Coast to Coast Climate Challenge
– the 24 subprojects

Coast to Coast
Climate Challenge

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Coast to Coast Climate Challenge

About 10 years ago, the first political interest on the consequences of climate change was raised. A heavy storm surge in Copenhagen in 2011 caused damages amounting to approximately DKK 5 billion. Two years later, the government instructed the municipalities to map local climate risks and to formulate contingency plans to prevent damages and destructions caused by climate change.

The Coast to Coast Climate Challenge, C2C CC, project was initiated to have a more coordinated and broader approach to the challenges. The 98 Danish municipalities were obliged to make their own plans concerning local conditions, and the C2C CC project would facilitate a broader, regional collaboration on climate actions – both between the municipalities and within each municipality. Moreover, other stakeholders affected by the climate plans would be involved.

The project took its starting point in the municipalities in Central Denmark Region. But the consequences of climate change do not respect municipal borders and it was thus obvious to include the municipalities bordering on Central Denmark Region to also take part in the project.

The focus was the specific challenges facing each municipality or challenges that would be facing each municipality in the future as a result of climate change. The project would not deliver solutions ready to implement in each municipality and then consider local climate adaptation to be a closed chapter. The goal was to build knowledge to enable municipalities to continue their work with climate adaptation as an element of municipal planning, development and transition.

> ***"It is a conscious choice to talk about climate adaptation and not climate proofing in the C2C CC project.***

It is a conscious choice to talk about climate adaptation and not climate proofing in the C2C CC project. To be protected from the consequences of climate changes is an attempt to keep them at bay; but to adapt means to integrate the consequences in everyday life and in the ongoing development and transition of society.

This approach is a challenge – but it carries a huge potential. This is clearly illustrated in the results of the 24 projects constituting the core of the C2C CC project, which are presented here.

The 24 sub-projects which make up thesix-year C2C CC project show how climate adaptation is a complex and extensive task. Especially when the adaptation must be integrated in society with transitions in several other areas simultaneously.

The projects in C2C CC are very different. Some focus on building the necessary knowledge base to be used in the other projects; others are focused on specific, local climate adaptation challenges. Furthermore, some projects cover research and development work or focus on communication, business development or interactions with the surrounding world.

> ***"The local projects in particular reflect the successful broad collaboration and integrated focus on the issue in question.***

Common to all projects is that they are all preparatory and entrepreneurial. C2C CC is first and foremost a knowledge project – a catalyst to initiate processes, build knowledge, develop tools, initiate collaboration, dialogue, insight and understanding.

The local projects in particular reflect the successful broad collaboration and integrated focus on the issue in question. C2C CC has several examples of how municipalities work with climate adaptation across municipal administrations and with local utility companies integrated in the long-term development of municipalities.

Development of this approach requires cultivation of a vibrant environment thatmakes broad collaborations possible, and where knowledge and inspiration can be collected, collaborators found, and development and completion of specific tasks can be made. For this to happen, knowledge must be accessible; the focus must

be on research and development, and there must be strong local support for the project in question.

The C2C CC project interacts so to speak with the Danish society – a society where all prerequisites are available. Denmark has a high knowledge level, a well-functioning administration – locally, regionally and nationally - educational programmes and research environments, an efficient business sector and several possibilities for financing of initiatives.

The 24 sub-projects are divided into four categories:

- Cross-disciplinary capacity building projects
- Open land projects
- Urban projects
- Cross-disciplinary innovation projects

Each category is part of the overall whole where knowledge and tools from the cross-disciplinary capacity building projects are used in the development of the open land and urban projects, which again contributes with knowledge of and experience in management of specific challenges.

The last category, cross-disciplinary innovation projects, is concerned with spreading knowledge, innovation and an entrepreneurial mind-set to the field of climate adaptation.

> ***"The C2C CC project interacts so to speak with the Danish society ...***

In addition, the project extends its six-year time frame. Already at this point, many results and experiences from C2C CC projects have been used in other projects, collaborations, research and development projects or as products in the business sector. And more will follow. The project has created a unique framework, which will continue in future projects.

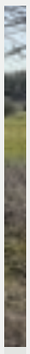
Water is a huge climate challenge for Denmark

Water is the overall theme in the C2C CC project on climate adaptation. In a country with 8,500 km coastline, 64,000 streams and 120,000 lakes of different sizes, water is the overall climate challenge.

The coasts, of which many are low-lying, are exposed if the sea level increases and storms become more frequent and severe. Many Danish urban areas along the coast, often situated along a fjord or bay close to a stream where there was once a natural harbour, are also exposed.

The amount of rain increases and so does the amount of water in streams and lakes. The shallow groundwater is rising; in many places the groundwater is just below the soil surface. Furthermore, flood risks increase with more heavy and intense rain, which only adds to the total vulnerability.

Rising sea levels will block the outflow of streams into the sea and thus create a risk of further and maybe permanent flooding. The rising sea levels will also increase the pressure on the coastline. This may force the groundwater up closer to the surface, and the infiltration of saltwater can destroy local supply of drinking water.
This complexity is reflected in the word climate adaptation. A society cannot protect itself from the consequences of climate change – not on a long-term basis. But society can adapt to the changes caused by the consequences. Adapt and live with it – but on the water's conditions. This is the core of the Coast to Coast Climate Challenge project and the 24 sub-projects show different ways of how to adapt to face the challenges.



The 24 sub-projects

CROSS CUTTING CAPACITY BUILDING PROJECTS

PROJECTS IN RURAL AREAS

PROJECTS IN URBAN CONTEXTS

CROSS-CUTTING INNOVATIVE ACTIONS

Climate adaptation of the Danish shores is a complex and diverse task:

- The Danish shores vary considerably – open, directly facing the sea, low-lying fjords with heavy tides, small and larger islands in internal waters, steep erosion coasts, tidal flats as well as areas with stream and river outlets and lagoon coasts. These variations require local climate initiatives adapted to the particular conditions
- The vulnerable nature along the shores must be protected but at the same time, the areas are very important for recreational activities and tourism
- The responsibility for the coastal areas is decentralized to the municipalities – to 78 of the total of 98 municipalities in Denmark.

Initially, the project has shown large variation in the management of climate adaptation and protection of the shores in each municipality. Many of the challenges in one municipality resemble the challenges in other municipalities. However, the level of knowledge and the local political interest in the field vary considerably from one municipality to the other.

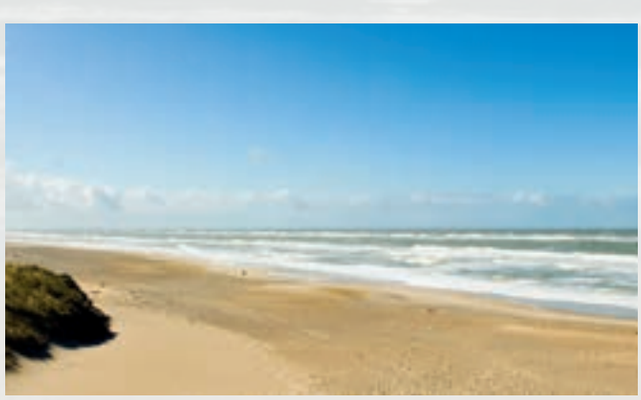
Creating a more uniform foundation for the municipalities working with shoreline climate adaptation has been a focus area. The overall goal has been to create a common knowledge base and promote the collaboration internally between municipal departments as well as between municipalities, government authorities, consulting companies, research institutions, NGOs etc.

The development of broad collaborations is necessary because shorelines cross municipal borders. Internally in each municipality, and in the interaction with government authorities, there is a need for a more holistic approach to climate adaptation. Experience shows that this approach will also rub off on other areas such as infrastructure, culture, tourism, nature protection and biodiversity.

Climate adaptation of shores require a broad collaboration and effort, as the Danish shores will be critically exposed to the consequences of climate changes in the future. Even if CO_2 emissions are successfully limited, sea levels will continue to rise. This, in combination with more extreme weather, will be a threat to the coastal areas and some may even disappear in the coming decades.

RESULTS

Inspiration from abroad is useful especially concerning the so-called Nature Based Solutions and multifunctional solutions to climate adaptation of shores. A strengthening of the political interest is necessary to increase collaborative efforts across municipal borders – not just in the municipalities but also centrally by e.g., adapting legislation.

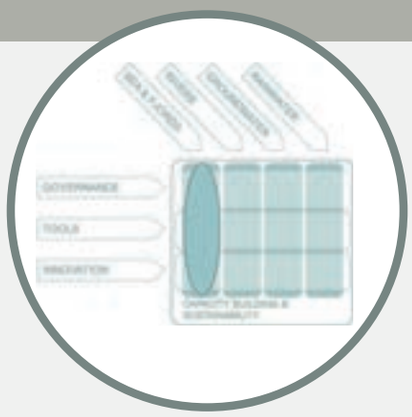


RELATION TO OTHER C2C CC PROJECTS

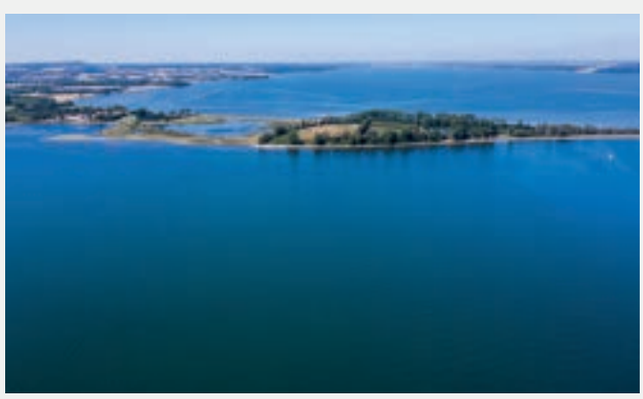
The results and knowledge of the overall C1 project: Sea and Fjord have been used in several other C2C CC projects and in particular in the following: C8: Håb to Håb – Hedensted Municipality, C9: Thyborøn Channel and the Western Limfjord, C11: Randers Fjord, C14: Horsens City Centre, C16: The Climate Ribbon and C18: Citizen-driven Climate Adaptation in Juelsminde.

C1: SEA AND FJORD

Of the 98 municipalities in Denmark, 78 are situated along shorelines and most are facing complex challenges of flooding and increased erosion of shores as a consequences of climate change. The Seas and Fjords project has introduced different climate scenarios and models, collected data and developed new knowledge on the necessary climate adaptation of coastal areas to strengthen the future contingency plans and develop broad and cross-disciplinary collaborations locally.



> ***Even if CO_2 emissions are successfully limited, sea levels will continue to rise.***



CONTINUATION

Previously, the Danish Coastal Authority was responsible for climate adaptation of the Danish coastal areas. The growing number of problems has made it relevant to create a forum for stakeholders to share knowledge and benefit from each other's competencies.

The National Network for Climate Adaptation has created a network for promoting knowledge sharing across professions and geography concerning climate adaptation of coastal areas. The results from the C1 project will be used in this network.

The Realdania project Cities and the rising sea levels has focus on research and project examples will demonstrate how cities can manage climate change at the shoreline.

Two projects from C2C CC are part of this Realdania project and they have received support from Realdania to continue their work. The projects are C16: The Climate Ribbon and C18: Citizen-driven Climate Adaptation in Juelsminde.

Denmark has approximately 64,000 km of streams and they are increasingly becoming a challenge for many municipalities. Flooding is more frequent because of interventions which have removed natural buffer zones to manage the fluctuating levels of water in the streams.

This project has focused on developing tools and initiatives in the municipalities to manage one or several streams. Focus has been on:

- Knowledge on how to manage water and the development of different tools, which together with weather data can predict water movements during and after heavy rain, to point to areas at risk of flooding
- Practical management of water such as nature-based solutions, use of water reservoirs and delaying water flow to control the water level
- Consequences and outcomes of initiatives such as removing weeds and sediments to promote outflow locally as well as the use of dikes and other types of protection against flooding in high-risk areas.

A number of these initiatives must prevent or minimize emergency flooding and act as a supplement to more permanent solutions such as overall climate adaptation plans for the streams and their hinterland.

This is a huge challenge. Along the streams, in their hinterland and the open land, areas are used for farming, housing, industry or natural resorts, protected and unprotected, as well as for recreational purposes or tourism. A more comprehensive and permanent approach to climate adaptation will unavoidably affect all of these areas.

