believe that the examples described here can be applied and improved upon in many other contexts.

### **3. Capacity building approaches to climate adaptation in African Rangelands: European institutional inputs and outcomes for livelihoods, wildlife and ecosystems.**

Michael Thompson, Frankfurt Zoological Society

Climate change impacts are being felt at cross-national and continental scales. Adaptation solutions similarly need to be framed at a cross national scale. UK and European institutions have been supporting governments and civil society institutions and the private sector to adapt to a changing climate in less developed countries. In savannah rangelands in eastern and southern Africa, a series of severe droughts since the turn of the millennium have had major implications for the livelihoods of millions of people dependent on livestock and small scale cultivation. The future of iconic wildlife species, which also form a lucrative income for some, is also in doubt. This paper describes the mechanisms by which European climate change adaptation expertise is being provided to help address these issues. The approaches adopted through international advisory programmes, development assistance, and civil sector peer support includes:

- building networks of expertise (North-South and South-South)
- supporting grass roots civil society movements
- and capacity building focussed on government and civil society institutions.

Case study examples of this work and the trajectory of likely outcomes will be provided for a selection of rangeland sites in Kenya-Tanzania, Namibia and Botswana. These case studies will describe the key features of these rangeland systems, the pressures these systems currently face and the benefits that these systems continue to provide.

The case studies will explore:

- The enabling framework of government policy and legislation to support an adaptive approach
- Climate impacts on human populations, development indicators and wildlife
- Assessments of the resilience of government and civil society organisations to diversify and react to climate pressures
- The response of indigenous populations to climate pressures
- The impact of European technical advisory and capacity building programmes
- And the likely outcome for people and wildlife of current savannah management policies

#### **4. Scaling back adaptation and development in a future of mega events? The case of Cyclone Pam in Vanuatu**

Johanna Nalau<sup>1</sup>, J Handmer<sup>2</sup>, M Dalesa<sup>3</sup>

<sup>1</sup>Griffith University, <sup>2</sup>RMIT University, <sup>3</sup>United Nations Development Program

The integration of disaster risk reduction (DRR) with climate change adaptation (CCA) is globally recognized as a rational use of resources benefiting both areas. Many countries are pursuing now such integrated approaches that are aligned with the Sendai Framework and UNFCCC National Adaptation Plans. While this policy integration is an important step in increasing enabling conditions for both CCA and DRR, lessons are needed for the actual functioning of these ideas in the context of mega disasters. This paper examines the way Vanuatu responded to the first category 5 cyclone, Tropical Cyclone Pam, in 2015. Although Vanuatu is a country with extensive experience in dealing with cyclones and other extreme events, TC Pam with wind speeds up to 320 km per hour led to unprecedented simultaneous destruction across multiple islands. The paper provides an analysis of a range of systemic and contextual issues that emerged in the response and recovery process, including adaptation and disaster risk governance models, compounding vulnerabilities, and challenges in dealing with sudden development setbacks. The research employed both deductive and inductive methods including literature reviews, collecting information on the cyclone from a variety of sources, and subsequent stakeholder interviews in Vanuatu across a range of stakeholder groups. The results demonstrate overlapping governance models employed by different stakeholders involved in the process, government capacity to manage complex unbounded problems such as mega disasters, and lessons learned in going forward. TC Pam also raises questions about climate justice, limits to adaptation, and the durability of sustainable development processes. If these mega storms are linked to anthropogenic climate change, then the losses and damages accruing from such events are likely to become windows for discussing reciprocal resource support for comprehensive risk management for adaptation and subsequently development.

#### **5. The Adaptation-Gender-Migration nexus: insights from the Mahanadi delta, India**

Giorgia Prati, University of Southampton

There is a growing interest in understanding shifts in migration patterns as response to environmental change. However, the feedback process of migration on the families left-behind is rarely explored and even less in known about its gendered implications for adaptive capacity. Adaptation strategies, including migration, could reinforce inequality and vulnerability of some social groups with differentiated effects on the socio-economic barriers and opportunities to adaptation in the communities of origin. Migration and adaptation are not gender neutral processes. Still, gender remains an often neglected dimension of the climate change-migration debate. This research seeks to investigate how migration shapes power structures, accessibility to livelihood capitals and socio-cognitive factors with consequences on the adaptive capacity of the populations that remain behind in the sending areas. This empirical study draws on field research conducted in the Mahanadi delta, in India, as part of the 'Deltas, Vulnerability and Climate Change: Migration and Adaptation' (DECCMA) project. In the Mahanadi delta migration remains a male dominant phenomenon that leaves women behind with social, economic and physical consequences. In contrast to traditional binary approaches, this study employs different qualitative tools to explore gender through the lens of intersectionality so as to disentangle the multiple dimensions of power and vulnerability. The findings show that migration can play a significant role in shaping adaptive capacity in the migrants' places of origin with differentiated impacts across the spectrum of caste, class, gender and other social identities. To fully understand the relationship between migration, sustainability and adaptation there is a need to investigate the implications for the adaptive capacity of those who remain behind in highly vulnerable areas, through analyses that unpack the complexity of intersecting inequalities.

This study provides insights into the interlinkages between and across SDGs crosscutting themes such as equality, gender and migration and relates that to adaptation and adaptive capacity.

## 10.5 Adapting Scotland's natural capital: appraisal methods, research and policy priorities

*Ragne Low, ClimateXChange*

### Agriculture & forestry

1. The Scottish Context – Adaptation, indicators and the link between research and policy (Ragne Low, ClimateXChange)
  2. A survey of decision-making approaches for climate change adaptation: Are robust methods the way forward? (Dominic Moran, Scotland's Rural College)
  3. Peatland restoration as a climate change adaptation option: what do we know about costs and benefits? (Andrew Moxey, Pareto Consulting)
  4. Livestock disease and climate change: identifying risks and opportunities (Naomi Fox, Scotland's Rural College)
  5. Economic appraisal of afforestation for flood management under climate change and associated ecosystem benefits (Ruth Dittrich, University of Portland)
  6. Supporting research priorities for adaptation policy through ClimateXChange (Sarah Govan and Anne Marte Bergseng, ClimateXChange)
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**Keywords:** Land use, natural capital, adaptation, economic appraisal, policy and research priorities

This session draws on the experience of researchers working at the interface of science and policy to understand the way that climate change impact on natural capital can be modelled and quantified in economic terms. We aim to consider the development of innovative economic appraisal methodologies (to consider adaptation costs and benefits) and how these can be applied to key capital assets in the agriculture and land use sector. The session will draw on a wider portfolio of adaptation research conducted through ClimateXChange, Scotland's centre of expertise on climate change, by Main Research Providers (SRUC, JHI and Moredun Institute) and experience of working with the Committee on Climate Change (Adaptation Sub -Committee),. The session will conclude by considering how a research agenda might inform the development of policy priorities.

The session focusses on impact assessment, policy priorities and economic appraisal in relation to natural capital. The session is of immediate interest to climate change researchers and decision makers (local and national) focussed on knowledge exchange across sectoral and disciplinary boundaries in natural capital adaptation.

### 1. The Scottish Context – Adaptation, Indicators and the link between research and policy

Ragne Low, ClimateXChange, Edinburgh Centre for Carbon Innovation

We are moving into a new phase in adaptation. Where the primary focus in the early days of adaptation dialogue was on 'arresting maladaptation' and addressing the adaptation deficit, we are now firmly in the phase of adaptation planning and informed decision making; we are perhaps at the early stages of a new phase: 'transformational adaptation'. Should we be problem-orientated or solution-oriented? There is a need for both approaches. Problem-oriented means working to better understand the problem, and the key thing now is for problem-orientated research to be truly transdisciplinary and collaborative. Solution-orientation implies working together to find answers and intervention options, rather than aiming only for an ever deeper understanding of the problem.

Adaptation research is making strides in ensuring stakeholders are not viewed as 'end users' but as partners. Co-design and co-production are now the norm, but some argue for even greater use to be made of knowledge from practitioners, non-academic experts and communities. 'Shared learning' is a very commonly used term, and



means involvement of stakeholders at all stages in the research, and indeed beyond the time span of specific projects, to support network building for continuing knowledge sharing.

The Scottish Government has demonstrated a clear commitment to addressing climate change, with significant policies to address mitigation and emissions reduction. But they also recognize the importance of early adaptation, and ClimateXChange plays a key role in supporting dialogue between knowledge providers and decision makers, supporting how the questions are framed and the evidence delivered. International developments, combined with those across Scotland and the UK set the context for research and practice and deliver real change on the ground.

## **2. A survey of decision-making approaches for climate change adaptation**

Dominic Moran, Scotland's Rural College

Applying standard decision-making processes such as cost–benefit analysis in an area of high uncertainty such as climate change adaptation is challenging. While the costs of adaptation might be observable and immediate, the benefits are often uncertain. The limitations of traditional decision-making processes in the context of adaptation decisions are recognised, and so-called robust approaches are increasingly explored in the literature. We discuss the limitations of standard cost-benefit analysis and alternative robust decision-making processes to identify which ones may prove most promising as adaptation planning for the natural environment.

## **3. Peatland restoration as a climate change adaptation option: what do we know about costs and benefits?**

Dr Andrew Moxey, Pareto Consulting

More than 80% of UK peatlands are degraded to some extent, negatively affecting ecosystem service provision, notably climate and water regulation. Degradation is expected to accelerate under future climate change. While degraded peatlands are likely to be susceptible to climate change pressures of higher temperatures and drier conditions, functioning peatlands are likely to be more resilient and continue to provide benefits as they themselves adapt biotically to changing climatic conditions. Therefore, efforts to restore currently degraded peatlands can serve both as a climate change mitigation option and an adaptation response to safeguard ecosystem service provision. Public and private investment decisions into restoration action benefit from an improved understanding of the social value of restoration in relation to private costs faced by land managers. This paper summarises current evidence on the economics of peatland restoration.

Results of a stated preference study valuing bundles of ecosystem services associated with improving the ecological condition of peatlands show that benefits vary by initial condition of peatlands and spatial allocation. On average, per hectare benefits are considerable suggesting a considerable potential of peatland restoration to yield net benefits for society. However, restoration is not a costless exercise and the distribution of costs is different to the distribution of benefits. Given reliance on the voluntary enrolment of land into restoration programmes as the main policy instrument, attention has to be paid to the private costs of restoration and how these can be compensated for when benefits mainly accrue elsewhere. Private costs also include recurrent opportunity costs from income forgone as a result of restoration. For example, both the quantity and quality of agricultural commodities yielded from a parcel of land may be reduced, leading to lower market returns. Equally, eligibility for agricultural support such as the Basic Payment may also be affected, and indeed in many cases will represent a more significant private loss than market returns. However, production effects vary according to site-specific circumstances and local management objectives whilst policy payment rules differ across the UK – meaning that opportunity costs are difficult to pin down. Nevertheless, ignoring opportunity costs challenges the usefulness of cost-benefit comparisons. Their consideration is crucially important if restoration ambitions are to be realised.