Long-term climate adaptation is focused primarily on adapting the solutions into existing structures. This sheds light on other concepts and efforts:

- Multifunctional distribution of land, where landowners give up land to be used for e.g., water reservoirs and are assigned land elsewhere
- Involvement of stakeholders in decision-making processes. It is well-known that local acceptance and support for climate adaptation is strengthened if citizens are involved in the preparatory work
- Climate adaptation is pivotal for the promotion of added value locally. Strengthening biodiversity, supporting tourism, and creating recreational areas etc. through different projects increases the importance of the project for the local community.

RELATION TO OTHER C2C CC PROJECTS

This project has been of major importance to almost all sub-projects in the C2C CC project, especially the two projects working with climate adaptation in the hinterland: C10: The Grenaa Stream and Hinterland, C12: The Gudenå River, C13: The Storå River, C14: Horsens City Centre and C16: The Climate Ribbon.

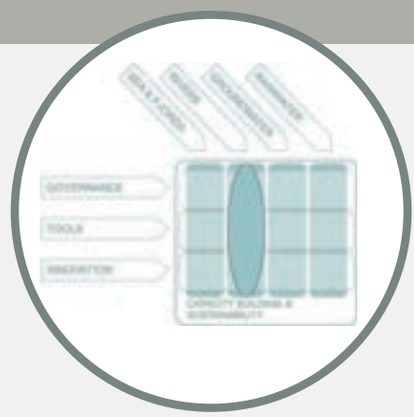
The Hydraulic Information and Prognosis System tool has used machine learning to detect groundwater close to the terrain. The same method has been applied in the development of a groundwater tool in project C6: Tools.

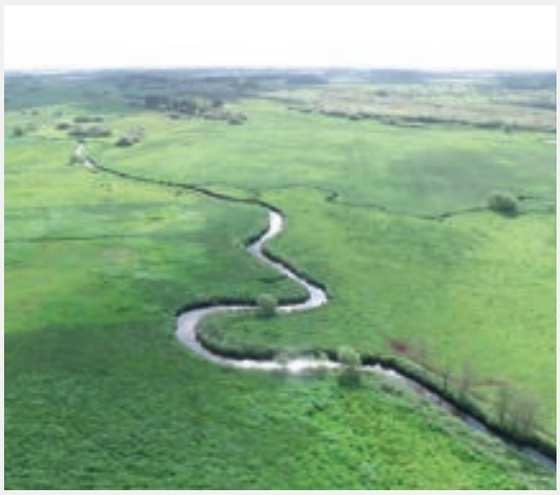
RESULTS

The project has introduced several municipalities to an overall climate adaptation plan along the streams involving data collection, development of solutions, collaboration with landowners and other stakeholders rooted in the local community.

Several tools have been developed and introduced to manage small and large streams and their hinterland. Throughout the project period, focus has been on the effect of climate projects on the nature in river valleys as well as legislation in this field.

The combination of increasing amounts of rain and 64,000 km of large and small streams constitutes a fast-growing challenge for many Danish municipalities. The focus that for decades have been on damming, stream straightening, effective redirection of water or inclusion of low-lying wet areas now turn out to have a drawback: flooding. Primarily during the winter but increasingly also in the summer period.





> ***Denmark has approximately 64,000 km of streams ...***

CONTINUATION

The collaboration with the Danish Agency for Data Supply and Efficiency and The Danish Environmental Portal will follow the development of more relevant tools for climate adaptation in Danish municipalities.

Increasing amounts of rain in Denmark has created an unexpected problem for many municipalities: high groundwater levels. When the amount of rain increases and exceeds the ability of the soil to direct the flow of water, the soil will become saturated with water and the subterranean water flow stops. The water then spreads further to the top soil layers and may even break through the surface.

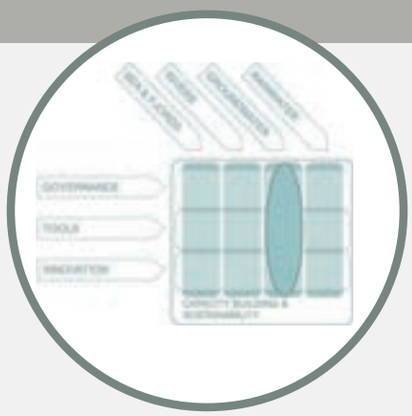
Reduced water use in households and the industry means that less drinking water is pumped up, which makes the problem worse. Along the coast, a higher sea level can press sea water into the underground and the groundwater will then be pressed towards the surface and worsen the situation locally.

The problems and solutions are complex. Pumping or draining may help if the water can be directed elsewhere. But if other and more permanent solutions should be found, an integrated effort is necessary. This project has seen the high groundwater level simultaneously as a resource and a problem to be managed.

- The project has worked with mapping of the groundwater in the municipalities participating in the C2C CC project to assist the municipalities in achieving basic knowledge on the high-level groundwater and how to manage it. This knowledge has been provided through seminars and workshops and a study trip abroad
- In connection with the project C6: Tools, several tools have been developed to map and visualise local presence of groundwater
- If the high groundwater level is considered a resource, it may be seen as a possibility for e.g., cooling and for use as process water for industry and households to limit the use of drinking water. This broad application is limited by current legislation in certain areas and the project has shed light on this problem.

C3: GROUNDWATER

The rising groundwater creates problems for Danish municipalities. Increasing amounts of water result in high groundwater levels locally – often just below the surface. This project focuses on exploring the problem further, spreading knowledge on water management in the municipalities participating in the C2C CC project as well as paving the way for the use of the water in households and the industry.



RELATION TO OTHER C2C CC PROJECTS

This project has been made in coordination with project C6: Tools, where a computer-based tool was developed for management of groundwater.

RESULTS

An initial mapping of the problem among the municipalities participating in the C2C CC has been made, a study trip to Holland as well as several seminars and workshops have been completed. Moreover, in connection with the project C6: Tools, mapping and visualisation have been made of the presence and problems related to groundwater locally.

CONTINUATION

Alongside the C2C CC project, Central Denmark Region has been the lead in the Interreg-supported project TopSoil, which focuses on developing knowledge on water in the top soil layers and includes the collection of valid data, development and implementation of solutions.

Instead of letting the rain flow into the sewerage system and strain the wastewater treatment systems, solutions for local use of rainwater are emerging. This includes the collection of water in reservoirs and ponds, seepage of water into the soil or directing the water into lakes and streams. The advantage of these solutions is that they a scalable when needed and can be established in gardens and in large residential areas. The water in open ponds can be a recreative element and promote biodiversity in cities and residential areas.

The need for local solutions is growing. In the preparatory work for the C2C CC project, 19 of 21 municipalities stated they were challenged concerning the management of rainwater and that one or several types of local solutions were applied.

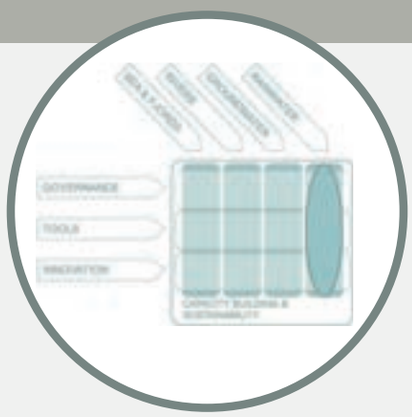
One challenge is that the collected rainwater may be polluted by waste from streets, roofs and facades or by air particles; purification of the water is thus necessary – a process balancing the type of pollution and subsequent use of the water. To ensure this process, local solutions for use of rainwater are subject to laws and legislation and the specific solutions must be approved by relevant authorities.

The starting point for C4: Rainwater project was to gather experiences in the use of local solutions, to shed

light on management of water pollution and develop methods to maintain the different systems.

Moreover, increasing groundwater may be problematic in relation to different local use of rainwater solutions. Filtration mail can be difficult or impossible when the soil is waterlogged.

The increasing amount of rain makes it necessary to develop water management technologies. It is a highly complex task, considering the environment, fighting pollution, protecting biodiversity and the groundwater – all regulated by law. The focus has been to find new suitable methods to manage rainwater, and the results have been used in several other C2C CC projects.



CONTINUATION

The Danish Technological Institute and Realdania run a project together during which partners of C2C CC and other stakeholders develop documentation of the effects of local solutions for the use of rainwater.

RESULTS

Through C2C CC, a network for staff in utility companies and municipalities has been established. Several innovative solutions for use of rainwater have been presented to inspire the development of specific local solutions.

Together with project C5: Governance, this project has contributed substantially to increase the knowledge and insight in the partnership on how to ensure involvement of citizens.

The project is continued in collaboration with the Danish Technological Institute, which has contributed with new knowledge in the field and continue to offer further training, education and exchange of experiences.

RELATION TO OTHER C2C CC PROJECTS

The projects C14: Horsens City Centre, C15: Climate Adaptation in Hedensted and Tørring, C19: Sustainable Urban Drainage Systems Used as Recreational Elements and C23: Potentials for Increased Infiltration. These projects have all dealt with aspects of local solutions for the use of rainwater. Moreover, the problem of discharge of rainwater has been dealt with in project C2: Streams.

The Danish Planning Act is the legislative basis on which common public interests must be managed. This includes the protection of nature, environment, and rural heritage or the prevention of pollution. It may also be more diffuse such as a balanced development in terms of growth, construction and business development in a particular community. In the Danish Planning Act, the State sets the general framework for spatial development on a wide range of different and very specific areas in regards to the planning in the municipalities, which then deal with the actual case-by-case procedure.

This approach ensures that centrally established rules can be implemented and that there is a certain uniformity in the processing of cases from municipality to municipality. However, it also means that the individual municipality becomes the focal point, and that each case is treated separately and delimited within the municipal border.

Consequently, this approach is not the optimal basis for dealing with a climate adaptation project that often crosses administrative boundaries.

As it appears in the different project descriptions, the local projects of C2C CC work with a broader and multifunctional approach. In order to create coherent and enduring climate adaptation, it is necessary to work with and within the whole of a given issue.

When low-lying polder areas along a river is converted from cultivated fields to wet meadows, it creates water retention areas that mitigate flooding along the river. At the same time, the high CO_2 emissions from this type of cultivated land are reduced or eliminated. And when the meadows are subsequently used for grazing, it creates habitats for plants, insects and birds. The result is water retention ponds, climate adaptation along the river, nature restoration and CO_2 storage in one and the same project.

Following existing legislation, all of these challenges must be dealt with one at a time in line with separate administrative procedures. An approach that there is neither time nor resources to follow and with the risk that a solution in one area creates a problem in another. The focus on the details risk to not address or benefit the whole.

In order to address the complex issues that transcend both the individual case areas and the specific municipality, the sub-project C5: Governance has introduced a holistic and coordinated approach to climate adaptation in the individual projects – with success, as several of the local projects show. In several cases, the project has succeeded in developing a broader approach, involving citizens, agriculture, businesses and other stakeholders in the development of solutions that incorporate several challenges at once.

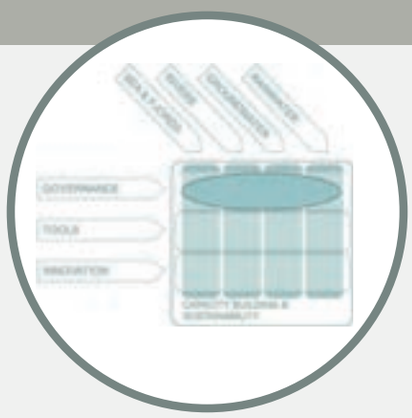
RELATION TO OTHER C2C CC PROJECTS

The projects C8: Håb to Håb and C18: Citizen-driven Climate Change Adaptation in Juelsminde are examples of projects where broad and coherent solutions have been created with strong involvement of local citizens in the process. More generally, the holistic approach has been applied in projects where it has been relevant.

RESULTS

Many of the proposed solutions developed in the local projects have evolved into broad proposals that, in addition to climate adaptation, include issues such as nature restoration, biodiversity promotion, CO_2 reduction, etc. Centrally in the C2C CC project, the methods Connective Negotiation and Systemic Change have been introduced and the methods have been applied in several of the local projects.

The regulatory framework that climate adaptation falls under mainly focus on the specific case areas and requires separate processing of each individual case. This makes it difficult to take an integrated approach to climate adaptation that places it in a broader context involving restoration of nature areas and biodiversity, reduction of CO_2 emissions or green transition. A number of projects within C2C CC have demonstrated the need for a more comprehensive approach to climate adaptation, and this can pave the way for a change in legislation and administration in the field.