#### **4. Livestock disease and climate change: identifying risks and opportunities**

Naomi Fox, Scotland's Rural College

Endemic, production-limiting diseases are a significant and ubiquitous constraint on efficient and sustainable livestock production globally. Dealing effectively with endemic livestock diseases represents opportunities to reduce emissions from the livestock sector, often without compromising productivity or farm economics. With potential for climate-driven changes in livestock disease risk, and consequent impacts on production efficiency, our aims are fourfold: to forecast changes in future parasite risk; to quantify impacts of parasitism on productivity and emissions; to identify target pathogens for eradication/control; to apply this knowledge to adapt to changing disease risk and optimise productivity.

By developing process-based models of parasite dynamics in livestock systems, we have explored how changes in climate-sensitive parameters can influence parasite outbreaks. We show that rising temperatures and non-linear responses in transmission dynamics can lead to 'tipping-points' in parasite burdens. Consequently, small changes in climatic conditions around critical thresholds could result in dramatic changes in outbreak patterns.

Given these parasite forecasts it is important to understand how parasitism affects production efficiency, and two complimentary approaches have been used for this. Through exploring productivity traits of lambs under different anthelmintic treatment regimes, it was shown that increased GHG emissions are associated with parasitism due to decreased production efficiency and increased time to reach target weight. In addition to higher overall feed intake due to increased time in the system, a second study revealed that parasitism also affects methane produced per unit of feed intake. With the use of respiration chambers, we showed that parasite infections in lambs can lead to a 33% increase in methane yield (gCH<sub>4</sub>/kgFeed). The knowledge from these studies will facilitate more accurate calculations of the true environmental costs of parasitism, and reveals potential benefits of mitigating emissions through controlling parasite burdens.

Given the predicted increase in parasite risk, and impacts of parasitism on productivity, a rapid evidence assessment was made to identify the emissions mitigation potential for other livestock diseases in addition to parasitism. This assessment provided a comparative analysis of available evidence for the control or eradication of twelve major livestock diseases in Scotland in terms of GHG abatement potential, cost-effectiveness and feasibility.

Overall, we aim to understand the changes in disease risk, the consequences for productivity, and the feasibility and abatement potential of targeting particular pathogens. This allows development and implementation of cost-effective control measures that enable livestock systems to adapt to a changing climate and the changing disease patterns this may bring.

#### **5. Economic appraisal of afforestation for flood management under climate change and associated ecosystem benefits**

Ruth Dittrich, University of Portland

Increased flood frequency is considered a major risk under climate change and protecting vulnerable communities is a key public policy objective. Natural flood management measures (NFM) are increasingly discussed as a less disruptive and more cost-effective means than hard engineered measures when providing flood regulation, particularly when considering additional ecosystem services beyond flood regulation. This paper provides a cost-benefit analysis over 75 years of the impacts of afforestation as a NFM on peak flows under climate change, and on additional ecosystem services in a rural catchment in Scotland. We model five scenarios, riparian woodland afforestation, 30%, 64% and 100% afforestation of the catchment with broadleaves, as well as a combination of 100 % afforestation and riparian woodland. These scenarios are analysed under climate change scenarios using UKCP09 weather generator data for the flood regulation impacts. We found significant positive net present values (NPV) for all scenarios considered. However, benefits are dominated by ecosystem services co-

benefits rather than flood regulation, with values related to climate regulation, aesthetic appeal, recreation and water quality contributing to a high positive NPV. All afforestation scenarios provide some flood regulation benefits, which increase with the degree of afforestation and are greater for higher frequency flood events. The investment in riparian woodland (under low and central climate change scenarios) delivers positive NPV alone when considering only flood regulation benefits. The case study suggests that afforestation as a sole NFM measure provides a positive NPV in some cases but highlights the importance of identifying and quantifying additional ecosystem co-benefits.

## **6. Supporting research priorities for adaptation policy through ClimateXChange**

Sarah Govan and Anne Marte Bergseng, ClimateXChange, Edinburgh Centre for Carbon Innovation

ClimateXChange is a centre for expertise on climate change, providing independent advice, research and analysis to support the Scottish Government as it develops and implements policies on adapting to the changing climate and the transition to a low carbon society. It has been instrumental in developing indicators to support monitoring and evaluation of policies that support a transition to a more resilient society. As part of this process, iterative dialogue was coordinated between academic researchers (who understand what we know now and where there are important questions that we should explore), and policy stakeholders (who need to support decision making in the short and the long term, and who need up to date information on the state of confident knowledge).

ClimateXChange has developed a series of research agendas focused on the key themes of natural environment, buildings and infrastructure networks and society, to explore what questions we should ask – and answer – in the short term to help frame early action. There has been careful reflection on critical cross-cutting themes to ensure a system-wide and transdisciplinary approach that can support Scotland's ability to adapt to a changing climate. We will explore the practical processes around the development and delivery of these research agendas to support decision making on adaptation in Scotland.

## 6.2 Tools for inclusive and local adaptation options

*Rob Swart, Wageningen UR*

### Participation and co-production

1. Fostering Urban Climate Adaptation via a smartphone app: the Urban ClimAdApp (Sanda Lenzholzer, Wageningen UR)
  2. Do-it-yourself (DIY) urban experiments: toward a local and civic way to adapt to climate change? (Geneviève Cloutier, Université Laval)
  3. Realizing the innovation and business potential of climate adaptation - how to facilitate commercially driven development of climate adaptation products (Mikkel Thomassen, Smith Innovation)
  4. Cooperation and knowledge exchange towards an integrated and participatory approach to climate change adaptation (Ana Romero, Merience)
  5. Decision-making options for robust climate change adaptation in forest management: agent-based modelling of institutional interactions (Calum Brown, University of Edinburgh)
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**Keywords:** Local adaptation, experiments, civic engagement, comparative analysis, collaboration, innovative practices, environmental justice, entrepreneurship, product development, knowledge exchange, good practices

This session explores a number of innovative approaches to assess climate risks and promote adaptation action. The 1<sup>st</sup> presentation addresses the question to what extent a smartphone app to identify risks and options can induce action by house owners and urban planners, based on an experiment in Amsterdam. The 2<sup>nd</sup> presentation introduces “Do-It-Yourself” greening initiatives and civic engagement projects as adaptation experiments to face climate change at the urban scale, highlighting lessons learnt and raising possible issues of such projects in terms of environmental justice and sustainability. The 3<sup>rd</sup> presentation addresses the interest in and need for climate adaptation to be transformed into entrepreneurship and new business opportunities that creates better cities and green growth, by reviewing how seven new products and services have been developed in commercial partnerships in Denmark. The 4<sup>th</sup> presentation acknowledges the importance of social networks and social capital factors as contributors to the gap between planned and autonomous adaptation and presents the results of a social network analysis amongst coastal communities in Taiwan in a climate adaptation context. The final presentation addresses mechanisms to exchange experiences and generate knowledge by collaboration regarding climate change adaptation in metropolitan areas, building on experiences in cities in Spain, France and the United Kingdom. In the discussion, the question will be addressed to what extent the methods and tools described may be upscaled or transferred to other places and conditions.

### Significance to adaptation practice, policy and/or business

Much research has so far focused on generating knowledge on climate change risks and options for adaptation. It is becoming increasingly urgent to use that knowledge to design and implement adaptation action. This session explores novel methods and tools to support action on adaptation in different contexts, in a number of different regions.

#### 1. Fostering Urban Climate Adaptation via a smartphone app: the Urban ClimAdApp

Sanda Lenzholzer, Wageningen UR

Currently many cities face adverse urban climate effects such as urban heat problems and wind nuisance that requires adaptation. Although a large body of knowledge with suitable adaptation measures exists, only few adaptation measures have been actually implemented.

Measures to counteract urban climate challenges often consist of small-scale interventions that add up, but they also consist of larger scale urban planning strategies. So, different groups of people have to implement spatial

adaptation interventions in the urban fabric. House owners can implement small scale interventions around their properties and designers of public spaces can implement small scale solutions in public spaces. Urban planners can implement measures on the large scale of city planning. For optimal achievements, all these groups have to take adaptation actions.

To inspire and facilitate such concrete adaptation actions and to make information easily accessible for all, we developed the Urban ClimaAdApp. The prototype of this smartphone app was made for the city of Amsterdam (Netherlands) and for the two main target groups of house owners and public space designers/ urban planners. This app shows high resolution urban climate maps, indicating urban climate problems and potentials for its improvement. The urban climate map was created with a combination of an automated generation of urban climate classifications according to the Local Climate zone system and a desk study on wind issues (danger spots and ventilation potentials). Additionally, the Urban ClimaAdApp provides place specific adaptation recommendations based on the degree of urgency to take action (e.g. implementing urban greening, providing wind shelter, etc.). The recommended interventions are illustrated with photographs and according to their efficacy, relative costs and maintenance. The first prototype of the Urban ClimaAdApp was launched on the 29th of August 2016.

However, the question is: will such a smartphone app indeed foster urban climate adaptation action? Hence, a user survey was held to inquire the usefulness of the app. The theoretical concept is based on the tripartite classification of mental activities into cognition, affection, and conation to describe people's attitudes. The questions accordingly deal with people's appreciation of the tool and its recommendations, its comprehensibility and in how far it really inspires them to take action. The results of the survey and the subsequent adjustments of the app will be presented in our conference contribution.

## **2. Do-it-yourself (DIY) urban experiments: toward a local and civic way to adapt to climate change?**

Geneviève Cloutier, Université Laval

At the local scale, climate governance experiments act as a way to explore original and innovative practices regarding climate change. Tactical greening of schoolyards, citizens' committees to build resilience to floods or neighbourhood associations organising shared cooling spaces are a few examples of climate governance experiments taking shape in cities around the world. Such experiments take form independently from national and international programs, they cross scales, jurisdictional and organizational boundaries and their goal is to offer a response to climate change in the face of uncertainty. The concept of experiment illustrates the way the debate on how to act and adapt the urban space takes place on different grounds and through new modes of collaboration. It also helps to evaluate the level of embeddedness of this major issue throughout the « regular » activities of cities and urban areas.

Local adaptation experiments offer a possibility to coordinate different types of interventions and available resources towards a common goal. In that sense, they participate to local adaptation without depending on public policies. Such experiments at the micro-scale have not been the focus of many empirical studies. How do they emerge and what are their potential benefits and co-benefits?

DIY greening initiatives and civic engagement projects can be seen as adaptation experiments to face climate change at the urban scale. Based on the results of a literature review, and of semi-structured interviews conducted with 30 stakeholders engaged in four different greening initiatives on public and semi-public urban spaces and on two local rainwater management projects in Canada, this paper exposes a comparative analysis. It argues that local and micro-local experiments projects can act as a way to explore innovative practices. In doing so, these initiatives create “free spaces”, where citizens and public officials cooperate and take over the issue of local adaptation to climate change. This is well illustrated by the cases, where dwelling owners and renters, young professionals and self-motivated individuals work independently from, but interact with, the local administration

and allow for demonstration projects to take form. The paper presents the cases, highlights lessons learnt and raises possible issues of such projects in terms of environmental justice and sustainability.

### **3. Realizing the innovation and business potential of climate adaptation - how to facilitate commercially driven development of climate adaptation products**

Mikkel Thomassen, Smith Innovation

How can the interest in and need for climate adaptation be transformed into entrepreneurship and new business opportunities that creates better cities and green growth? This presentation reflects on this question by reviewing how seven new products and services has been developed in commercial partnerships as part of the Danish campaign Klimaspring.