> ***"The focus on the details risk to not address or benefit the whole.***

CONTINUATION

The continuation of this project is divided into two tracks:

- A general one that is based on the results of the sub-projects to formulate a strategy for working holistically with climate adaptation in Denmark. The focus must be on multifunctional and nature-based solutions to incorporate the added value that this type of solutions create.
- A concrete one, which brings together the many experiences from the various projects in an inspiration catalogue, which can form the basis for the development of new, locally anchored climate adaptation projects.

The two tracks will also form the basis for a continued dialogue with national authorities, the EU and Danish politicians on changing the legal framework to promote holistic action.

The consequences of climate change make it increasingly necessary to predict the movement of water. The increasing amounts of water challenge many municipalities, and solid knowledge is a prerequisite for being able to manage the challenges locally – both to have proper contingency plans for emergency situations but also to manage water on a long-term basis, and thus include this in the municipal planning.

The original goal was to develop a computer-based tool to draw an overall picture of the water flow in a specific area, which could be a knowledge base for deciding on local municipal climate adaptation initiatives. This tool could provide answers to questions such as: How will groundwater and surface water develop locally on a short- and long-term basis? Where will floodings take place and where will there be shortage of water? If interventions are made in a specific location, will this create problems at another location?

The development resulted in a tool able to map and predict groundwater movements as well as the development of a storm surge map based on the ability of the soil to absorb water. These two elements were lacking in computer-based tools available on the market.

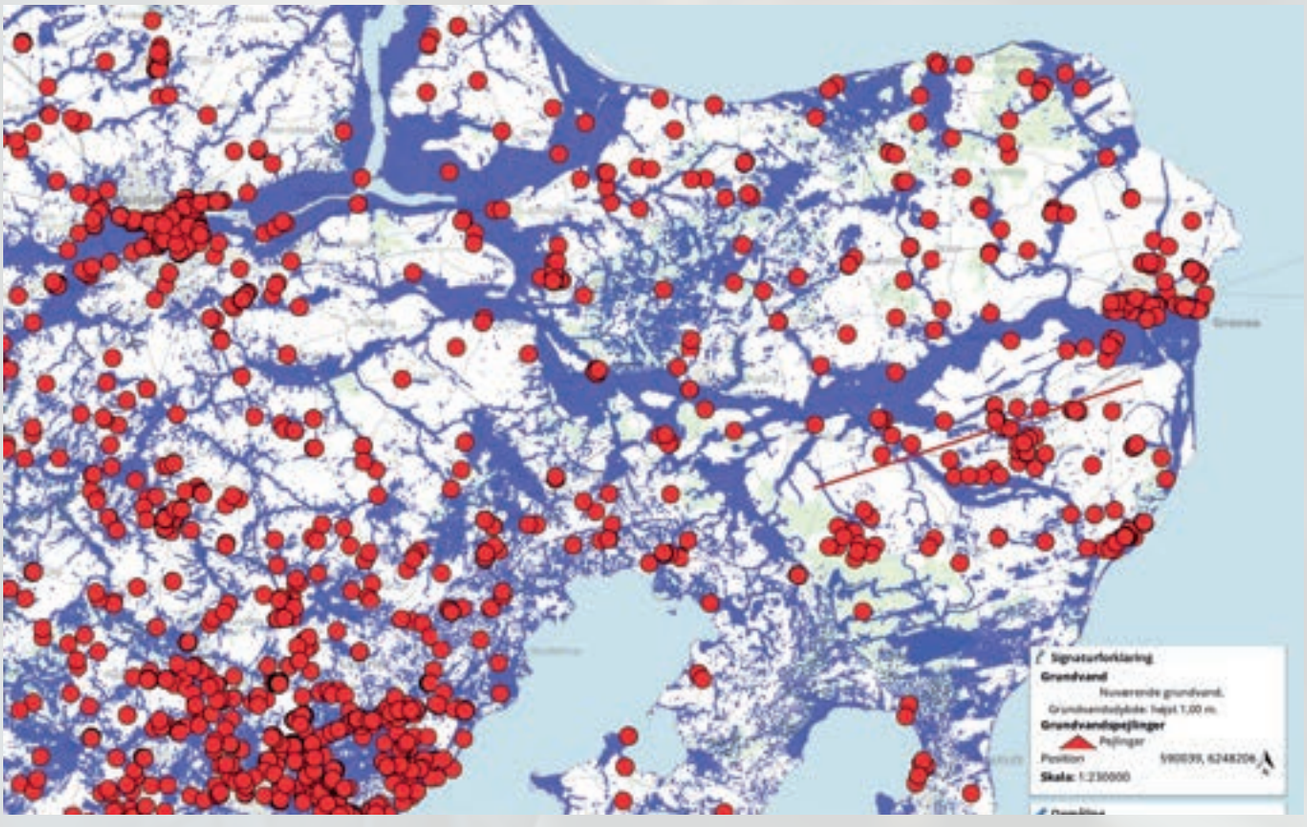
Using data from existing groundwater measurements, machine learning was used to inform computers on how to predict groundwater movements with a very high accuracy in areas where the groundwater level had not been measured previously.

The two projects were integrated into an already existing tool, SCALGO Live, developed by the Danish company SCALGO, specialized in algorithms, geometry, and data management. This provided access to a tool for screening of the risk of flooding for the entire groundwater flow. The tools were made available to all participants in the six-year C2C CC project.

CONTINUATION

The use of machine learning to predict the shallow groundwater level has also been used to develop the groundwater part of the Hydraulic Information and Prognosis System, made by the Agency for Data Supply and Infrastructure with contributions from Central Denmark Region.

As a result of the collaboration with the C2C CC project, the Danish company SCALGO has made a tool to manage the entire water flow to be incorporated in the work with climate adaptation. This may have a huge impact on local climate adaptation projects.



This project is a breakthrough in the development of computer-based tools to manage water. A tool to work with existing data on soil conditions, proximity of surface water, terrain etc. has been successfully developed. The tool can accurately predict the location of groundwater close to the terrain in a specific area. Together with a storm surge map, this tool has been integrated in the existing tool SCALGO Live.

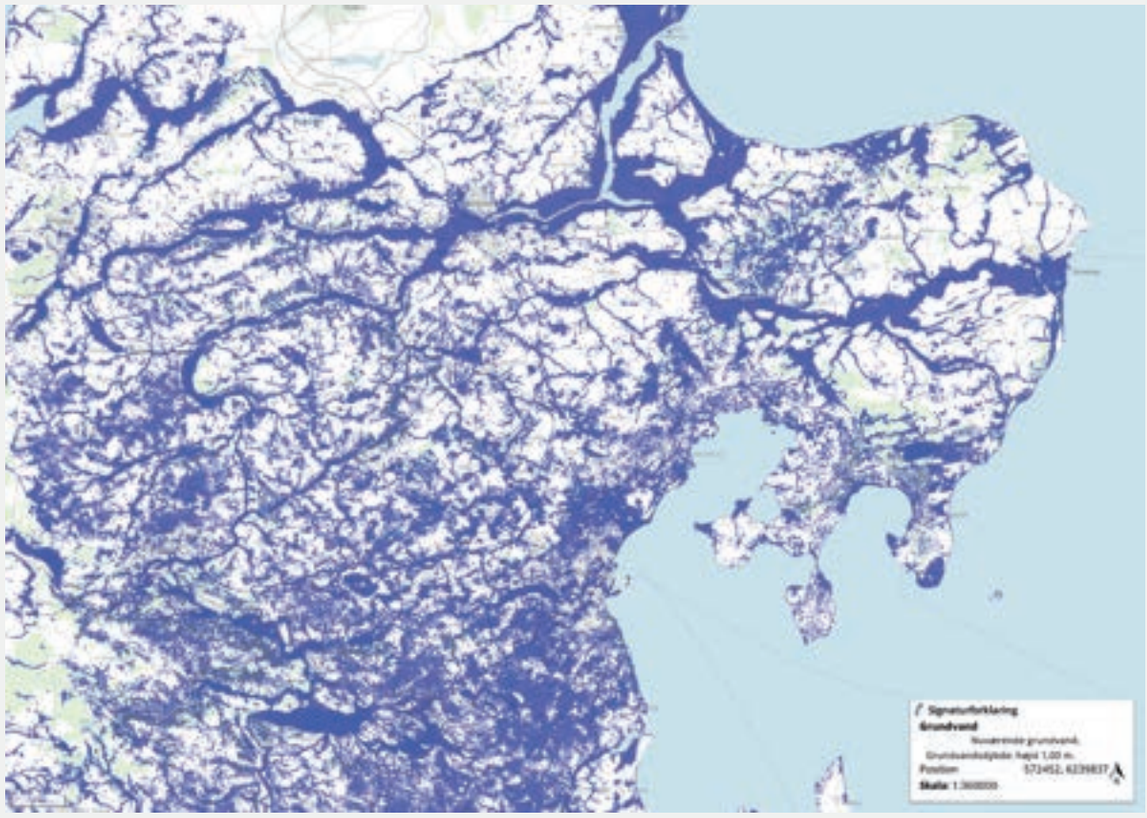
> ***"The development resulted in a tool able to map and predict groundwater movements ...***

RESULTS

Results from C6: Tools are applied in basically all local sub-projects in the overall C2C CC project. The tools developed provide basic knowledge important to almost all kinds of climate adaptation concerned with the management of rain.

RELATION TO OTHER C2C CC PROJECTS

The goal was to develop a tool available for everybody. Within the field of groundwater, there was a lack of data to investigate the possibilities, calculate and make predictions. The use of machine learning for this purpose became a shortcut to a very well-functioning and accurate tool.



The project covers the support for development of purely technical solutions to integrate climate adaptation in sustainable ways by using natural resources – the so-called ecosystem services. The tasks are broad and sometimes immeasurable but at the same time, they precisely reflect the climate adaptation challenges for society.

Ideas and inspiration from this project are applied in other C2C CC sub-projects and will also be used in the follow up project C2C CC AFTER Life.

The pivotal point has been to build a network as an informal platform for people within the water sector to meet and exchange experiences and knowledge. The purpose has been to promote innovative thinking within the area of water, with emphasis on sustainable and broad climate adaptation solutions while on a long-term basis strengthen the export markets for Danish water businesses.

Part of this work has been done in collaboration with other organisations such as the Danish Technological Institute, which has a broad network in the Danish business sector. Moreover, several companies working with water technology have obtained help from the Central Denmark EU Office with applications for funding of development projects, many of which have been a part of the C2C CC project.

Participation in various specific arrangements at the International Water Association conference has been one way of paving the way internationally for Danish water companies and their technology.

A more thorough and groundbreaking approach to climate adaptation has been introduced through the concept ecosystem services, which combines nature and biodiversity with nature protection. This approach has been used to integrate climate adaptation, especially in the open land, and create a sustainable way of managing the consequences of climate changes.

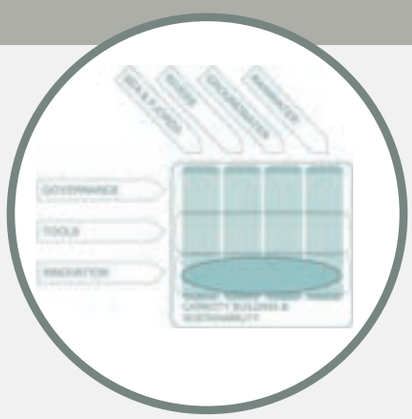
RESULTS

Many of the initiatives are used in two other C2C CC sub-projects: C20: AquaGlobe and C21: Climatorium, which both play an important role in the follow up project C2C CC AFTER Life.

The intentions behind working with ecosystem services have been used in two specific projects:

- ReDoCO2, involving mapping and assessment of peatland in agricultural fields with the aim of limiting CO_2 emissions by building a stronger knowledge base of the peat thickness
- BioScape, focusing on the concept of multifunctional land consolidation. Agricultural areas with potential to storeCO_2, protect areas for drinking water collection, delay water in the hinterland or create recreational areas are converted to more robust areas. BioScape is part of the C2C CC project C8: Håb to Håb Hedensted Municipality.

Managing the consequences of climate change is challenging and new knowledge and technologies are needed to meet these challenges. Hoever, this is only one side of the problem; the other side involves integrating climate adaptation into a well-functioning society and aligning it with the many stakeholders. This requires a holistic approach and a focus on synergies in climate adaptation initiatives. The ambition with this project is to create a foundation for the multifunctional development of climate adaptation and to integrate innovation and sustainability in the individual solutions.