Funded by the philanthropic organization Realdania Klimaspring was initiated with the purpose of developing new commercial solutions with co-benefits for managing rainwater in the dense urban city. In this presentation we will share our experiences as the secretariat and catalyst for the campaign and invite you as a policy maker or company to discuss the opportunities and barriers for developing similar programmes across Europe.

Unlike traditional product development new climate services can in most cases not be developed by single companies and within the existing business areas. Rather, multidisciplinary and interfirm collaboration is needed as a response to extreme weather. Traditional sewage systems are no longer sufficient or optimal for handling the increasing amounts of rain. Extreme rain crosses boundaries thus requiring our solutions to do the same. Underground solutions need to surface in the city thus changing from being merely mono academic engineering feats to being the object of multiple disciplines, interests and not least opportunities. Water management is no longer 'secret service'. Nor is it purely 'public service' for the solutions need to be found, financed and used across public and private actors, existing and new types of customers. In order to succeed, we need to develop solutions drawing on all the different agents and areas of expertise involved in managing and utilizing rainwater. This means managing not only water flows but also decision and funding flows in a field rife with rules and regulations. It takes innovative thinking and new collaboration patterns.

The participants in the Klimaspring consortiums have focused on developing the new solutions. Our focus as the facilitating part have been to develop the framework for a new way of collaborating. In this presentation we will introduce the methodological framework for the campaign and share our experience with leading commercial partners from an initial idea to a ready for market climate adaptation solution. We will invite you to participate in the dialogue about how this approach could be adapted to different geographical locations, and what the challenges are in developing new solutions for a new future.

### **4. Cooperation and knowledge exchange towards an integrated and participatory approach to climate change adaptation.**

Ana Romero, Merience

Climate Metropole+ is an initiative of Barcelona Metropolitan Area and Metropolis in cooperation with Berlin Metropolis, Lyon Métropole and Liverpool City Region. The aim of Climate Metropole + is to exchange experiences and generate knowledge regarding climate change adaptation in metropolitan areas. The project was launched in June 2015 and ends in December 2016. The No Regrets Charter is used as the framework for assessing practice on climate change adaptation in the different metropolitan areas across the spheres of ecology, economics, politics and culture. Four workshops were conducted in each of the partner cities to present the plans and strategies, challenges and actions faced by metropolitan areas to adapt to climate change. This presentation will focus on the good practices shared by the cities to improve knowledge on adaptation and resilience to climate change. For instance, the focus on climate change adaptation differs between the participating cities. Significant attention is placed on urban heat island effects in Barcelona and Lyon, whereas Liverpool's challenges are more centred around extreme weather events such as adapting to intense rainfall and flash flooding events.

The project helped to see climate change adaptation as a cross-cutting topic. The No Regrets Charter proved to be a useful framework to consider different dimensions of adaptation which are generally overlooked, mainly culture and economy, compared with the environmental dimension. In fact, climate change adaptation actions are seldom linked to economic propositions. Climate change adaptation is an opportunity to encourage cross-departmental approaches and partnerships between private and public actors, engaging city stakeholders in the process.

## **5. Decision-making options for robust climate change adaptation in forest management: agent-based modelling of institutional interactions**

Calum Brown, School of Geosciences, University of Edinburgh

A range of information is available to forest managers to assess ecosystem services. This information comes from different sources, including modelling and simulation studies that take account of climate change impacts. However, information is not always sufficiently clear or consistent across services, limiting the extent to which it can support the multi-criteria decision making of managers and policy makers. Furthermore, few attempts have been made to anticipate other factors or pressures such as the demands for services by stakeholders, organisations and the public. This can exacerbate disagreement between different stakeholder groups with contrasting values and requirements because it precludes robust and transparent consideration of synergies and trade-offs in management outcomes.

One approach to help bridge the gap between model results and management decisions is agent-based modelling (ABM). ABM allows explicit modelling of the dynamic interactions between the supplies of different ecosystem services and the demands of multiple stakeholders representing diverse institutions. We applied the 'CRAFTY' ABM framework to the forest landscape at Loch Ard in Scotland, which is subject to a wide range of distinct ecosystem service demands and stakeholder interventions, focused for example on timber production, flood prevention, recreation, biodiversity preservation and carbon sequestration. We used the ABM to explore forest management strategies supporting the provision of ecosystem services and climate change adaptation. We used existing simulation data for six ecosystem services assessed under climate change scenarios (11 RCM UK models) to generate potential levels of ecosystem service provision under different forms of management. Our results reveal points in space and time where the Loch Ard forest might start to provide substantially different levels of forest ecosystem services under specific stakeholder demands and management strategies. For example, levels of the currently dominant timber service show divergent trajectories over the next 30 years, which can affect levels of biodiversity and recreation, in particular, and can constrain future management options. The interplay of different stakeholder interests and interventions in the system are also found to have significant effects on the levels and distributions of ecosystem services. These findings can help forest planners/managers to assess the feasibility of current plans and adjust them to take account of future conditions. This work contributes to the growing need for integrating not only quantified ecosystem services but also the preferences and strategies of stakeholders and managers.

## 6.3 A tour of local adaptation in Europe

*Ad Jeuken, Deltares*

### Monitoring and evaluation

#### Flooding

1. Local adaptation to climate change in Europe: a comprehensive overview (Francisca Aguiar, University Of Lisbon)
2. Review of climate mitigation and adaptation plans of metropolises and medium-sized cities in Germany (Annegret Thieken, University of Potsdam)
3. Closing the gap between individuals and institutions - Best practice in bottom-up citizen initiatives for flood preparedness (Thomas Thaler, University of Natural Resources and Life Sciences, Vienna)
4. EU and the nation-state in transboundary water governance: direct and transnational climate impacts in the Tagus and Guadiana river basins (Adis Dzebo, Stockholm Environment Institute)
5. Local Climate Impacts Profile across Sectors – Requirements for Buy-In from the ‘Unusual Suspects’ (Ellie Murtagh, University of Strathclyde)

### 1. Local adaptation to climate change in Europe: a comprehensive overview

Francisca Aguiar, University Of Lisbon

During the last 14 years, European countries have published national and local climate change adaptation strategies. The present work systematically reviews local adaptation strategies in Europe, with the objective of analysing how local communities are responding to climate risks.

We quantified and statistically analysed, 147 Local Adaptation Strategies (LAS) of municipalities or metropolitan areas, across Europe, encompassing 19 European Union member states plus Norway. LAS were screened regarding the following topics: i) Triggers of adaptation, ii) Main vulnerabilities, iii) Adaptation by sectors, iv) Implementation by sectors, v) Barriers to adaptation, vi) Funding sources, vii) Type of stakeholders involved. In order to summarize climate risks, local political commitments and urban trends to adaptation, we used Multiple Responses Frequencies, Cochran's T tests, McNemar tests, hierarchical clustering and Principal Coordinate Analysis.

Results provided evidence that the most significant triggers for the elaboration of local adaptation plans were the financial, scientific and technical support from research (40.8%). The implementation of European Union directives (European Adaptation Strategy) (38.8%) and the occurrence of extreme climatic events, namely heat waves and droughts (26.5%), and storms (26.5%), were also important triggers for local adaptation. Urban and rural flooding (24.3%), droughts (8.6%) and extreme temperature and heatwaves in cities (12.7%) were found to be the main vulnerabilities identified in the local strategies.

Consequently, the priority sectors considered for adaptation were flood protection and water management (128 LAS; 10.6%), built environment (8.9%), urban planning (8.5%), the protection of forests and natural areas (7.7%), and civil protection (7.0%) and human health (7.0%). The lack of financial and human resources was found to be the major barrier to implement adaptation measures (reported in 48 LAS, 15%).

Most important source of funding for adaptation came from local public level (30.2%) followed by national funds (20.9%) and private sectors (12.1%). In most of the LAS (97.5%) was recognized the importance of stakeholder engagement in the elaboration and implementation of adaptation plans (e.g. local municipalities, NGOs, farmer's associations, and private organisations).



We concluded that in Europe local climate change adaptation strategies are crucial to deal with urban, rural and coastal climate-related risks, but the scarce human and financial resources hamper adaptation actions, which are taking place much slower than current needed, given the reported vulnerabilities and risk projections.

## **2. Review of climate mitigation and adaptation plans of metropolises and medium-sized cities in Germany**

Annegret Thieken, University of Potsdam

Cities are responsible for up to 70% of global greenhouse gas emissions, but they can also be severely affected by impacts of climate change, such as extreme weather events. Hence, cities are important actors in climate policies and many of them have started to develop strategies or action plans that explicate how the city aims to mitigate and/or adapt to climate change.

Although climate mitigation and adaptation have been on the political agenda for many years in Germany, a thorough overview of municipal strategies is missing. Therefore, this study provides a first comprehensive synthesis of such municipal strategies while differentiating three city sizes: big metropolises with more than 500,000 inhabitants, small metropolises having 100,000 to 500,000 inhabitants, and medium-sized cities with more than 50,000 inhabitants that have the same statutory framework than metropolises.

Altogether, mitigation and adaptation plans of 99 German cities were searched and investigated by content analyses. The analysis reveals that mitigation plans are much more common than adaptation plans: 91 cities had a mitigation plan, while only 34 had an adaptation plan by the end of March 2016. There is also a clear dependence on the city size, particularly with regard to adaptation plans since no adaptation plan could be found in a medium-sized city. This highlights that climate change adaptation is a young policy domain: a national funding programme that supports cities to develop adaptation plans was launched in 2015, while a comparable programme for climate mitigation was already established in 2008.

With regard to the contents, measures to reduce greenhouse gas emissions in the transportation sector and in urban development are the most popular. With regard to adaptation, planned actions and measures are much more diverse and thus context-specific. It is, however, striking that fields of actions that were identified by national and European policies as being important, such as the health sector, are often not considered in the municipal plans. Hence, more cooperation and exchange is needed between different policy levels. This is further supported by the fact that city networks were identified as an important driver for the development of mitigation and adaptation plans.

## **3. Closing the gap between individuals and institutions - Best practice in bottom-up citizen initiatives for flood preparedness**

Thomas Thaler, University of Natural Resources and Life Sciences, Vienna

Increasing flood risks under climate and societal change, as recently experienced during extreme hydrological events in Europe, have significantly transformed the roles held by multiple actors in flood risk management. This new policy agenda strives to delegate responsibilities and costs from the central government to local authorities on the one hand, and from the public administration to private citizens on the other hand. The resulting locally-based strategies for risk reduction are expected to tighten the feedback loops between complex environmental dynamics and human decision-making processes. However, managing local risks easily exceeds the technical and budgetary capacities of municipal institutions, and individual citizens struggle to carry the full responsibility for flood protection.