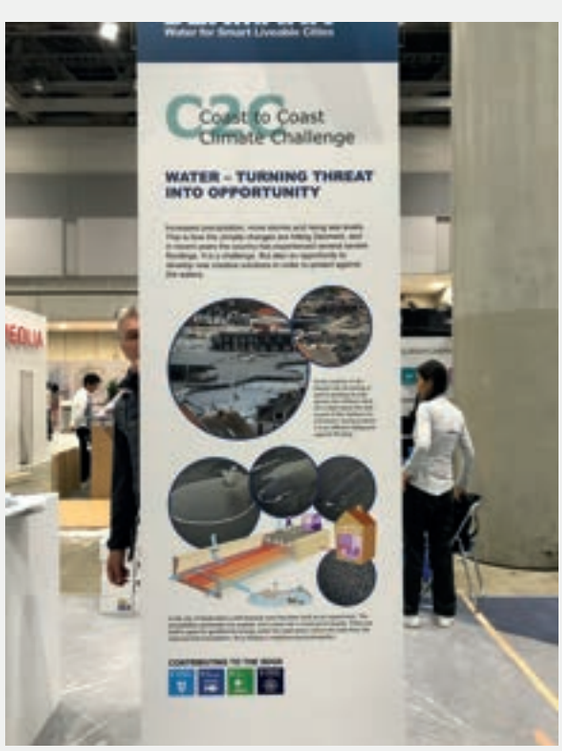
> ***"A more thorough and groundbreaking approach to climate adaptation has been introduced ...***

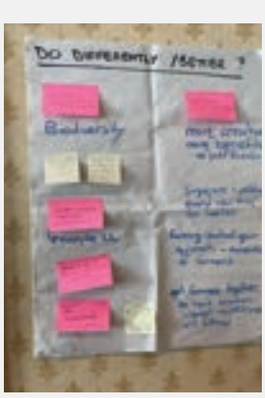
RELATION TO OTHER C2C CC PROJECTS

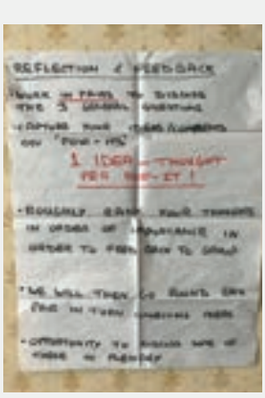
Due to political changes, this project has only had at limited role in connection with other projects. However, the foundation of this project has in many ways played a role in several solutions developed in the other projects.

CONTINUATION

In relation to climate adaptation and the C2C CC project, the various projects will continue to be part of the C21: Climatorium and C20: AquaGlobe projects.







The Håb to Håb project is conducted at the east coast of Jutland in an area with a mix of coastal and low-lying areas with several smaller streams running through.

If the sea level rises, the low-lying parts of the coastal area will be flooded. This will also fully or in part block the outlet of the streams to the sea, and thereby increase the risk of flooding in the area. At worst, the landscape will markedly change; a part of the current area may disappear completely, and the rest will develop into small islands and islets.

Along the shores, there are several holiday homes and low-lying areas are used for farming. The focus of the project has been to develop a long-lasting and sustainable climate solution for the area – a solution which will allow further local growth and development.

The project has gathered all stakeholders in the project: Citizens, politicians, the municipal administration, farmers etc. to find common ground for the future process.

An important point has been to understand climate change and its consequences in a historical perspective. Historically, conditions for human beings have constantly changed and the changes happening to this area could be seen as a ongoing example of this.

The starting point for the dialogue in the project has been three scenarios:

- To do nothing
- To open the area between the sea and streams and allow climate change to take its natural course
- To close the area with locks and dikes.

This project has particularly focused on including different groups in the development of the future initiatives for local climate adaptation as a result of the consequences of climate change. The result was a fourth and broader scenario for the future of the area, including elements such as alternative local energy supply, development of local outdoor tourism, promotion of biodiversity and development of the local villages.

> *"The project has gathered all stakeholders in the project ...*

RESULTS

Several mappings and reports of the area have been made:

- Mapping of values and risks of the Håb to Håb area
- Value analysis and priority of interests in Håb to Håb
- Landscape analysis of Håb to Håb

Moreover, folders on the sub-areas have been made to focus on local citizens.

RELATION TO OTHER C2C CC PROJECTS

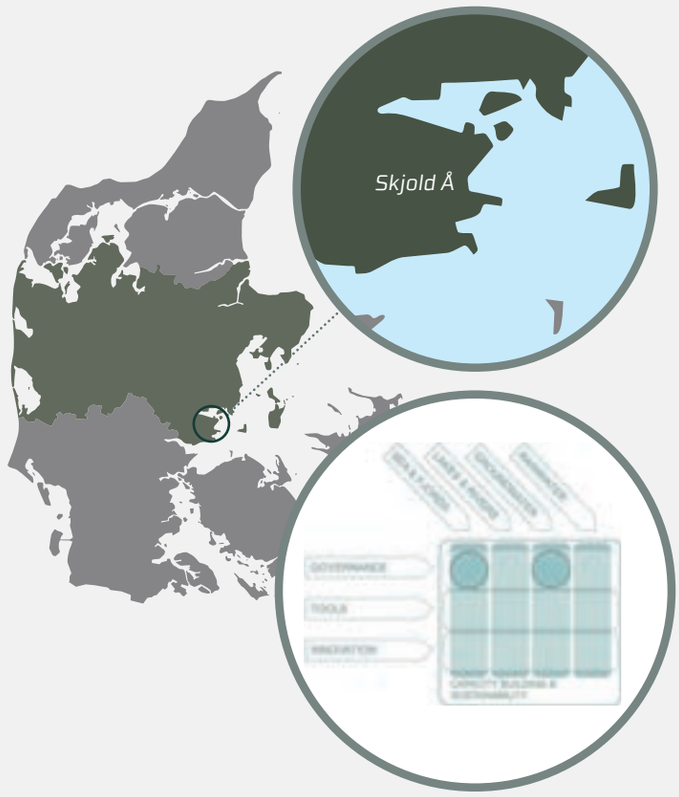
The project was completed together with another C2C CC project: C4: Climate history – cultural history, which has put local climate adaptation projects into a historical and cultural perspective.

CONTINUATION

The work is continued in the BioScape project supported by EU LIFE. This project will establish wet areas in parts of the area and the stream Skjold Å will be restored to its natural flow. These initiatives will retain water, delay the outflow of local streams, limit emission of nutrients and reduce the risk of flooding caused by the stream Skjold Å. Moreover, a pasture will be established for farmers in the area, which will promote biodiversity.

C8: HÅB TO HÅB – HEDENSTED MUNICIPALITY

Increasing sea levels combined with increasing amounts of rainfall constitutes a risk of partly flooding a local area at the coast of Eastern Jutland while transforming it from a land area to a low tide area with smaller islands and islets. The focus of the project is the future possibilities for the area that is to be developed in a close dialogue with local citizens and stakeholders; the work will continue in a new project, BioScape.



The western entry to the Limfjord, Thyborøn Channel, has a breath of only one kilometre. However, the channel opening poses a threat to the seven municipalities along the western part of the fjord. The ocean currents deepen the channel which allows for more water to enter. During a storm surge, the amount of water pressured into the fjord will result in flooding parts of the municipalities Struer, Holstebro, Skive, Vesthimmerland, Morsø, Thisted and Lemvig. The flooding will affect urban areas, holiday homes, landscapes and the vulnerable nature along the Limfjord.

The seven municipalities have established local contingency plans and protection against flooding. The consequences of climate change causes a more severe development of the channel and the current local plans will not be adequate in a long-term perspective.

This project focuses on a joint effort to protect the area by reducing the inflow into Thyborøn Channel without limiting the comprehensive ship traffic in the channel. The channel is the only western entry into the Limfjord and the harbour town Thyborøn. The harbour in Thyborøn is an emergency port when storms hit the North Sea.

Calculations and hydraulic modelling have shown that the inflow during a storm surge can be reduced by extending the two existing piers on both sides of the entry. Narrowing of the channel can limit flooding to the current level during storm surges for the next 40-50 years – and this level is manageable by local protection and contingency plans. Narrowing of the entry will thus give the necessary time to prepare for a more permanent solution.

The project is an example of a dilemma in climate adaptation. Increasing amounts of water in the Limfjord will gradually flood and destroy large parts of the vulnerable and unique nature; on the other hand, reducing the water flow in the Limfjord will deteriorate the aquatic environment in the fjord.

C9: THYBORØN AND THE WESTERN LIMFJORD

The sea gradually deepening Thyborøn Channel, the western entry to the Limfjord, and there has been events of extensive flooding along the fjord during previous storms. In the future, storms, and the consequently higher sea levels, will be more frequent due to climate change. This will increase the risk of more severe flooding. The project has analysed and described a possible solution but has also shed light on dilemmas in climate adaptation, as the process of climate proofing the area as well as potential flooding can affect the vulnerable nature in and along the fjord.

CONTINUATION

The seven municipalities and their utility companies cannot manage financing the extension of the two piers at the entry of Thyborøn Channel alone. Financing must be obtained from other sources, and this work continues.

RESULTS

A study performed by a consulting engineering company concluded that narrowing of the entry will maintain the current level of flooding for the next 40-50 years.

The study also showed that a stepwise narrowing of Thyborøn Channel may to some extent balance the dilemma between avoiding flooding on the one side, and on the other side ensuring the exchange of water in the Limfjord. The extended piers will reach one kilometre into the North Sea and provide new opportunities for recreational fishing and water sports.

RELATION TO OTHER C2C CC PROJECTS

The problems related to the western Limfjord are very specific and local. However, the approach to working with other values and initiatives as a part of climate adaptation such as nature, environmental protection and tourism is also a part of other C2C CC projects.

Project C10: Grenaa Stream and Hinterland combines all issues related to climate adaptation in one project:higher sea levels, increasing amounts of rain, outlet of the local stream into the sea and local management of rainwater. These challenges are to be dealt with in combination with multiple different stakeholder interests. In addition, the project area is on the border between two municipalities.

Grenaa Stream runs through Grenaa city flowing into the habour. The stream has an annual outlet of approximately 60 billion liters of water to the sea. This water flow from the hinterland, especially the dammed and cultivated area Kolindsund, which was the largest lake in Jutland 150 years ago.

The gradient of Grenaa Stream is very small and in case of high water levels in the sea caused by e.g., a storm, the sea water is pushed into the lower part of the stream blocking the outlet. Consequently, large parts of Grenaa city are flooded.

It is necessary to pump water away from the Kolindsund area to keep the fields dry. More rain will increase the amounts of water to be removed, and this is a challenge with future higher sea levels and more frequent storm surges. Moreover, there is a groundwater reservoir with sea water below the dammed area. The continued draining of the area will increase the risk of seawater seeping into local groundwater drillings.

The problem is complex. A tide gate will stop the sea from flowing into the stream in crisis situations but if the flow of water from the stream is blocked, it causes high risk of flooding. The interaction between increasing sea level and more rain weakens this solution. Studies show that the drainage of Kolindsund has changed the groundwater flow, and in combination with increasing amounts of rain, this rain causes a risk of high groundwater level in the area.

Multiple interests in the area are highly contradictory. The farmers with fields in the dammed area would like to continue their production. Other local citizens wish for the lake to be restored and in Grenaa, the citizens wish to be protected from possible flooding.

RESULTS

The project has focused on mapping the many challenges and creating a foundation for dialogue between the many local stakeholders. The challenges have been investigated and described in several reports and presented at citizen meetings, on websites and in local media.

It has not been possible to gather the many stakeholders around a joint initiative. The evaluation has concluded that the project should not have been presented as one overall project, but rather as minor projects to be managed locally.

The two municipalities sharing the project and the internal municipal departments have, however, developed a closer collaboration supporting the continuation of the project.

RELATION TO OTHER C2C CC PROJECTS

Project C8: Håb to Håb – Hedensted Municipality, C9: Thyborøn Channel and the Western Limfjord, C11: Randers Fjord, C14: Horsens City Centre and C18: Citizen-driven Climate Adaptation in Juelsminde all share similar problems. Moreover, knowledge from C2: Watercourses has been relevant to this project.

C10: GRENAA STREAM AND HINTERLAND

Complex climate challenges, diverse stakeholder interests and strongly opposing views and wishes for the future, constituted the starting point for project C10: Grenaa Stream and Hinterland. The damming and cultivation of an area that happened 150 years ago, which was once the largest lake in Jutland, constitute thecurrent climate threat to the habour and city Grenaa on the east coast.

CONTINUATION

Other projects have been developed to continue the work. Realdania has made a report showing that Grenaa is the second most exposed coastal city following Copenhagen which is number one. The report has been the starting point for a climate adaptation project in Grenaa related to water.

Limiting CO_2 is also a focus in the local climate adaptation work. The dammed area Kolindsund consists of soil emitting large amounts of CO_2. This emission can be limited if these areas are not used for farming.

Randers Fjord is approximately 30 km long and narrow, situated between Randers and Norddjurs municipalities. The fjord is one of 14 areas in Denmark at particular risk of flooding in case of storm surge and covered by the EU Floods Directive. The fjord is outlet for Denmark's longest river, Gudenå River. Every day, approximately 40,000 liters of water per second run into the fjord from Gudenå River, and in case of prolonged rain in the large hinterland, the amount of water is easily doubled.

The fjord is a risk area because storm and high tides in the sea can force large amounts of water into the fjord through the outlet into Kattegat. The water can pose a threat to the low-lying farming area and nature resorts, of which large parts are dammed, as well as the towns along the fjord.

Due to the risk status of the area, the two municipalities must take initiatives to prevent flooding and secure the area in a crisis – from new rules for housing development in the area to establishing of contingency plans.

The two municipalities are faced with an extremely complex task. There are many interests to protect, and the numerous initiatives must be aligned with the consequences of climate change.

The two municipalities have worked on a joint strategy to manage the demand for local risk management. This strategy must integrate climate adaptation considering nature, biodiversity and urban development along the fjord as well as how citizens use the areas and financing.

The project has been based on existing risk management plans and must ensure a joint and coordinated effort. Originally, the idea was to focus on a tide gate at the outlet of the fjord. This solution has been postponed, and currently the project works with different models for less comprehensive ways of securing and adapting the area.

RESULTS

A common understanding has been reached between the two municipalities on the need to secure the area along the fjord and for the benefit of a strategy for the future work.

Coordination with the climate adaptation project for Randers city has been a significant part of creating an overall, long-term plan for the entire area.

Moreover, this process shows how broad projects develop over time. Experience has shown that such a project should not be planned in detail, and it must be possible to make changes along the way.

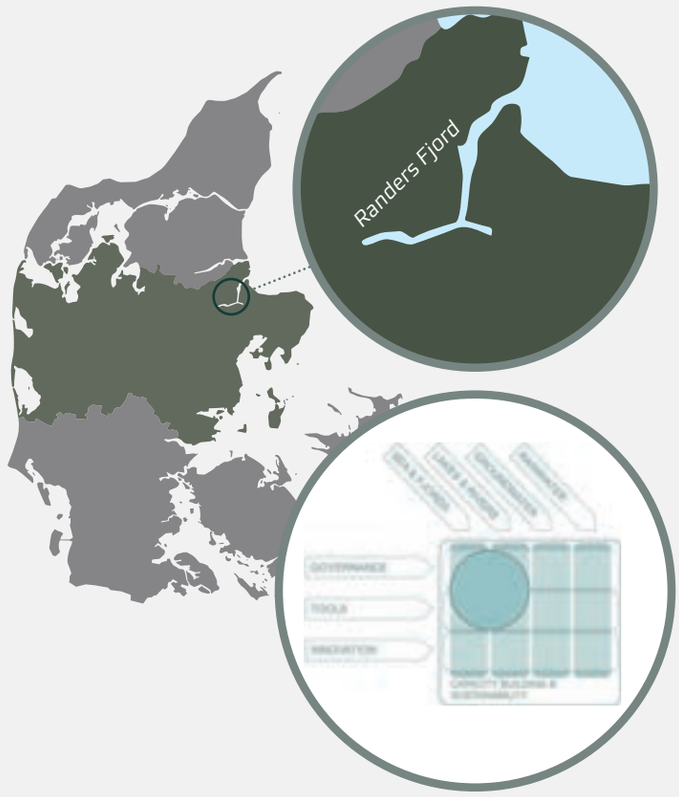
RELATION TO OTHER C2C CC PROJECTS

The project around Randers Fjord involves another C2C CC project C16: The Climate Ribbon, focused on climate adaptation of Randers city.

The climate-related problems represented by the projects involving the fjord and Randers are also known in other parts of Denmark. The C2C CC project C14: Horsens City Centre focuses on a similar problem.

C11: RANDERS FJORD

Two municipalities share the responsibility for the long and narrow Randers Fjord, which is a flood risk area designated by the EU Floods Directive. This project focuses on making it possible to develop a joint municipal plan for risk management of the fjord and a strategy for implementation of the plans.



> ***"The project ... must ensure a joint and coordinated effort.***

CONTINUATION

The project will be terminated by the two municipalities and the results will be included in municipal planning and risk management of both urban and other areas along Randers Fjord.

Gudenå River is the longest river in Denmark. From the outlet in Randers Fjord, Gudenå River flows through seven municipalities, 11 Natura 2000 nature reserves, several towns and large farming areas. The river drains a hinterland the size of Funen and in recent years the river has frequently overflowed its banks. Earlier this happened most often during the winter, but now it happens in the summertime as well.

Any river will sometimes overflow its banks – it is a part of its natural dynamic. But in recent years, the flooding has become more intense and more frequent, which is the result of natural and man-made interactions.

- The amount of water in Gudenå River has increased by 10% during the last 100 years. Historically, it rains more and more in Denmark, and in recent years there has been severe storm surges and periods with prolonged rain, especially in the autumn and winter
- Invasive clams are spreading in the river, draining the river for algae and filtering the water. This improves the growth conditions for aquatic plants and their intense growth blocks the flow of water
- Several small and larger towns are situated along the river with houses often close to the water. These areas are exposed and are easily flooded when the water level rises
- Drainage of areas along the river has caused soil to settle up to 2 meter, leading these areas to flood very easily.

The problems along the river are easily recognised but hard to solve. There are many stakeholders and flooding along Gudenå River cannot be solved fast and easy. The primary focus has been to create a foundation for succeeding projects to solve the many challenges posed by the river and the water.

Gudenå River and its hinterland has been studied as one coherent water system during the work with climate adaptation, because changes in one location have consequences along the entire stretch of the river. This

approach is necessary to create a balance between the many stakeholders and combine the necessary adaptation with the protection of the many local values.

A comprehensive mapping of stakeholder interests has been made. The citizens have been involved and several suggestions for solutions have been presented and discussed to create a broader understanding of the complexity in management of the water in Gudenå River.

A water flow model has been developed, which can calculate different scenarios as well as a prognostic model, which can predict the water level three days ahead and thus warn about flooding.

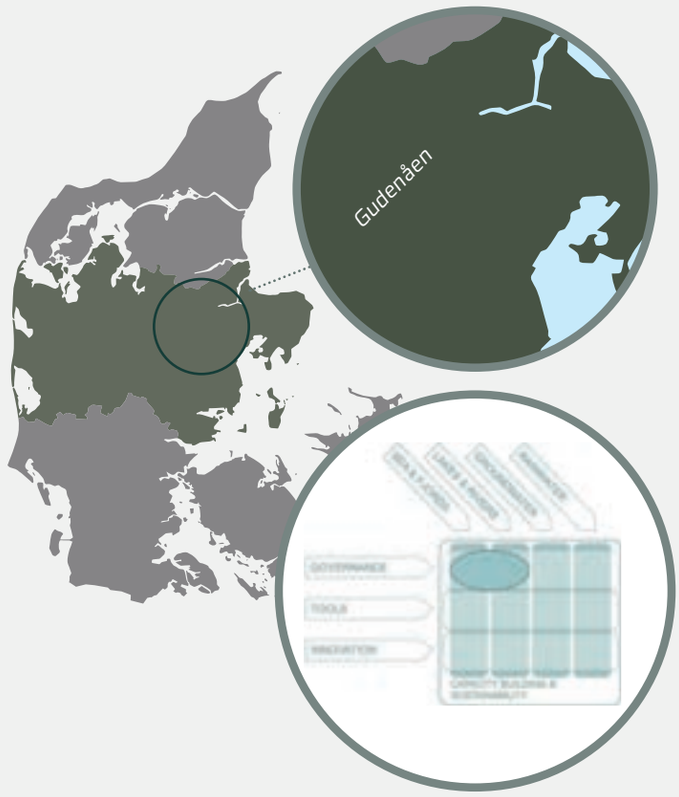
RELATION TO OTHER C2C CC PROJECTS

It is a major challenge to gather many stakeholders around a complex problem such as climate adaptation. Success depends on the ability to create a balance between a common understanding and foundation for the work, while considering local and specific conditions and necessary initiatives.

This very complex problem is also seen in other C2C CC projects and generally in the implementation of climate adaptation projects. The project has drawn on knowledge from the C2C CC projects C2: Streams, C3: Groundwater and C6: Tools.

C12: GUDENÅ RIVER

Denmark's longest river, Gudenå River, is 160 km long. The primary focus of the project has been to understand the dynamics of the river, develop suggestions for initiatives and ways to manage the water and moreover to involve the many stakeholders along the stretch of the river to find out how they see the problems caused by the river. The challenges around the Gudenå River are complex. On one side, there is the increasing amount of water and frequent flooding. On the other side, the river flows through seven municipalities and 11 nature reserves, several towns and large farming areas.



RESULTS

The project has contributed to qualify and clarify the further work with an overall plan for the entire Gudenå River water system. It has generated general knowledge on how to work with complex transitions and development projects in an area with multiple and different stakeholders.

Moreover, the project has strengthened the work in the Gudenå River committee, which advise the seven municipalities along the river on nature and environment protection as well as recreational use of the Gudenå River water system.

CONTINUATION

Knowledge and experiences from project C12: Gudenå River are continued in a joint working group established by the seven municipalities along the river. The task of the working group is to make an overall plan for water management along Gudenå River. This was approved by the seven municipalities in the beginning of 2022.

The municipalities along Gudenå River have agreed on a pilot project on an overall plan for flooding of the hinterland. This is a part of the preparatory work for the government's future national climate adaptation plan.

Storå River runs through central and western parts of Jutland and flows into Nissum Fjord close to the North Sea. The river is 100 km long and runs through Holstebro where it has flooded parts of the town several times.

One of the reasons for the floodings is found in the hinterland of the river. Storå River runs through major farming areas where comprehensive areas have been dammed and smaller streams have been straightened and made deeper to direct the water away from the fields and into Storå River. Especially in the winter periods with heavy rain, the result is large amounts of water flowing into the river.

Several initiatives are intended to stop the water in the open landscape and hold back parts of the large amounts of water before the river runs through Holstebro. Among the initiatives proposed are water storage with controlled flooding of selected areas, less drainage of fields and the establishment of wetlands, which can be flooded when needed.

These initiatives will benefit nature. Wetlands and periodic flooded areas will improve conditions for animals and plants. Today, drainage water washes a substantial amount of ochre and nutrients into Storå River. This can be limited by retaining the water, and in this way reduce the strain on the nature reserve Nissum Fjord where the river flows out.

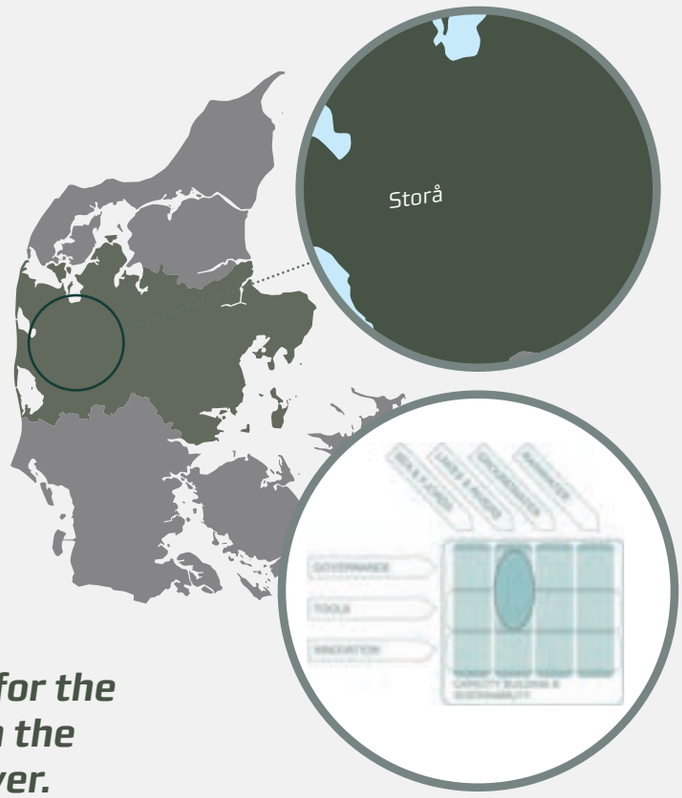
The project has several challenges: Storå River runs across three municipalities which must all participate in the work. The farmers across the river must accept that use of the land may be limited. Water can be retained partly in nature reserve areas and must be managed carefully.