Bottom-up citizen initiatives may close this gap by complementing mainstream top-down, centralized approaches. In this paper, citizen initiatives are understood as community-based, self-organized groups where private households at risk band together for local preventive action, such as inspecting and monitoring hazard focal points for early warning signals, conducting emergency and evacuation exercises, sharing product

information and experiences on effective building retrofitting, providing neighbourly help in flood recovery, or lobbying to local and national governmental bodies. Bottom-up citizen initiatives may function as intermediaries and facilitators between individuals at risk and institutions tasked with flood risk management. These initiatives may channel local adaptive capacities, workforce and expertise towards increased social resilience. In a broader sense, they may drive societal transformation and disrupt embedded policies, although they are often pursued by local actors solely with the narrow aim of addressing local problems or to seize local opportunities.

Drawing on an assessment of exemplary bottom-up initiatives in Europe from document analysis and actor interviews, this paper illustrates the critical socio-cultural drivers and challenges why bottom-up initiatives emerge and establish themselves in the risk policy arena. Typical activity fields of bottom-up initiatives are identified and contrasted to the prevalent institutional framings of responsibility (who should act), efficacy (who is capable to act) and participation (who decides on action). These results provide policy-relevant insights into the driving forces behind bottom-up initiatives and the settings required to build a cooperative process between various stakeholders involved in flood risk management.

#### **4. EU and the nation-state in transboundary water governance: direct and transnational climate impacts in the Tagus and Guadiana river basins**

Adis Dzebo, Stockholm Environment Institute

Management of transboundary water basins is a complicated process of complex socio-ecological systems with spatial and temporal implications. More than often, various levels are included in the decision-making, including local, national, transboundary, and supra-national, and there are governance challenges on all levels. In addition, current and future impacts of climate change provide another layer of uncertainty, particularly with the increasing knowledge of climate impacts beyond geographical borders, so called transnational climate impacts (TCI). This complexity implies that water issues cannot be governed at one scale and multi-scale models are necessary for effective governance.

This paper analyses the various roles and responsibilities of different actors in adaptation-related decision-making in transboundary water governance. It applies a transnational climate impacts approach to the water sector in order to broaden the analysis of multi-level governance of transboundary waters. The framing of the paper focuses on the Tagus and Guadiana water basins shared between Spain and Portugal and EU policy via the Water Framework Directive and the Floods Directive. It attempts to answer the question at which level should direct and transnational climate impacts be governed and what are the roles and responsibilities of different decision-makers at national and EU level in this context? Transboundary water basins are particularly interesting to analyse from a transnational climate impacts perspective as this research area is typically viewed as a local or a national issue and more recently as a basin-level issue.

The analysis builds on semi-structured interviews with key decision-makers from various sectors from Spain, Portugal and the EU. The interviews focused on objectives, support systems and decision-outcomes related to the two water basins as well as the two EU Directives. The paper finds that there is a multi-level governance gap in several issue areas, including policy, administration, information, capacity, finance, objective, and accountability. Water-related issues are multifaceted and addressing them requires the inclusion of more than one scale in governing transboundary waters. Different aspects of water management issues need to be addressed at different scales and strategies to include adaptation to climate change impacts in transboundary water governance must consider the international dimension of climate risk and identify specific ways in which decision-makers – and the socio-ecological systems that they govern – will be able to make informed decisions.

## **5. Local Climate Impacts Profile across Sectors – Requirements for Buy-In from the ‘Unusual Suspects’**

Ellie Murtagh, University Of Strathclyde

The impacts of climate change vary considerably across regions; as such climate adaptation necessitates an understanding of local scale climate impacts in order to plan for resilience. Improved knowledge surrounding drivers of climate change impacts can assist municipalities with decision making for appropriate adaptation, project design and communication. The collection and sharing of information on local climate change impacts is also an effective way to engage citizens with their own experiences of climate change and to encourage adaptation considerations.

One method to gather such information is the Local Climate Impact Profile (LCLIP), a tool used to examine the impact local weather and climate currently has on a specific area. To carry out the LCLIP a database of extreme weather events and their related impacts is built via a media trawl and review of departmental records. This data is supplemented with the results of semi-structured interviews and analysed to show the impacts of climate and weather on the local authority.

It is the aim of this paper to evaluate the effectiveness of the LCLIP tool as a catalyst for raising awareness and stimulating action for adaptation within a UK city. This study updates the LCLIP for Glasgow for 2011-2016 and compares results with previous LCIP findings from 2005-2010. This paper expands the LCLIP beyond the local authority to include local academia and business institutions, to assess the awareness of climate impacts amongst different organisations. As part of this, the data and evidence needs from various sectors required to get buy-in to climate adaptation activities will be assessed.

The utility of the LCLIP and accessibility of the process will be assessed, both in relation to previous and current iterations. The impacts of carrying out the LCLIP, how it contributed to or improved knowledge on climate impacts will be examined. The limitations of the LCIP process in assessing vulnerability will also be considered. A critical evaluation will be undertaken to evaluate the use of the LCLIP and how such approaches can evolve and improve to ensure an appropriate return on investment considering the work involved. An assessment of how LCLIP findings assist with creating a narrative of current local problems and how these can be integrated to global context will be carried out. Finally, the LCLIP findings will be studied to assess which local communities or sectors are affected most within Glasgow and how the city’s post-industrial legacy has influenced risk distribution examined.

## 4.9 Is adaptation taking place? The practice of implementing adaptation strategies, climate mainstreaming and pilot activities within multilevel governance environments

*Marco Pütz, Swiss Federal Institute for Forest, Snow and Landscape Research*

### Governance

### Monitoring and evaluation

The Swiss adaptation pilot programme: triggering adaptation practice in cantons, regions and municipalities (Thomas Probst, Swiss Federal Office for Environment)

1. National climate change adaptation in Germany: institutionalisation, mainstreaming and stakeholder-participation (Andreas Vetter, German Federal Environment Agency)
  2. From policy to practice: current implementation of the national adaptation strategy in Austria (Wolfgang Lexer, Environment Agency Austria)
  3. Local adaptation to climate change: agenda-setting and implementation in small municipalities (Reinhard Steurer, University of Natural Resources and Life Sciences, Vienna)
  4. Identifying and tracking key actors in adaptation to climate change: the UK landscape from 2006-15 (Suraje Dessai, University of Leeds)
  5. The Dutch approach of adaptation to climate change: The second National Adaptation Strategy of the Netherlands (Kim Van Nieuwaal, Climate Adaptation Services Foundation)
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**Keywords:** Mainstreaming adaptation, adaptation practice, pilot programme, multilevel governance, climate adaptation governance

Adaptation progress has been made in terms of developing adaptation strategies (mostly at the national level), designing adaptation action plans, assessing climate impacts, vulnerabilities and risks, setting adaptation priorities through consultation and participation, and raising adaptation awareness in public authorities, private businesses and society. What has been not so much in the spotlight so far is in how adaptation is actually taking place and what types of measures and interventions are implemented. How are adaptation strategies and plans implemented? Which factors motivate adaptation action? How do current adaptation practices differ between countries, regions or sectors? What features characterize good adaptation practice? To discuss these questions and to better understand adaptation practice, the session takes stock of experiences, success stories and failures regarding the implementation of adaptation strategies, climate mainstreaming and pilot activities. Adaptation practices include the development of guidance and support tools, adaptation training, stakeholder involvement, creating new administrative units responsible for adaptation in public administration, integration and mainstreaming of adaptation issues into other policy fields and decision-making processes, as well as pilot programmes and other model activities. Focusing on the implementation of national adaptation strategies within multilevel governance environments, the goal is to highlight the variety of adaptation practices and to identify similarities as well as contrasting experiences from different countries.

### Significance to adaptation practice, policy and/or business

The session is significant to adaptation policy and practice in two ways. First, the oral presentations are significant because they provide insights into adaptation practice and the implementation of adaptation policies from practitioners' points of view. These practitioners also represent different countries and different concepts of adaptation. Second the session is significant because by organizing a panel discussion in the second part of the session it enables dialogue between practitioners and policy experiences from different countries. This dialogue is helpful to develop robust recommendations for future adaptation policy and practice.

## **1. The Swiss adaptation pilot programme: triggering adaptation practice in cantons, regions and municipalities**

Thomas Probst, Swiss Federal Office for Environment,

As climate change adaptation is still a relatively new issue, practical activities and experiences on regional and local level are widely lacking. Therefore, the Swiss «Pilot program adaptation to climate change» was set up by the Federal Office for Environment in 2013 as a national funding initiative to support cantons, regions and municipalities in tackling climate change related challenges. The 31 funded projects cover a wide range of issues with need for action (water scarcity, natural hazards, ecosystem changes, urban development, knowledge transfer), territorial levels and stakeholders (administration, enterprises, associations, research, etc.), ending after 3 years' runtime by the end of 2016. This contribution will present key lessons learnt with regard to horizontal and vertical cooperation within and beyond the programme, based on evaluation and governance analysis results.

## **2. National climate change adaptation in Germany: institutionalisation, mainstreaming and stakeholder-participation**

Andreas Vetter, German Federal Environment Agency

In December 2015 Germany published the first progress report to the German adaptation strategy. The main elements of this report are:

- a) a monitoring report based on a set of indicators for the different action fields of the strategy,
- b) a vulnerability assessment that identifies the most effected regions and systems using a cross-sectoral, nation-wide standardised methodology, and
- c) a second adaptation action plan.

The progress report thereby marks a new level of information about past, current and future climate change and impacts as well as politically agreed action needs in Germany. Thus, the report is a valid source to address decision-makers on different policy levels in order to foster their implementation efforts. However, there is a lack of implementation of necessary adaptation measures. Intensifying implementation also means further developing governance systems. The presentation focuses on three aspects.

- Adaptation as a policy field needs to be institutionalized by different steering and coordination bodies to manage horizontal and vertical integration. A new network of 16 German agencies and different research institutes was built to discuss and agree about the results of the vulnerability assessment to advise the intergovernmental working group. It is planned to continue the network of Federal agencies on an ongoing base for the development of the next policy documents. Experiences, opportunities and challenges of such a network structure will be presented and discussed.
- Mainstreaming is one of the main principles of the national adaptation strategy. The aim is to integrate adaptation to climate change in all relevant planning processes and development strategies as systematically as possible. One starting point is to identify main national strategies that are of high relevance for adaptation to climate change. Recommendations to better manage the interfaces of these strategies in relation to the adaptation strategy will be presented.
- Different formats of stakeholder participation, e.g. stakeholder dialogues, regional market places and workshop series on local level, were conducted in the German strategy process. These formats will be presented by their main characteristics, aims and achievements so far.

### **3. From policy to practice: current implementation of the national adaptation strategy in Austria**

Wolfgang Lexer, Environment Agency Austria

Having a national adaptation strategy and action plan in place since 2012, Austria has recently traversed the first monitoring, evaluation and revision cycle of its adaptation policies on federal level. Based on the first progress report and a comprehensive review of the state of implementation, the first update of the national adaptation strategy package has been prepared, submitted to political consultations, and is scheduled for political adoption by the federal government at the end of 2016. This makes Austria one out of 22 European countries that have developed a national adaptation strategy, of 18 countries with a national action plan, and of 14 countries that report to be in the implementation or monitoring and evaluation stage of the adaptation policy cycle, respectively. In parallel to progress in national policy making and advancement, the focus of adaptation activities in Austria has increasingly shifted towards implementation. Over the last two years, a range of new practices, initiatives and programmes has been launched to support, govern and steer implementation of adaptation actions across levels, sectors and actors. These include development of sub-national adaptation plans on the level of provincial governments, cooperation pathways and governance arrangements for vertical coordination, a new funding programme for climate change adaptation in model regions, new communication and stakeholder interaction formats, enhancement of the knowledge base through cooperation between the science and policy communities, development of new support tools and other capacity-building efforts, in particular directed at supporting adaptation at the local level. The present contribution gives an overview of the state of play of adaptation practices in Austria from the national perspective, highlights new and innovative approaches, formats and instruments, reflects on experiences made, and addresses related challenges and barriers in a multilevel governance context.

### **4. Local adaptation to climate change: agenda-setting and implementation in small municipalities**

Reinhard Steurer, BOKU - University of Natural Resources and Life Sciences, Vienna, Austria and InFER – Institute of Forest, Environment and Natural Resource Policy

Although adaptation to climate change is often framed as a key concern for all levels of government (in particular for the local level), it is difficult (for many countries even impossible) to identify small municipalities that have already implemented adaptation measures. Consequently, research on local adaptation policies usually focuses on large cities and ignores small municipalities. In the present paper, we address this research gap by analysing why and how small municipalities implement adaptation policies. Thanks to a survey on local climate change adaptation in Bavaria/Germany we were able to identify more than 10 small municipalities with 1,000-20,000 inhabitants that have implemented at least one climate change adaptation measure. To learn more about why and how these municipalities did so and what kind of adaptation measures they implemented, we are about to conduct two to three interviews per municipality. The paper will describe the types of adaptation measures and implementation mechanisms we found in small Bavarian municipalities, the driving forces behind them, relevant barriers as well as success factors, support they received and their needs for (additional) support. Based on these findings we will discuss what most other municipalities that still ignore climate change adaptation can learn from the self-declared “adaptation frontrunners” in Bavaria and in how far these lessons can be transferred to other countries.

### **5. Identifying and tracking key actors in adaptation to climate change: the UK landscape from 2006-15**

Suraje Dessai, Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds, UK

To understand progress towards adaptation to climate change it is necessary to examine which actors are at the heart of this process. We develop a methodology to identify and track adaptation actors over time, which we apply to the adaptation landscape in the UK, a country often considered a leader on adaptation. Through the Climate Change Act 2008, the UK was the first country to make both mitigation and adaptation to climate change legally binding. With the Act the government has established a governance framework for adaptation, which

through the Climate Change Risk Assessment (CCRA), the National Adaptation Programme (NAP) and the Adaptation Reporting Power not only identifies, but also mandates the country's key actors on adaptation to take action. To establish a clearer understanding as to which actors are considered key players in progressing towards a well-adapted society, this paper develops a methodology to identify actors that emerge as central in the top-down UK adaptation landscape from 2006-15. The methodology is based on a structured review of documents, strategies and research conducted or commissioned by the UK government during this period. Through qualitative content analysis and based on the frequency with which actors were mentioned across all documents, 595 actors considered central to adaptation were identified. Whilst covering a range of sectors, 50% of actors fit into one of three categories: public administration (26%); professional/scientific/technical (14%); and transportation/storage (10%). Actors from the public sector have dominated throughout the decade, and the Department for Environment Food and Rural Affairs, the Environment Agency and Local Authorities are persistently observed as key actors. Very few actors from other key sectors impacted by climate change such as agriculture, forestry and fishing, were mentioned. Furthermore, we find that amongst the public sector actors 44% are from local government, highlighting that local government and its associated local level public sector actors are seen as key adaptation actors by central government. An exploratory examination of the capacity of these actors together with the finding that there is only limited diversity of actors across sectors, highlights that understanding the actor landscape is key to evaluate a country's progress towards adaptation to climate change. These insights can particularly help to inform and guide what the UK government's next CCRA and NAP will need to focus on, if the vision of a well-adapted society is to be realised.

## **6. The Dutch approach of adaptation to climate change: The second National Adaptation Strategy of the Netherlands**

Kim Van Nieuwaal, Climate Adaptation Services Foundation

The Netherlands is presenting its second National Adaptation Strategy early 2017. The goals of this NAS NL are to encourage all relevant parties to put climate adaptation into practice, to increase awareness, to further embed climate adaptation into mainstream policies and policy instruments and ensure that it is fully embedded as such by 2020, to demonstrate how climate resilience can be practically achieved in the short term, to instigate concrete actions at all levels and sectors of society, and to prepare the monitoring of results.

The NAS NL provides a state-of-the-art palette of the effects of climate change at stake for Dutch society as a whole, based on both research and societal consultation rounds. A number of those effects are designated as 'high impact effects', of which some are addressed sufficiently by policy or research programs, whereas others require additional and immediate attention, amongst which (a) heat stress, (b) failure of critical infrastructure due to extreme weather conditions, (c) impacts on agriculture and food supply due to extreme weather, (d) the shift of climate zones, and (e) the increase of allergies and infections on human health.

Additionally, assessing social and scientific trends, NAS NL addresses several key issues for which concrete actions are proposed. Among those key issues are (a) disruptive social impacts as a result of cascading effects, (b) cross-overs between policy domains, (c) governance aimed at awareness and responsibilities, (c) valorisation of knowledge and expertise, and (d) learning from examples.

The Dutch approach of climate adaptation is a knowledge-intensive and participative process, that has its roots in the collaboration of governments, knowledge institutes, businesses and societal parties since the first national adaptation strategy in 2007 and the subsequent national research programs.

In this presentation, an outline will be given of the process that has led to the second National Adaptation Strategy of the Netherlands, the main features of the actual strategy, and the follow-up steps. This could be of particular interest to those involved in national adaptation strategies elsewhere in Europe, as this is the year when the European Commission expects all member countries to present their national adaptation strategies. An

interesting point for question is the question what the possible advantages and disadvantages are of a collaborative and adaptive process which is the backbone of the Dutch approach to climate adaptation.



## 11.5 Hey people, where are you? Resident-inclusive flood risk management and implications for modes of governance

*Peter Driessen, Utrecht University and Dries Hegger, Utrecht University*

### Flooding

### Governance

1. Collaborative governance arrangements for climate change adaptation: mapping citizen–municipality interactions (Ebba Brink and Christine Wamsler, Lund University Centre for Sustainability Studies)
  2. The actual and potential role of residents in flood risk governance – framework and preliminary results based on a literature review (Dries Hegger, Utrecht University)
  3. Conditions for citizen engagement in a resilient, efficient and legitimate flood risk management. A tentative framework. (Hannelore Mees, University of Antwerp)
  4. Residents’ participation in local climate adaptation – What can municipalities do to keep afloat? (Caroline Uittenbroek and Heleen Mees, Utrecht University)
  5. The Dutch Climate Alliance (Madeleen Helmer, The Dutch Climate Alliance)
  6. Discussion (Peter Driessen, Utrecht University)
- 

**Keywords:** flood risk management; flood risk governance; residents; citizens; public-private divide; bottom-up initiatives; modes of governance

To deal with increasing flood risks, the involvement of residents is crucial. Some private property level measures (e.g. decreasing soil sealing; implementing green roofs) can only be taken with their consent or after they take initiatives. Residents may also form bottom-up governance networks that take flood risk management action. Residents’ involvement is, furthermore, necessary to offer them a say in issues in which they have a stake. Governmental actors in several countries are struggling with the role of residents in flood risk governance. Problems that are repeatedly reported in literature and in practice include: a lack of risk awareness, a tendency to attribute responsibility for flood protection to governmental actors, a lack of support for measures such as local water storage areas, and a struggle with the more general question of whether at all, when and how residents should participate.

The proposed session brings together the results of several ongoing and recently completed research projects and presents some hands-on experiences with engaging residents in flood risk governance. After an opening by Chairman Prof. Peter Driessen, Dr. Christine Wamsler and Ebba Brink will map out and theorise the ways in which municipalities (can) interact with citizens to sustainably address climate change adaptation. Dr. Dries Hegger will then provide a framework for looking at the actual and potential roles of residents in flood risk governance, making a distinction between residents’ capacities as citizens vis-à-vis governments; consumers in the market and as member of civil society. Next, Mrs. Hannelore Mees will present a tentative framework on the conditions for a citizen engagement which enables a resilient, efficient and legitimate flood risk governance. Next, two presentations will follow on three local Dutch case studies of bottom-up initiatives in flood risk governance. Dr. Heleen Mees will present a diagnostic tool for the analysis of citizens’ adaptive capacity. This tool can be used to inform policy interventions to overcome weaknesses regarding citizens’ awareness, ability and/or agency. Dr. Caroline Uittenbroek will address the concrete participation mechanisms employed in the three cases and their resulting outcomes in terms of input-, throughput- and output legitimacy. Finally, Mrs Madeleen Helmer of the Dutch Climate Alliance will share her experience in setting-up different dialogues between local citizen initiatives and municipalities related to flood risk governance. The presentations will last 10 minutes each and will be followed by a discussion on the five presentations combined (30 minutes) moderated by Prof. Peter Driessen.

## **Significance to adaptation practice, policy and/or business**

The session addresses the question of “what works where, when and how?” when it comes to including residents in flood risk governance. In so doing, the session will lead to concrete recommendations for governmental actors that want to improve their flood risk governance practices by better including residents in these. It furthermore sketches potential opportunities for other private parties, including flood risk management businesses, for engaging with residents.

### **1. Collaborative governance arrangements for climate change adaptation: mapping citizen–municipality interactions**

Ebba Brink and Dr. Christine Wamsler Lund University Centre for Sustainability Studies (LUCSUS), Sweden

The impacts of climate change represent a challenge for sustainable urban development, including the actors involved and the demarcation of their responsibilities when dealing with hazards such as floods, heatwaves and storms. In this context, the importance of more distributed risk governance through increased city-citizen interaction is increasingly recognised. However, there are hardly any empirical studies and related theory development that address and systematise interactions and related responsabilisation between citizens and city authorities in managing and adapting to climate-related risk. Against this background, we map out existing interactions in Swedish municipalities and analyse how related responsibilities for climate change adaptation manifest and are (re)negotiated. The results show that city-citizen collaborations are hardly considered in cities’ adaptation planning. The interactions that could be identified emerged out of other local processes, including top-down, bottom-up, contestation and collaboration processes. These interactions involve both citizens at high and low risk, and their outcomes have shown a range of positive outcomes: improved risk-reduction measures, increased citizen awareness and institutional learning. However, systematic evaluation is lacking. The results further show that fostering city-citizen collaboration for climate change adaptation requires the active consideration of the following strategic issues: ownership equity and responsabilisation, systematic adaptation mainstreaming and the support of nature-based approaches. Finally, we present a heuristic framework for theorising the ways in which municipalities (can) interact with citizens to sustainably address climate change adaptation.