RELATION TO OTHER C2C CC PROJECTS

The project concerns the same problems as in C12: Gudenå River. Knowledge from C2: Streams and C6: Tools has been used for this project.

C13: STORÅ RIVER

One of Denmark's large rivers, Storå, runs through the city centre of Holstebro in the western part of Jutland. The river has repeatedly flooded parts of Holstebro, typically in the winter period when the water level in the river is high. The project will eliminate the risk of flooding, improve biodiversity along the river and protect the nature reserve at the outlet of Storå River.



> ***"One of the reasons for the floodings is found in the hinterland of the river.***

RESULTS

Originally, the different initiatives to slow down and store the water were expected to minimize the risk of flooding of Holstebro. Calculations have shown that these initiatives were not enough. More comprehensive solutions must be found if Holstebro is to be protected from flooding in the future. One possibility currently pursued is the establishment of a dam to control the water level in Storå River east of Holstebro.

CONTINUATION

The work is continued in a joint committee with representatives from the three municipalities, from the farmers in the area and local green organisations.

The three municipalities are part of a pilot project supported by the Danish Environmental Protection Agency on overall planning of flood protection in the hinterland near a stream. This project will be part of a future national plan of action in climate adaptation.

Horsens is placed at the bottom of Horsens Fjord at the outlet of two large streams. The consequences of climate change result in a potential threat of flooding – a threat which many urban areas in Denmark face and must adapt to both on a short- and long-term basis.

Historically, the combination of stream outlets and the fjord has been an easily accessible natural harbour, and the flat area around the outlet has been easy to use for construction. Over time, the harbour and large parts of the city have been built on filled land at the bottom of the fjord and today, a large part of the city centre is lower than 1.5 m than the daily water level in the fjord. The situation is further complicated by the limited gradient of the streams at the last stretch before they flow into the fjord. When the water level is high in the fjord, water is pressed into the streams and the water rises and obstructs the flow of water running from the streams and rainwater from the city going into the fjord.

Increasing amounts of rain will cause the water in the streams to rise and the higher water level in the fjord will limit the outlet of the streams. During storms, water is pressured into the fjord and rain increases the amount of water in the streams, which may quickly cause flooding of both the harbour and the city.

The low-lying parts of the city and harbour have been flooded several times, and Horsens Municipality considers this a risk area with the highest priority being to protect the area from flooding. A combined road and dam across the fjord with a high tide gate will protect the city from flooding caused by the fjord. Along the streams in the hinterland, several water catchment areas are made to make space for the rain from the city at the last stretch of the streams. Finally, a pumping system will redirect water from the streams and rainwater into the fjord when the natural course of the streams are closed; hence, flooding of the city centre can be kept below the critical level.

Horsens is undergoing a major transformation. Industries have been relocated or closed and the harbour no longer plays the same role as before. Instead, new housing is constructed, and space has been made for other types of businesses at the former industrial sites and the harbour. Climate adaptation is an integrated part of the city development to make the city attractive, vibrant and climate-robust by combining urban development, climate adaptation and development of infrastructure.

RELATION TO OTHER C2C CC PROJECTS

C14 Horsens City is an example of the overall challenge in Project C1: Sea and Fjord. The projects C16: Climate ribbon and C11: The Gudenå outlet focus on similar issues.

> ***"Climate adaptation is an integrated part of the city development ..."***

C14: HORSENS CITY

This project illustrates a key problem in climate adaptation in Denmark – a low-lying city situated where the fjord meets the outlet from one or more streams. This causes a potential threat of flooding from both the fjord and streams; this threat will only grow due to climate changes. The primary focus of the project has been to plan and implement the necessary long-term climate adaptation initiatives in a growing city, which is transforming from an industrial city to a knowledge-based city.

RESULTS

The focus of the project has been to create a foundation for integrating climate adaptation in the overall urban planning. The project results are used as a reference framework for recommendations and demands to municipal plans, projects and to private stakeholders.

To integrate the long-term protection from flooding with the management of rain and a need to renew the city's sewerage system, the local utility company, Samm Utility Company, has played a major role in the project.

CONTINUATION

As a result of the project, a joint steering committee between the local Samm Utility Company and Horsens Municipality has been established. The steering group coordinates municipal activities in connection with participation in the C2C CC project.

The work is continued in a municipal partnership group in connection with the DK2020 climate action plan. This plan is initiated by the DK2020 network run by Realdania. The network focuses on promoting climate adaptation in Danish municipalities.

The primary draining of the two towns in Hedensted Municipality, Tørring and Hedensted/Løsning, is a stream. With the longest river in Denmark, Gudenå River, running through Tørring and Gesager Stream running through Hedensted.

Gudenå River drains a very large hinterland and the gradient of Gesager Stream drops slightly around Hedensted. Already today, it is difficult to manage local amounts of water in connection with storm surge, heavy or prolonged rain. More rain is expected in the future, and the risk of periodic flooding in and around the two towns is high.

The municipality works with several solutions to delay and store the water temporarily both in the hinterland and in the two affected towns.

The municipality has involved the citizens in the water management in the two towns – partly by mapping former flooding episodes and partly by suggesting where and how to retain the water locally. There has also been focus on using the water e.g., by integrating it as a recreative element.

To make collaboration with citizens as close and concrete as possible, focus has been on minor areas along the water and on the citizens in those areas who are directly affected. Citizen meetings have been organised, local projects have been presented and the future movements and amounts of water have been visualised. This has sharpened the interest and local citizens have made several concrete suggestions on how to manage the water in the future.

RESULTS

The project has shown that by maintaining a strong local perspective, it has been possible to involve citizens and create a local understanding of the complexity that makes it impossible to meet all wishes and needs.

Use of computer programmes to visualise water flow and flooding have proven suitable to create a broader understanding among citizens of the challenges faced by the increasing amounts of water.

The project has provided the municipality with experiences on how to involve citizens and how to organise this to arrive at a good result.

RELATION TO OTHER C2C CC PROJECTS

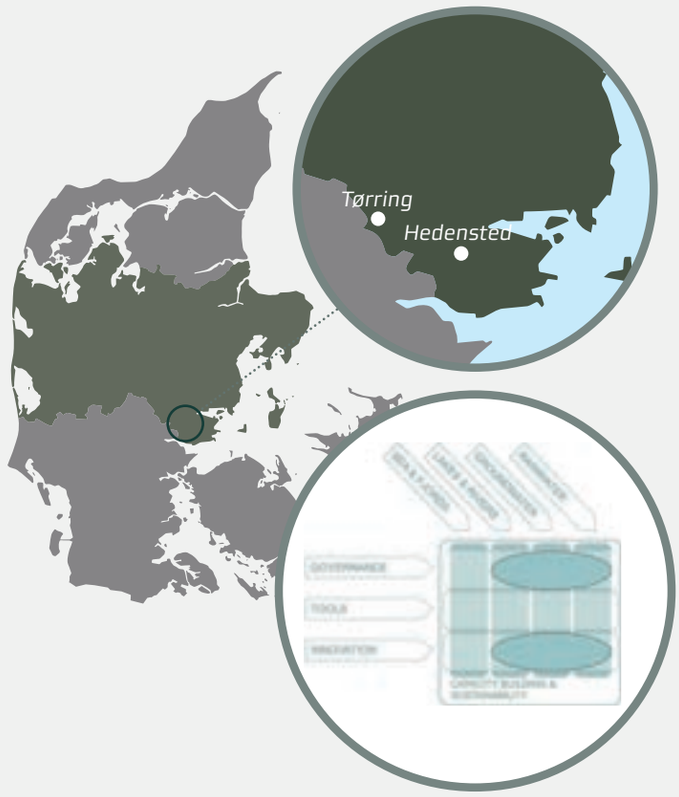
This project builds on knowledge from the projects C2: Streams, C3: Groundwater and C4: Rainwater. The project has provided knowledge for C5: Governance and knowledge and experiences have been exchanged with project C12: Gudenå River.

CONTINUATION

The municipality continues working with two concrete suggestions for climate adaptation in the two towns to clarify if they can be carried out and if they will have the desired effect.

C15: CLIMATE ADAPTATION IN HEDENSTED AND TØRRING

Establishment of initiatives such as water storage and contingency plans to prevent local flooding of urban areas requires close interaction with citizens – both in the planning phase where focus is on pointing out critical locations and in the development of possible solutions. This project has succeeded in maintaining a focus where citizens have been involved locally in the management of the challenges they are faced with.



> ***"The municipality has involved the citizens in the water management in the two towns ...***

On the coast of East Jutland, Randers Fjord flows into the Kattegat. Randers is the sixth largest city in Denmark and placed at the bottom of the 30 km long Randers Fjord. The longest river in Denmark, Gudenå River, starts here, and this constitutes a threat to the consequences of climate change. Randers Fjord is officially pointed out as a flood risk area.

Already today, flooding is not unknown to Randers and a six km corridor is being developed, which is central to protect the city from flooding.

The ambition is to integrate the necessary adaptation to climate change in the overall development plan for the city, which is currently undergoing a major transition. The habour is gradually relocated further down Randers Fjord making room for urban planning at the low-lying habour area close to the city centre.

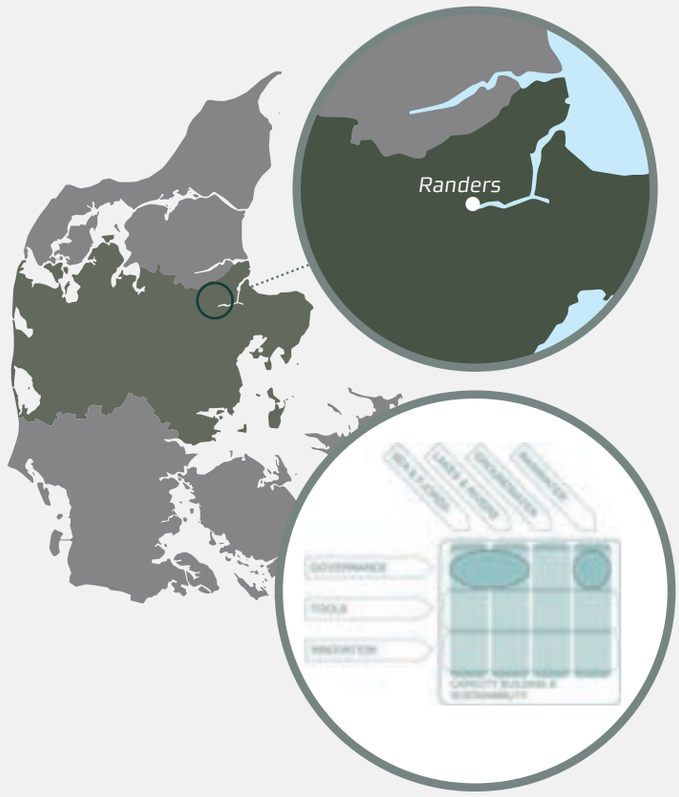
The urban development project Flodbyen Randers aims to integrate water and nature in the further development of Randers. Housing, offices and smaller companies will make up the former harbour area and the water will no longer constitute a threat but be an asset to the city. The goal is to combine the city and the water and create space for nature, biodiversity and recreational areas as an integrated part of the future city.

The project has been inspired by similar international projects. The focus has been to find new, innovative solutions without constructing a barrier for the water but instead bring the city and the water closer together. Several challenges related to climate adaptation have been discussed with stakeholders, politicians and others. This has resulted in different solutions with the aim to bring the city closer to the water and nature, though still ensuring that the city is protected from future flooding.

Throughout the project, involvement of citizens and users has been prioritised. Schools and educational institutions in Randers have been involved and the dialogues between the many stakeholders has been facilitated by the municipality through a project exhibition area and several both digital and physical ways of involving the different target groups. Among these an app was made for the design of different solutions along with electronic voting, debate on social media and educational offers have been launched.