### **2. The actual and potential role of residents in flood risk governance – framework and preliminary results based on a literature review**

Dr. Dries Hegger, Utrecht University

Flood risk governance literature has hitherto devoted limited attention to the roles of residents (homeowners/tenants). Yet their role is crucial in addressing non- or maladaptation, as their initiative or consent is often necessary to take private property level measures. This presentation addresses this knowledge gap by exploring potential additional roles for residents in flood risk governance in and around the home. A literature review was carried out on the actions of residents. To structure the results, we used a distinction between three forms of residents’ commitment to flood governance: as (a) citizens falling under the jurisdiction of various governmental levels; (b) consumers (including home owners) in the market; (c) civil society members/partners. While this is an established categorization in other domains of environmental governance, it has not yet been systematically applied to flood risk governance. For each form of commitment, we identified mainstream and additional roles of residents, with reference to the Dutch domains of flood risk management and stormwater management. We found that there would be scope for additional roles for residents, especially as consumers in the market and civil society members. The findings seem to be of significance for the global debate on residents’ roles in flood governance and suggest that broadening the scope of literature and practice by addressing all three forms of commitment may enhance the implementation of private property level measures as well as the legitimacy of these measures, residents’ awareness regarding adaptation and societies’ potential to innovate.

### **3. Conditions for citizen engagement in a resilient, efficient and legitimate flood risk management. A tentative framework.**

Hannelore Mees, University of Antwerp

In several countries in Europe, a trend can be observed to increase the role of citizens in the implementation of flood risk measures (e.g. UK, Netherlands, Belgium, France, Germany). This in contrast to the traditional flood management approach pursued in several of these countries, which involved almost exclusively governmental actors. Research conducted in the framework of the STAR-FLOOD project ([www.starflood.eu](http://www.starflood.eu)) observed that the main rationales for policymakers in Belgium, England, France and the Netherlands to foster the involvement citizens in the implementation of flood risk management are the increase of its resilience, efficiency and legitimacy. In literature, however, several questions are raised on the positive impact of citizen engagement in terms of these aims.

The paper presented in this session investigates which conditions flood risk management should fulfil in order to allow for citizens to engage in its implementation while being considered resilient, efficient and legitimate. Hereto, a tentative framework has been developed, based on literature review and first experiences in England. The framework is structured by different building blocks, whereby a first row of primary conditions exists of citizens' risk awareness, perceived responsibility and self-efficacy. These primary conditions are highly dependent on a second row of building blocks, namely citizens' knowledge, economic capacity and social capital. In turn, these conditions can be strengthened by the government through the investment of financial and human resources (e.g. subsidies, expert support), bottom-up co-planning and by defining a clear responsibility distribution between authorities and citizens.

The framework presented contains an inherent tension between the criterion of resilience/legitimacy and efficiency. The paper therefore calls for a broad interpretation of the concept of efficiency, which is directed to the maximisation of the management's benefits instead of cost reduction. Hence, it is argued that increased citizen engagement in the implementation of flood risk management can only be successful when aiming to increase public spending's return on investment instead of reducing it.

### **4. Residents' participation in local climate adaptation – What can municipalities do to keep afloat?**

Dr. Caroline Uittenboek and Heleen Mees, Utrecht University

Climate change is expected to lead to (amongst other things) an increase in extreme downpours, which can lead to fluvial and pluvial flooding. Municipalities have to consider ways to adapt the public (and private) space to enlarge the water storage and infiltration capacity. Municipalities need to interact with residents if these changes in public space are to be considered legitimate by the residents. More importantly, residents themselves can invest in adaptation measures on their own properties and in this way share responsibility in addressing climate change. Yet, municipalities seem to struggle in how to engage residents and moreover, how to convince them to share responsibility in taking climate adaptation measures.

In the Netherlands, municipalities recognize the future (and current) flood risks and are willing to facilitate climate adaptation measures in public space. Through public participation processes, they aim to include residents to participate in the planning and implementation of these measures. However, there is not one way to organize public participation and the level of legitimacy might vary per case. Through a detailed evaluation of the input, throughput and output legitimacy the paper looks at various forms of participation, such as the appointment of a professional mediator who represents the interests and voices of the residents, the organization of public community meetings, the creation of a residents' feedback group, and the organization of climate ateliers.

Three case studies in The Netherlands have been selected that address water-related climate adaptation issues, and where municipalities have included residents in the planning, implementation and maintenance of the

project. Based on these two criteria, the following projects are selected: Rooftop park Rotterdam, Kockengen Waterproof and Waterplaza Tiel-Oost. In each case, we have interviewed key actors, such as representatives from the municipality, water authorities, urban designers, housing associations and residents. Over 30 semi-structured interviews were held and included questions concerning the established participatory arrangement and its legitimacy.

## **5. The Dutch Climate Alliance**

Madeleen Helmer, Dutch Climate Alliance

The Dutch Climate alliance is one of the few Dutch NGOs running a programme on adaptation. One of the activities is organising dialogue meetings between the different stakeholders in a chain of climate related risks, like extreme weather and festivals, local heat plans, and linking the chains in water management, from citizens to the regional water authorities. Citizens initiatives are welcomed, but how well are they linked to other actors in the chain? What role do they have within the overall objective of climate resilience? What are the new governance questions popping up? Mrs. Helmer will link her practical experiences with these issues to the findings contained in the preceding presentations.

## 12.3 The effectiveness of Ecosystem-based approaches to climate adaptation and mitigation in urban areas

*Pam Berry, ECI, University of Oxford and Nicolas Faivre, DG Research & Innovation, European Commission*

### Ecosystem services and NBS

#### Urban, energy & infrastructure

1. Impacts of grey/green infrastructure interaction on urban climate – insights into the role of nature-based solutions on resilience and sustainability (Jorge H. Amorim, Swedish Meteorological and Hydrological Institute)
  2. Mitigating heat and heavy rain events via urban green infrastructure: nature-based solutions for urban adaptation planning (Teresa Zölch, Technical University of Munich)
  3. The cooling effect of different water bodies in Amsterdam during hot days. (Lisette Klok, University of Applied Sciences Amsterdam)
  4. Greening the city to adapt to climate change and improve liveability (Laura Kleerekoper, Amsterdam University Of Applied Sciences)
  5. How to reduce the impacts of climate change on air quality at microscale? A numerical study in Porto's urban area (Vera Rodrigues, University of Aveiro)
- 

An increasing number of people live in urban areas, and are likely to be particularly affected by climate change, including higher temperatures, increased frequency of high intensity rainfall and localised flooding. In Europe, for example, over 70% of people live in urban areas which only cover 1.5% of the land surface. However, the use of nature, through ecosystem-based approaches, the development of green infrastructure or nature-based solutions in these areas, can contribute to adaptation and/or mitigation, with many actions being synergistic, or providing other ecosystem services. These multiple benefits are typical of well-implemented and managed ecosystem-based approaches to climate adaption and mitigation.

In this session, we will start by examining what are the possible climate challenges that will be experienced by urban areas, especially in terms of modelled urban temperatures (Amorim et al.). Modelled and observed temperature differences between built up areas and parks will be compared for Stockholm and Bologna, so that the effectiveness of green infrastructure can be assessed, with a view to enabling planners to improve the climate resilience of cities. Urban areas will also experience other extreme events, and Zölch et al. will assess the potential of urban green infrastructure, not just for adaptation, but also the provision of multiple benefits through the delivery of regulating ecosystem services. This will be demonstrated through the modelling of scenarios of trees and green roofs in Munich and synergies and trade-offs discussed. Another way of reducing urban temperatures is through the use of water and the third paper (Klok et al.) will evaluate the effect s of different types of water bodies in Amsterdam on air temperature, thermal comfort and thermal sensation, so that planners can know how best to use water features in urban design. Kleerekoper et al. will use a study of eight neighbourhoods to demonstrate the monetary and non-monetary social costs and benefits of green and blue infrastructure. Climate change can also affect air quality and thus human health, so finally, Rodrigues will demonstrate the role of green infrastructure on the urban microclimate and in improving air quality in Porto, under future climate scenarios. Thus, this session will demonstrate the effectiveness and importance of integration green spaces into urban planning and design.

Speakers have been asked to include information on:

1. how they measure the effectiveness of nature-based solutions (NBS) in their case study,
2. how they do/can compare their results with NBS implemented elsewhere and non-NBS,

3. if and how this information was used by decision-makers.

We will then use the remainder of the time to discuss further with everyone the available tools and methods to conduct impact assessments, their limitations as well as their contributions to better-informed decision-making. We count on the audience participation to stir the discussion on i) the geographic and temporal scales, ii) replicability and iii) relevance to multiple stakeholders of assessment methods to demonstrate NBS effectiveness. There will also be opportunities for all participants to share their ideas and experiences on these issues at the stand in the session room and using social media (@NatureBasedSolu).

### **1. Impacts of grey/green infrastructure interaction on urban climate – insights into the role of nature-based solutions on resilience and sustainability**

Jorge H. Amorim, Swedish Meteorological and Hydrological Institute - SMHI

There is strong scientific evidence showing that urban physiography, vegetation, and human activity are key drivers of urban climate, generating strong urban to rural gradients and distinct microclimates even within the city. In UrbanSIS, a proof-of-concept project within the Copernicus Climate Change Service (C3S), we are interested in knowing how, and to what extent, urban planning affects the city's response to the climate signal. UrbanSIS aims at delivering climate and impact indicators at fine resolution over selected European urban areas, with a focus on the infrastructure and health sectors.

In this work, the urban downscaling of the Numerical Weather Prediction system HARMONIE is carried out by the Town Energy Balance (TEB) model, with lateral boundaries provided by the UERRA reanalysis. Detailed land-cover is included through the implementation of a method for generating refined 1x1 km<sup>2</sup> resolution physiography data over urban areas. For this purpose, open-access data from ECOCLIMAP-II, Urban Atlas 2012 (Copernicus Land Monitoring Services), OpenStreetMap, and leaf area index (Copernicus Global Land Service) are processed and aggregated.

Results for a 5 years historical period over Stockholm, Sweden, and preliminary outputs for Bologna, Italy, are shown. The model data is compared against local meteorological observations within the city and rural outskirts. Emphasis on the analysis of data from the Observatoriet weather station in central Stockholm, a 4 ha urban park, is given with the aim of quantifying the magnitude and dynamics of the park cool island (PCI), and its impact on the city's urban heat island (UHI). The ability of the model to represent the physical processes involved in the interaction of vegetated and built-up surfaces with the atmosphere, namely through the transfer of momentum, heat and water, is discussed.

By delivering high-resolution urban climate data over selected European cities, the C3S project UrbanSIS aims at providing valuable insight into the potential of Nature Based Solutions (NBS), and particularly Green Infrastructure (GI), to deliver innovative and efficient solutions for adapting to climate change, by improving the resilience and sustainability of cities. Key purveyors of this data include environmental consultancy companies, urban planners, engineers and scientists that have a concrete need for climate services in the context of urban adaptation to hazards driven by intense rainfall, heat waves and air pollution episodes.