C16: THE CLIMATE RIBBON

Situated at the junction of one of Denmark's largest rivers and one of the longest fjords, ultimately all expected consequences of climate change constitute a threat to the city of Randers. The purpose of the Climate Ribbon is to make climate adaption in close connection to the city centre, as an integrated part of the overall spatial development of the city to create space for the city, water and nature.



RESULTS

Generally, flood protection and climate adaptation initiatives have been made concrete and present by focusing on simple and robust solutions, including promotion of nature and biodiversity.

The work has created considerable knowledge of specific initiatives, which have been implemented in the development plan for Flodbyen Randers. This plan will guide the development of the areas along the water for the next decades and ensure integration of flood protection in the future urban development plans.

Thyborøn in the north-western corner of Denmark is located in a complex interaction of climate challenges. Thyborøn is situated at the tip of an isthmus, Harboøre Tange, and surrounded by water on three sides: the North Sea, the Limfjord with the Thyborøn Channel and large salt and brackish lagoons on the isthmus.

Actually, the town is surrounded by water on four sides. The groundwater level is high, and the soil is wet. When it rains, the wet underground prevents water from seeping into the soil. To manage the water, it is collected and pumped away in a separate piping system draining approximately 1 million m3 of water annually.

The underground of the town is unstable and parts of the town are built on drained water-filled areas. At some places, the underground subsidence is up to 1 cm annually and the subsidence challenges underground piping systems for wastewater, rain and water supply.

Movements cause the piping system to shift and even break down, and continuous maintenance is necessary to maintain the systems. If the piping system for draining of rainwater is not in place, the water will not flow to the pumps. If the piping system for the wastewater system is leaking, the high-level groundwater flows into the system and the extra amount of water causes an unnecessary strain on the wastewater treatment plant.

Being situated at an isthmus exposes Thyborøn to storm surges. Dikes are placed around the town, but a small stretch from the harbour area in the north-eastern corner of the town is still unprotected and constitutes a potential threat.

The consequences of climate change, such as more rain and more frequent storms and storm surges, is expected to worsen the current situation in Thyborøn. Already today, the seawater is pushed under the beach causing the groundwater to be pushed further up towards the surface. The future perspective with more storms, higher sea levels and more rain will expose the town even more.

This project has developed specific solutions to manage rain, the high groundwater level and the exposed piping systems. The climate-related challenges are part of an ongoing process to develop more comprehensive and overall solutions to the challenges in Thyborøn.

RELATION TO OTHER C2C CC PROJECTS

This project has drawn on knowledge from C1: Sea and Fjord, C3: Groundwater, C4: Rainwater, C9: Thyborøn Channel and the Western Limfjord and C6: Tools.

Moreover, the project has provided knowledge and experiences for several local projects in C2C CC.

RESULTS

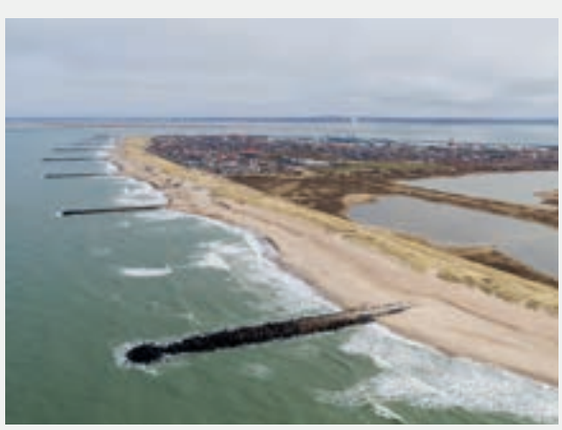
Throughout the project period, a groundbreaking method has been developed to map the underground movements of Thyborøn, which can be followed and measured by satellite. This enables easier and cheaper maintenance of the piping system. Rain- and groundwater are monitored by a hydro-dynamic, interactive tool, 3DI, which can be used to manage the overall water cycle.

Using satellite monitoring and measuring support, it is estimated that the rainwater system can manage rain and groundwater for the next 25 years, which offers time to find other and hopefully more permanent solutions.

Protection of the last part of Thyborøn from future storm surges is a part of the future strategic plan. The plan is connected to Project C9: Thyborøn Channel and the Western Limfjord, to narrow the entry into the Limfjord. If the project is completed, Thyborøn will be protected for the next 40 years.

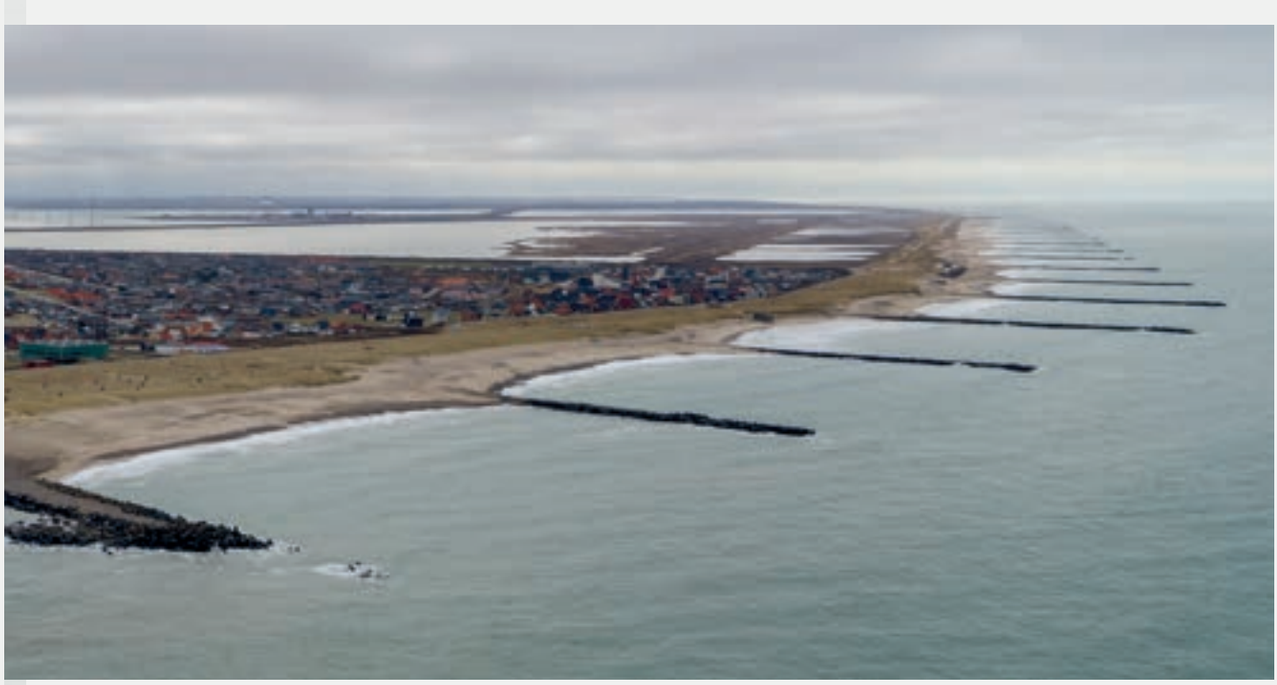
C17: THYBORØN TOWN AND HARBOUR

In the north-western corner of Denmark, Thyborøn is facing a complex climate challenge due to the interaction between high groundwater, subsidence, rising sea level, more rain and an increasing number of severe storm surges. These challenges cannot be solved once and for all but must be alleviated and managed through several different initiatives.



CONTINUATION

In 2021, Lemvig Municipality, where Thyborøn is situated, approved a climate action plan in the network DK2020 run by Realdania. The municipality will work with reducing CO_2 emission and further climate adaptation initiatives. The results of this work will also be a part of the ongoing work of adapting to future challenges in Thyborøn.



Is it possible to move a local climate adaptation project away from municipal planning and instead leave it in the hands of the very citizens who will be faced with the consequences of sea level rise? And can this be done at a time when only the problem has been introduced and there is not yet any specific plans for a solution?

The answer is yes – and with huge success. Hedensted Municipality has handed over all decision making on climate adaptation to the local citizens. Alternatively, the municipality initiated a process of providing information about the local climate challenges and only helped the group of citizens to stay on track during the process. Hence, the municipality left it to the local citizens to make all decisions.

Juelsminde is a low-lying town surrounded by sea. A water level of just 1.8 m above normal will flood parts of the town. The town is very exposed in the event of a storm surge, but the permanently increasing sea water level will also cause the water level to be higher around the town. This will erode the coast and the sea water will press groundwater in and around the town towards the surface.

The process leading up to a finished proposal for climate adaptation in Juelsminde was an open process with many different arrangements. Problems and solutions were discussed at citizen meetings, in panel debates and hiking in the nature illustrated the various problems. At a workshop, different specific solutions to the problems were outlined combining the overall architecture, functionality and landscape. The citizens were invited to debate the solutions.

The result was backed by all stakeholders – citizens, holiday home owners, farmers and businesses. This formed the foundation for the future work to find a solution to protect Juelsminde from flooding.

"Hedensted Municipality has handed over all decision making on climate adaptation to the local citizens.

C18: CITIZEN-DRIVEN CLIMATE ADAPTATION IN JUELSMINDE

The municipal authorities in Juelsminde engaged the local citizens to drive the process of developing a climate adaptation project while only supporting the process from the side lines. The result was a solid citizen commitment and a solution which enjoyed extensive local support.

CONTINUATION

The further work has led to a new local project, Citizen-driven tide water protection financed by Realdania, a business association with the purpose of creating quality of life through the built environment, as well as the Danish Coastal Authority, the Ministry of Environment and the Ministry of Food, Agriculture and Fisheries.

RELATION TO OTHER C2C CC PROJECTS

The climate challenges in this project are covered in the projects C1: Sea and Fjord and C3: Groundwater. Knowledge and experiences have been exchanged with the projects C8: Hope to Hope, in the same local area, C9: Thyborøn and the Western Part of Limfjorden, C11: Randers Fjord, C14: Horsens City Centre and C17: Thyborøn Town and Habour.

RESULTS

A common understanding of the climate challenges facing Juelsminde was achieved and the citizens are engaged in the flood protection of Juelminde now and in the future.

A concrete result of the citizen-driven effort and commitment was the establishment of a local dike association, which will head the future work with adaptation to climate change.

The project led to the establishment of a cross-disciplinary team in the municipality consisting of the departments that focus on Juelsminde. This idea has now spread to other towns in the municipality.

The project has three focus points: Water storage along a stream in the case of storm surge. Restoring another stream and its outlet into a fjord as well as restoring nature. Preparing for drought by collecting water.

The climate adaptation project consists of three sub-projects to be implemented to protect from future flooding and strengthen the environment, biodiversity, recreation and tourism at the island of Samsø.

In the middle of Samsø, the harbour town Ballen is a low-lying area and in the case of a storm surge, the local stream flowing into Ballen harbour can be pushed back and flood low-lying areas of the island. This can be avoided by establishing water storage along the stream where the water can be collected temporarily during a storm surge or when the sea water level is high around Samsø.

In the north-east corner of the island, the stream Sørenden has been converted to a discharge passage, which today drains a moor and several dammed areas. The original outlet of the stream running into a low water fjord has been blocked and the water is pumped into the sea.

The dammed area is partly or fully converted to wetland as a possible original nature restoring project, which makes it possible to reopen the original outlet into the fjord. Possibilities are explored for collecting water to irrigate the island golf course in periods with drought.

The sub-projects are made in close collaboration between Samsø waste water company, the municipal administration as well as citizens and civic associations.

RELATION TO OTHER C2C CC PROJECTS

Knowledge and tools used for the Samsø project originate from the overall projects in C2C CC with focus on various challenges related to rain, streams and water management.