### **2. Mitigating heat and heavy rain events via urban green infrastructure: nature-based solutions for urban adaptation planning**

Teresa Zölch, Technical University of Munich

Future climate change with more frequent and more intense extreme events is projected to especially affect cities due to high building densities and surface sealing. Hence, urban planning needs to foster adaptation measures to cope with heat and heavy rain events. Traditional, hard infrastructure measures are often perceived as expensive and inflexible. In addition, competition for urban space makes it difficult to introduce new infrastructure that serves only single objectives of risk reduction. Therefore, urban green infrastructure has gained increasing

attention as a nature-based solution to climate change adaptation that provides multiple benefits. However, adaptation potentials of urban green infrastructure still lack quantitative assessments, particularly, when it comes to the provision of multiple adaptation benefits through the delivery of regulating ecosystem services. The paper addresses this gap by investigating the mitigating potential of different green infrastructure types to heat as well as heavy rain events. Scenarios of trees and green roofs are modelled by two simulation approaches, a microclimatic and a hydrological one, for a densely built-up inner city area in Munich, Germany. The scenarios' effects on outdoor thermal comfort of pedestrians and the regulation of surface runoff are compared to each other. Finally, synergies and trade-offs between the mitigation of heat and heavy rain are discussed to support urban planners in decision-making for effective climate change adaptation.

### **3. The cooling effect of different water bodies in Amsterdam during hot days.**

Lisette Klok, University of Applied Sciences Amsterdam

Urban green and shading are adaptation measures that reduce urban heat. This is evident from meteorological measurements and investigations with surveys and has been described in many papers (e.g. Klemm et al., 2015). The cooling effect of these adaptation measures is reflected by lower air temperatures and an improved thermal comfort. Shading and urban green are also experienced as cooler than impervious urban spaces without vegetation or shading. However, the cooling effect of water bodies in cities, such as rivers, lakes, ponds, canals, fountains, is not clear yet (Steeneveld et al., 2014). Several studies show that the cooling effect of water bodies in cities is small, or can even be a source of heat during nighttime. The effect depends on the characteristics of the water body and the meteorological conditions. Nevertheless, water is often mentioned as an adaptation measure to reduce urban heat.

To support urban professionals in designing cooler urban environments by using water bodies, we investigated in more detail how different water types in Amsterdam contribute to cooling the environment. During five summer days, we measured the cooling effect of five different water bodies: a pond, a fountain, a canal, and two rivers. We used measurements from mobile weather stations (air temperature, relative humidity, wind speed, global radiation and globe temperature) and collected almost 1000 surveys near the water bodies and a reference location. From these data, we could determine the effect of the water bodies on air temperature, thermal comfort and thermal sensation. The research question that we tried to answer with this study is: What is the cooling effect of different water types in the city of Amsterdam during hot days? The study has been carried out within the framework of a Dutch research project 'Urban climate resilience – Turning climate adaptation into practice' and supports urban professionals to decide on the right adaptation measures to reduce urban heat.

### **4. Greening the city to adapt to climate change and improve liveability**

Laura Kleerekoper, Amsterdam University Of Applied Sciences

Green is often mentioned in policy documents as an instrument to increase climate resilience (Sussams et al. 2015). For instance, to reduce heat stress or to buffer water during heavy rainfall. In practice, however, implementing (more) green is one of the first elements that is cut when space is scarce or budgets are tight.

Various studies show that the benefits of urban green are by far larger than the costs (Bade 2010, Joye 2010, Urbanisten 2016). This research aims at identifying benefits of green with an additional focus on climate proofing the area. The idea is that this will help to strengthen the position of green in a climate resilient street design. As a start of the research, an inventory of benefits of urban green gives insight in the broad spectrum of influenced themes including health, the energy and water system, economic and social issues. This research has a specific focus on the benefits of green for heat and water resilience, such as, the cooling potential and the water buffering capacity of green.

In the research we developed case study designs for eight neighbourhoods based on a proven social cost-benefit analysis (Kluck et al. 2016) and a tool to value urban green (teebstad 2016). Water and heat resilience are

designed with green, where possible. The benefits of the green elements in the design are expressed in economic value for avoided damage costs and other benefits that can be expressed in money such as energy reduction, housing values and additional income through taxes. Benefits that relate to social issues are also expressed in economic value. These are presented separately because they include more assumptions and insecurities. The results give insight in possible benefits of green or show the capital that is destroyed by removing green.

We have investigated points of attention for choosing climate proof urban green, such as green in combination with water storage that needs to be resistant to periods with long dry and wet circumstances. Green for cooling should be supplied with a water reservoir for more cooling potential and to be able to develop a large crown to shade the street or facades.

This research shows the options and feasibility of green in climate resilient design of the public space. The costs for green are not a constraining factor, but the battle for space is. Integrated green is one of the solutions.

## **5. How to reduce the impacts of climate change on air quality at microscale? A numerical study in Porto's urban area**

Vera Rodrigues, University of Aveiro

Climate change impacts are recorded worldwide through extreme weather events. Among these events, heat waves have become a commonly recorded effect (e.g. in southern Europe) with a strong impact on human health, ultimately leading to the loss of human lives. Meanwhile, in urban areas due to the well-known continuous growth of population, human health is becoming alarmingly threatened by climate change and air pollution impacts. Furthermore, air pollutants dispersion is highly affected by climate related events. A better understanding of the urban microclimate and air quality is therefore crucial to circumvent these impacts. Besides, given the expected increase of extreme weather events, adaptation of societies to climate change in the coming decades is of extreme importance. Designing and implementing several resilience measures in densely populated urban areas is therefore an important goal to adapt to climate change and to mitigate the changes in urban metabolisms.

In the framework of the CLICURB project – Urban Atmospheric Quality, Climate Change and Resilience – future climate scenarios were considered, aiming to evaluate a set of resilience measures to climate change impacts in the urban area of Porto, in Northern Portugal. In order to study the impacts of the selected measures on air quality under a climate change scenario, the Representative Concentration Pathway RCP8.5, a cascade of numerical models, from the global to urban scale was applied to a heat wave in future climate (2050).

In this paper we assess the impacts at local scale of green resilience measures. For this purpose, we have performed a set of numerical simulations using the CFD model VADIS, to estimate the impacts of green infrastructures on the urban microclimate and air quality under future climate scenarios. In this study, the air quality analysis is focused on particulate matter with an equivalent aerodynamic diameter lesser than 10  $\mu\text{m}$  (PM10), which remains one of the most critical air pollutants in Europe. Air quality records in Porto urban agglomeration also point out several exceedances of PM10 legal limit values.

The obtained results show that the selected measures lead to an increased resilience to climate change, usually promoting a reduction of PM10 concentrations. The results clearly show the effects induced by green infrastructures and their role in improving air quality under future climate scenarios.



## 9.2 Energy and Transport Infrastructure under Climate Change: Adaptation, Mitigation and Resilience

*Olivier Dessens, University College London*

### Urban, energy & infrastructure

1. Croatian Strategy for Low Carbon Development of Electricity Sector Until year 2050 (Zeljko Tomsic, University of Zagreb)
  2. Combining the expertise of federal agencies to increase the resilience of transport infrastructure to climate change impacts in Germany (Stephanie Hänsel, Deutscher Wetterdienst)
  3. Adaptation of the French railway system: climate change as a strategic driver of decision making? An in-depth case-study. (Vivian Depoues, I4ce - Institute For Climate Economics)
  4. Taking action with strategy: Examples from the Swedish Transport Administration's work on climate change adaptation (Eva Liljegren, Swedish Transport Administration)
  5. A new freezing rain impact indicator for the European energy sector (Otto Hyvärinen, Finnish Meteorological Institute)
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**Keywords:** Adaptation; Mitigation; Resilience; Climate services; Risk assessment; Extreme events; Energy; Transport.

Within the theme “urban, energy and infrastructure” this session will concentrate on two specific sectors: energy and transport. This session is well positioned in the science/practice interface of the sectors included.

The energy sector presentations share the theme of the energy supply side. More precisely the energy supply in the future under the development of renewable sources and large electrification of other economic sectors. The synergy between mitigation and adaptation is extremely relevant to the electricity sector. Mitigation will drive a significant reduction in greenhouse gas emissions from the electricity sector (with probable global decarbonisation after 2050 to achieve the Paris goal) as well as electrification of other sectors (industry, transport), these mitigation could push the development of renewable sources share in the electricity generation, some presenting large variability in their output. This expansion in variable renewable drives the need in knowledge of the geographical and temporal availability of the future resources as well as the ability to transport the energy vector to the customers in a secure and stable way.

The transport infrastructure encompass all the modes of transport, however from the presentations chosen in this session the in-land transport seems to dominate. Contrary to the energy sector the transport part mostly pay attention to adaptation to climate change and resilience to extreme events in the future. The climate change mitigation options are not studied here. The elaboration of risk assessment studies of the present transport sector under climate change conditions and the development strategies and investments to mitigate the climate change impacts are the main subjects of these presentations. The analysis are mostly qualitative and the results are outlines on how the sector is taking into consideration the possible changes, the adaptation needed to produce resilience and finally the framework to deliver efficiently the adaptation policies.

### **Significance to adaptation practice, policy and/or business**

This session is positioned at the interface between science and practice with focus onto two sectors: Energy and Land Transport. Several presentations describe the build-up of a climate service with fully co-designed elements. Climate change mitigation is also included as a main economic development, long term planning and environmental strategy. Scenarios are also presented to achieve low carbon electricity in line with stability and reliability of supply grid.

This session serves policy, industry and researchers. The dialogue between users will provide guidance for future management and investment decisions related to the energy and transport infrastructure and will facilitate the implementation of the suggested mitigation and adaptation measures.

## **1. Croatian Strategy for Low Carbon Development of Electricity Sector Until year 2050**

Zeljko Tomsic, University of Zagreb

The concept of Low Emission Development Strategies (LEDS) has been introduced by the Conference of Parties to the UNFCCC as a common but differentiated approach to meet the overall emissions reduction objectives: “All countries shall prepare Low Emission Development Strategies ...nationally-driven and represent[ing] the aims and objectives of individual Parties in accordance with national circumstances and capacities” (Cancun Agreement). The starting point of EU policy for the way towards low carbon economy is a goal of reducing greenhouse gas emissions in Power sector by 93-99% by 2050. In line with this objective, in 2014 the European Council adopted the climate-energy frame of 2030, which sets the goal of reducing emissions -40 % by 2030. Also, there is the goal of renewable energy sources to 27% and an indicative target is to reduce energy consumption by 27%. In the electricity sector, in addition to reducing greenhouse gas emissions her goal is to increase the security of energy supply, sustainability of energy supply, increase the availability of energy and reduce energy dependency. It is assumed that a number of measures can be implemented with priority in the promotion of energy efficiency, renewable energy, resource efficiency, advanced network and intelligent energy supply system, low emissions vehicles and vehicles with electric drive, energy storages but also the possible application of technology to capture and storage of CO<sub>2</sub> in geological formations.

In developing low carbon strategies was analysed a variety of scenarios. In the electricity sector challenges are numerous, in terms of the position of individual types of energy, the expected energy prices; fulfil energy efficiency and renewable energy policies. It was analysed the costs and benefits of switching to low-carbon development scenarios. This paper presents results of work on preparation Croatian Strategy for Low Carbon Development of Electricity Sector Until. Analysis cover period until 2050. Croatian power system is modelled in PLEXOS model and several scenarios are analysed and compared. Croatian LEDS is based on analysis of three scenarios: NUR – business as usual scenario; NU1 – huge energy efficiency measures implementations and consequently lowered electricity demand and NU2 – large scale electricity usage implementation, especially in transport sector and consequently increased electricity demand. This paper focuses on power system and Grid Stability and Reliability with large share of renewables sources (wind and PV).

## **2. Combining the expertise of federal agencies to increase the resilience of transport infrastructure to climate change impacts in Germany**

Stephanie Hänsel, Deutscher Wetterdienst

Resilience to the adverse impacts of climate change and extreme weather events is needed for a sustainable operation of traffic and of transport infrastructure. The German Federal Ministry of Transport and Digital Infrastructure combines the expertise and competencies of its departmental research institutes in a research network focusing on interdisciplinary knowledge, skills and action. Generating knowledge about the spatial pattern of expected climate change impacts and of the vulnerability of transport infrastructure by combining the competencies of experts in Germany ensures the development and implementation of targeted adaptation measures. Within the network a consistent basis of scenario data is coordinated and provided. This includes building a framework for the ensemble-based analysis of potential climate impacts using regional climate projections processed for the user-specific needs. Climate change related impacts and possible management options along the federal roads, railways and water ways are assessed with a focus on the risks posed by floods, storms, landslides and low water situations. The results of hazard specific analyses are integrated in a risk assessment tool that aims at providing decision support to users across the whole country. This tool builds on the risk potential that is analysed as a function of cause (hazard potential) and effect (potential impact). Thereby,

increasing the understanding of the cause-effect relationships is important for advancing the risk assessment methodology. The tool will provide a comparison between the risks posed by different hazards within different assessment periods building on the current state of the infrastructure. Besides this national risk assessment, specific analyses integrating different risks and encompassing different modes of transport are conducted within pilot studies in focus regions of the German coastal and inland areas. Adaptation needs and possible adaptation measures are assessed based on the risk analysis results. These include the examination of current (technical) regulations (e.g. rail), the test of material adjustments (road surface), the assessment of sediment management options (waterways) and the evaluation of modal shift in case of traffic disruptions due to extreme weather events. The implementation options for specific measures are discussed with the operators of the transport system. Thus, the research network creates innovative solutions for climate change adaptation and a sustainable development of the German transport system in a dialogue between science, policy and practice.

### **3. Adaptation of the French railway system: climate change as a strategic driver of decision making? An in-depth case-study.**

Vivian Depoues, I4ce - Institute For Climate Economics

This talk will present the results of the first stages of a research project on the institutional uptake of climate change related scientific information by a large scale organization in charge of the management and operation of heavy infrastructures such as a national railway network. It will focus on how this information is understood and used to implement adaptation measures. The talk will outline significant changes to be adopted by the organization to deal with climate-sensitivity, uncertainty and unavoidable transformations.

The work undertaken by this research project and that will be discussed with the talk attendees is the result of on an undergoing in-depth case-study of a section of the French railway network (between two French southern cities) exposed to several climate impacts (sea-level rise, heatwaves and flash floods). This case study is conducted in the framework of a partnership between I4CE – Institute for Climate Economics, the French Environment Agency (ADEME) and the French National Railway Company (SNCF).

Combining complementary approaches from science and technology studies and economics, this research seeks to take into account the decision context, common practice and existing processes to understand how scientific inputs are perceived and fostered by individual and teams inside the organization. Rather than designing new decision making tools, the objective of this project is to question the conditions of uptake and use of existing relevant tools and methods by teams and individuals involved in decision making.

Beyond a general understanding of the sector dynamics and structure, this presentation will present results of the analysis at three levels:

- *Operational level*: Daily operations such as vegetation management or maintenance planning revealing tensions between system rigidities and dynamic changes.
- *Investment and strategic level*: Large investments projects in which climate change has to become an important variable location, technical options and sizing choices.
- *Long term planning and prospective view*: Assumptions and baselines (of service demand, future mobility uses, etc.) used for strategic planning at a territorial level challenged by climate change scenarios.

Preliminary results show that, contrary to other sectors, climate change is not perceived yet as a key variable to be taken into account at the described decision levels. Setting up alternative dialogue and decision making tools in the organisation could open opportunities to tackle the problem differently provided that those evolutions, which might imply to significantly reframe climate challenges, are acceptable for the stakeholders and compatible with existing processes.

#### **4. Taking action with strategy: Examples from the Swedish Transport Administration's work on climate change adaptation**

Eva Liljegren, Swedish Transport Administration

The need to work with climate change adaptation is obvious. This is stated over and over again in the ICCP's reports, the COP agreement, the EU's climate change adaptation strategy and in the SENDAI framework for disaster risk reduction. A common approach to start adaptation work is to produce strategies or common frameworks for a specific field - for example the state road network. However, having a strategy or a framework is not enough. These documents need to be transformed into action. This abstract presents how the Swedish Transport Administration (STA) transformed its climate change adaptation strategy into 18 different, and rather down to earth, activities.

The STA is responsible for four different transport modes: roads, railways, shipping and aviation. Being a large country, covering several climatic and geographical zones, adapting to climate change is, and will always be, a challenge. To face this challenge the STA launched a climate change adaptation strategy in 2014. The strategy is divided into three parts. The first part deals with issues related to creating conditions for efficient climate change adaptation work. The second part focuses on creating a robust road and rail network. In the third part the need for managing the effects of the impact of the climate is highlighted.

In order to implement the strategy an action plan was formed in 2016 in which the three parts of the strategy were made into 18 activities with deliverables, deadlines and an appointed person responsible for each activity. The activities include, for example, producing a communication plan for STA's climate change adaptation work both within and outside the administration, and an analysis of the need for national and international cooperation. Several of the activities deal with risks, for example updating inspection routines or making an inventory of affected parts of the infrastructure, such as culverts, stone arch bridges and switchgears.

The activities also cover the need to act when something happens, for example when a road is flushed away or when a wild fire closes down railway traffic. In these cases the emergency planning needs to be updated for climate related impacts, and the appointed diversionary roads chosen so that they are not affected by the same natural hazard.

The work with the activities started in June 2016 and all of them should be completed by June 2017. The first activities were already completed during autumn 2016.

#### **5. A new freezing rain impact indicator for the European energy sector**

Otto Hyvärinen, Finnish Meteorological Institute

Extreme winter events, such as storms and freezing rain, belong to the costliest impact phenomena for the energy sector, causing major damage to power distribution infrastructure, roads and forests. An assessment of probabilities of such events on European scale for the energy infrastructures in the present and projected climate has not been available.

A freezing rain indicator, based on climate scenarios, is evaluated and demonstrated. It will help assessing the risks and potential losses caused by freezing rain events at climate projection time scale. Such assessment is important for the transmission system operators.

Transmission system operators bear the responsibility to guarantee a continuous and sufficient transmission of electricity from power plants to the regional level. As the both legislative and customer needs are becoming more stringent, there is a growing need to be better prepared for freezing rain events in both long term planning, design and investment (e.g., new standards for the designed strength of the structure) as well as day-to-day operational management of the transmission and distribution networks.

In the C3S CLIM4ENERGY project, a freezing rain impact indicator is being developed with focus on energy sector that provides information on the spatial variation of probability of damaging freezing rain events in the current climate and projected changes in the future climate over Europe. The indicator allows development of strategies in minimizing the risk of damage and economical costs in energy sector as well as societal impacts. CLIM4ENERGY will provide a web tool that allows practitioners to examine the results in more detail in the geographical region of interest.

The two impact thresholds for the freezing rain indicator (10 mm/day and 25 mm/day) were defined taking into account the damages of freezing rain events on energy infrastructure, and based on a survey conducted with six European stakeholders and literature review. The occurrence of freezing rain events above these two impact thresholds were calculated, as well as changes between the baseline (1971-2000) and the future period (2021-2050), that is of primary interest for energy stakeholders. Future estimates were based on an ensemble of EURO-CORDEX regional climate models with medium (RCP4.5) and strong (RCP8.5) emission scenarios.

# Theme Convenors

## 1. Evidence for action: data, climate services & communication

- Jens Christensen, Danish Meteorological Institute (lead convenor)
- Tim Carter, Finnish Environment Institute
- Svetlana Jevrejeva, National Oceanography Centre
- Piero Lionello, University of Salento

## 2. Planning ahead: delivering resilience in the face of climate uncertainty

- Mario Pulquério, University of Lisbon (lead convenor)
- Christopher Reyer, Potsdam Institute for Climate Impact Research
- Calum Brown, Karlsruhe Institute of Technology
- Rob Dunford, Centre for Ecology and Hydrology & University of Oxford

## 3. Business and finance: mobilising investment in climate change adaptation and building low carbon, climate resilient economies

- Marco Grasso, University of Milano-Bicocca (lead convenor)
- Andrea Roventini, Scuola Superiore di Studi universitari e di perfezionamento Sant'Anna
- Jochen Hinkel, Global Climate Forum

## 4. Making it happen: organisations, policy, governance, justice & ethics

- Tiago Capela Lourenco, University of Lisbon (lead convenor)
- Robert Biesbroek, Wageningen University & Research
- Henrik Carlsen, Stockholm Environment Institute
- Marco Grasso, University of Milano-Bicocca

## 5. Working together: co-production of knowledge between science, business, policy, practice and local communities

- Saskia Werners, Wageningen University & Research (lead convenor)
- Kirsty Lewis, UK Meteorological Office
- Niki Frantzeskaki, DRIFT
- Tim Rayner, University of East Anglia

## 6. Adaptation in practice: case studies, monitoring, support tools and guidance

- Marjolijn Haasnoot, Deltares (lead convenor)
- Kit England, SNIFFER
- Kasper Kok, Wageningen University & Research
- Mark Rounsevell, Karlsruhe Institute of Technology
- Sally Brown, University of Southampton
- Rob Swart, Wageningen University & Research
- Hans Sanderson, Aarhus University
- Ad Jeuken, Deltares

## 7. Global challenges: climate adaptation and the UN Sustainable Development Goals

- László Pintér, Central European University (lead convenor)
- David Tàbara, Sustainability
- Ralph Lasage, University Amsterdam

## **8. Whole system sustainable solutions: acting across multiple sectors and scales**

- Jill Jäger, Independent Researcher (lead convenor)
- Ian Holman, Cranfield University

## **9. Urban, energy & infrastructure**

- Olivier Dessen, University College London (lead convenor)
- Sen Li, University of Oxford

## **10. Agriculture & forestry**

- Marcus Lindner, European Forest Institute (lead convenor)
- Stephen Sitch, University of Exeter
- Stefan Fronzek, Finnish Environment Institute
- Ana Iglesias, Technical University of Madrid

## **11. Water security & flooding**

- Agustín Sánchez-Arcilla, University Polytechnic of Catalonia (lead convenor)
- Michalis Voudoukas, European Commission Joint Research Centre
- Martina Flörke, University of Kassel
- Luis Garrote, Technical University of Madrid

## **12. Biodiversity, ecosystem services & nature-based solutions**

- Pam Berry, University of Oxford (lead convenor)
- John Haslett, University of Salzburg
- Rachel Warren, University of East Anglia
- Carles Ibáñez, IRTA

## **13. Health and wellbeing**

- Vladimir Kendrowski, World Health Organization (lead convenor)
- Caroline Zickgraf, The Hugo Observatory, University Of Liège
- Sara Vigil, The Hugo Observatory, University Of Liège
- Sari Kovats, LSHTM
- Emma Terama, Finnish Environment Institute