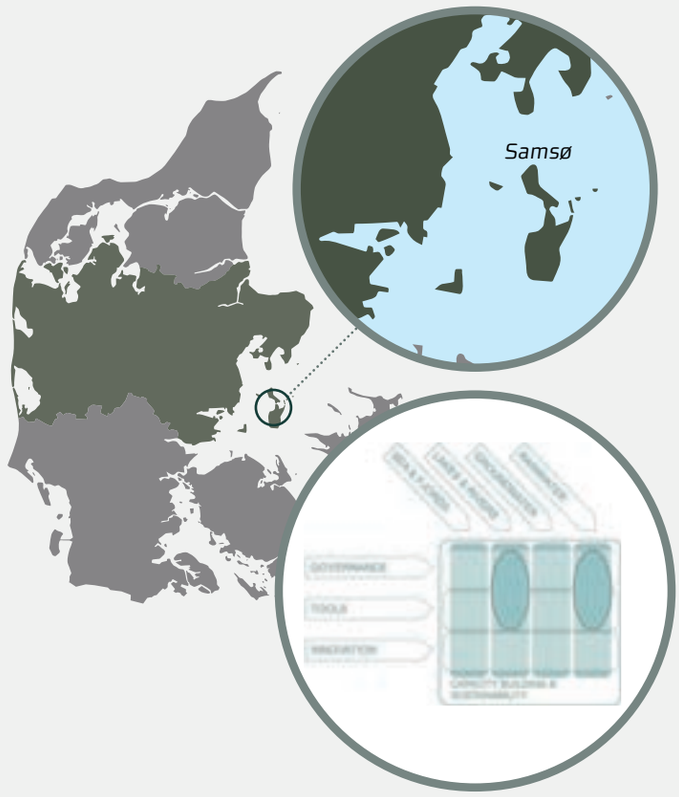
Project C2: Streams, C3: Groundwater, C4: Rainwater and C6: Tools.

CONTINUATION

Samsø works with obtaining funding for the different projects possibly in collaboration with one of the large Danish funds which supports the restoring of nature.

19: SUSTAINABLE URBAN DRAINAGE SYSTEMS USED AS RECREATIONAL ELEMENTS

Increasing amounts of water is an ongoing problem in most climate adaptation projects. Drought is another possible consequence of climate change. In this project, rain and surface water is retained in the hinterland in a local stream used for irrigation of one of three focus points. The other two focus points are local flood protection from another stream and restoration of nature and biodiversity locally, which has a tourist and recreational potential.



RESULTS

In all phases of the project, focus has been on involving and engaging the local communities at Samsø to create a stronger interest in and understanding of the challenges when working with local climate adaptation in a smaller island community.

The project has successfully obtained high citizen involvement and the local politicians have also become focused on promoting climate adaptation locally.

AquaGlobe is one of two centres for technical development, communication and knowledge-sharing related to climate adaptation and climate challenges in the C2C CC project. Situated in the middle of eastern Jutland in the ice age landscape with lakes and streams and with close relations to Skanderborg Utility Company, AquaGlobe is the natural centre for problems related to freshwater, climate adaptation as well as water supply and water technology.

The development work in AquaGlobe is performed in close interaction with Skanderborg Utility Company on one side and companies, knowledge institutions and other stakeholders in water and climate adaptation on the other. Specific problems are formulated as development projects by the utility company to the stakeholders and the solutions are subsequently implemented and tested.

The development environment benefits both water management in Skanderborg Municipality and the many stakeholders and their constant development of knowledge, technology and technical solutions. AquaGlobe is thus a key stakeholder to gather companies and others and to obtain insights into the work and challenges of the utility company and in this way qualify the services offered at both Danish and export markets.

Within the AquaGlobe framework, water technology companies can construct pilot projects to test different technical solutions in collaboration with the water company and demonstrate these solutions to potential customers and other stakeholders. The centre also facilitates workshops, company visits, network, and dialogue with stakeholders on current solutions and future challenges in water management.

The AquaGlobe model is relevant for the many small and medium-sized companies working with water solutions in Denmark. AquaGlobe will give companies access to networks of knowledge working on different challenges and not least potential collaborators.

CONTINUATION

Current activities will continue and be further expanded in the coming years. Moreover, AquaGlobe in collaboration with project C21: Climatorium and Central Denmark Region will carry on the results from the overall C2C CC project in the follow-up project C2C CC After LIFE.

RELATION TO OTHER C2C CC PROJECTS

Throughout the C2C CC project, AquaGlobe has been the focal point for many of the other projects as well as the host of seminars and conferences on different relevant topics related to climate adaptation and water management.

C20: AQUAGLOBE

Skanderborg Utility Company manages wastewater, climate adaptation and drinking water initiatives in Skanderborg Municipality. The company has established AquaGlobe, which is both a development platform and a knowledge and communication centre for climate adaptation and water technology solutions.

RESULTS

Skanderborg Utility Company has developed several products, sub-projects and initiatives for knowledge-sharing within the AquaGlobe framework, based on the collaboration model of the centre.

One of the notable projects has been Safe Lakeside Bath II, monitoring the water quality in the popular lake Knuds Sø. The goal is to develop a technology with surveillance in real-time. Thus, warning can be made when the threshold value for alga and bacteria is exceeded.

In 2021, AquaGlobe collaborated with Skanderborg Municipality to initiate teaching modules of all teachers of natural science in climate and sustainability to make climate adaptation and sustainability a more active and practical part of teaching of primary and lower secondary schoolchildren. AquaGlobe contributes with knowledge and resources, and the initiative may become a standard offer in the future.

The Climatorium is one of two centres for knowledge-sharing concerning climate adaptation and climate challenges in the overall six-year C2C CC project. The main focus area for the Climatorium is climate challenges related to the coast and sea. The centre is physically located in Lemvig where these challenges are obvious. Climatorium is strongly linked to the two local C2C CC projects, C9 and C17, and the Danish Coastal Authorities that are also situated in Lemvig.

The Climatorium concept has been developed in connection with the C2C CC project. Initially, several analyses were completed to understand the wishes and interests of potential target groups. Moreover, tender documents and foundations for financing have been made.

The new building at the harbour in Lemvig is used for exhibitions on current projects and has facilities for conferences and meetings while also offering employment. The building hosts the annual two-day national climate summit, where current climate-related issues are in focus. The summit is followed by an event for schoolchildren – the children's climate summit.

The Climatorium communicates knowledge and results from the C2C CC projects and is intended to be a future climate communication centre.Therefore, the centre is pivotal for the projects which will continue after 2022 when the C2C CC project ends. In addition to exhibitions and arrangement for a broad audience, the Climatorium collaborates with several educational institutions to bring climate challenges into the everyday life and education of schoolchildren and students. This collaboration involves various arrangements, communication of knowledge and visits.

Within the business sector, the ambition is to create a broader framework for projects involving public authorities, private businesses, educational and research institutions and the civil society. A quadruple helix model approach will involve all four stakeholders.

Today, approximately 30 businesses and educational institutions are members of Climatorium. The benefit of this effort is that any project will be able to integrate the knowledge of all the other stakeholders and a broad foundation is thus created to solve individual and specific tasks.

This approach gives each member the possibility to continue working individually with a specific problem and translate the result into new products, services, research, education – or other development projects involving participation of different partners and start a new development helix.

The idea behind the Climatorium and the close collaboration illustrated by the quadruple helix approach have gained international recognition. Climate challenges in New Zealand are rather similar to the challenges in Denmark and New Zealand is very interested in learning from the Danish experiences. A Climatorium following the same concept as in Lemvig is being constructed in New Zealand and the C2C CC project 22: Permeable Road Surfaces has been transfered to New Zealand through the Danish Climatorium.

CONTINUATION

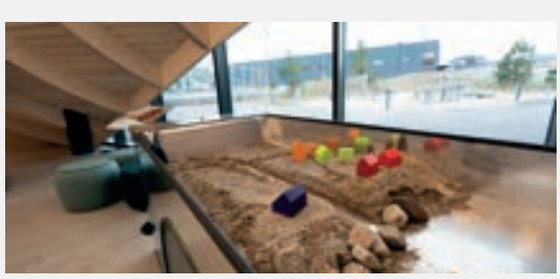
The Climatorium together with project C20: AquaGlobe and Central Denmark Region continues the results of the overall C2C CC project in the C2C CC After LIFE follow up. Moreover, the Climatorium continues as a climate development centre for climate adaptation, business development, research and innovation. The results of the C2C CC and other projects will be visually presented and communicated with focus on ongoing climate adaptation.

RELATION TO OTHER C2C CC PROJECTS

Visitors at the Climatorium are able to explore the C2C CC projects on their own through descriptions and visual presentation of all the projects. Moreover, the Climatorium projects have provided knowledge for other projects including C9, C17 and C22.

C21: CLIMATORIUM

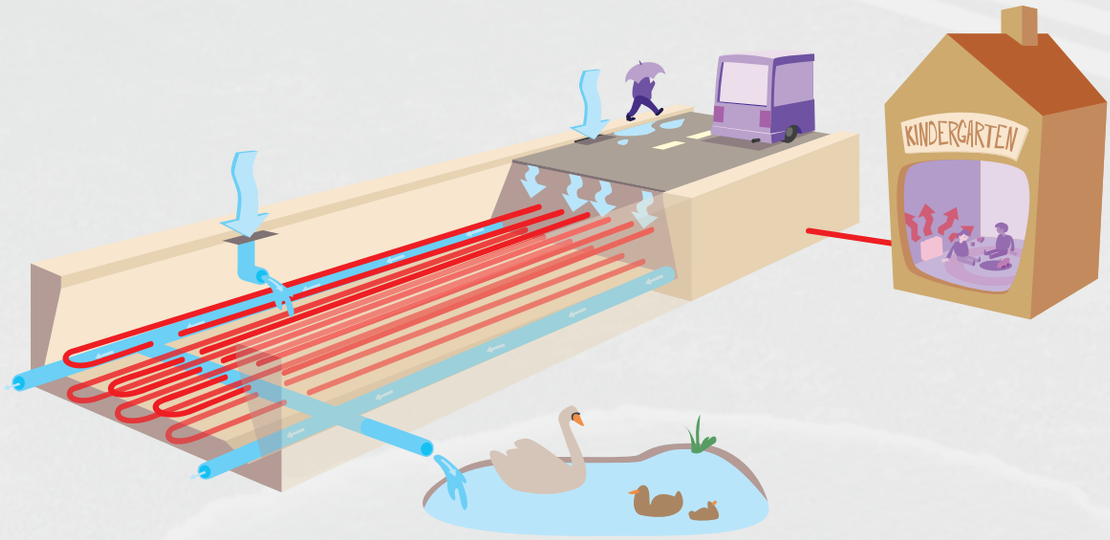
A new and characteristic building on the harbour in Lemvig constitutes the physical framework for creating visibility, communicating results and promoting business development centred around climate adaptation. The building hosts the Climatorium, a centre for collaboration and development related to climate, especially challenges related to the sea. Knowledge and results are communicated through exhibitions and arrangements. Companies, researchers, students, public authorities and civil society meet around development projects. The first business projects have been completed and the concept behind the Climatorium has spread to Nelson in New Zealand. The city has copied the idea – in collaboration with the Climatorium in Lemvig.



RESULTS

Several projects have been created within the Climatorium framework such as:

- An overall surveillance system to monitor movements in the underground based on satellite measurements – used in e.g., the C2C CC project 17: Thyborøn Town and Harbour
- Collection and reuse of fishing nets to be used in various plastic products
- Test site for permeable road surfaces; an offshoot of project 22: Climate Road
- A PhD project on cleansing polluted rainwater, which is e.g., relevant for project 22: Climate Road
- Participation in the regional beacon for water technology solutions. The Climatorium hosts eight projects and participates in another 11 projects.



Can a city imitate the way nature handles rainwater? Can a road be constructed allowing water to seep through the surface where it is collected instead of transporting the water through the sewerage system? And can the water collected be used for heating of houses?

It may sound as a very ambitious project planned at an office desk – but it can actually be done.

Hedensted Municipality at the east coast of Jutland has established a 50-meter climate road with permeable asphalt allowing rainwater to seep through. The water is collected in gravel and is directed to a nearby pond.

Below the road surface, pipes with fluids are placed extracting heat from the collected water and the gravel. The heat is concentrated in a heating pump and the 50-meter road hereby provides constant heating and hot water supply for a childcare centre. The project is an example of how climate adaptation can be integrated in other current global transitions.

- If the power for the heating pump is delivered by wind turbines or solar cells, the production of heat is both sustainable and CO_2 neutral
- The climate road can be used as a local solution to manage rainwater without the need to direct or manage the water in other ways
- The road can be used for water storage to temporarily relieve the sewerage system during storm surge or heavy rain.

Another advantage is that the system can be adapted to existing roads and residential areas.

RESULTS

This project has shown how a local climate adaptation project can be a catalyst for new and innovative solutions focusing on green transition. The project is a close collaboration between Hedensted Municipality, VIA University College, University of Aalborg, the Danish contractor NCC, Central Denmark Region and the C2C CC project Climatorium.

CONTINUATION

Results have led to a new project, the thermo road, which in addition the rainwater management and production of heat, will also deliver cooling. The thermo road will be constructed in a residential area in Hedensted.

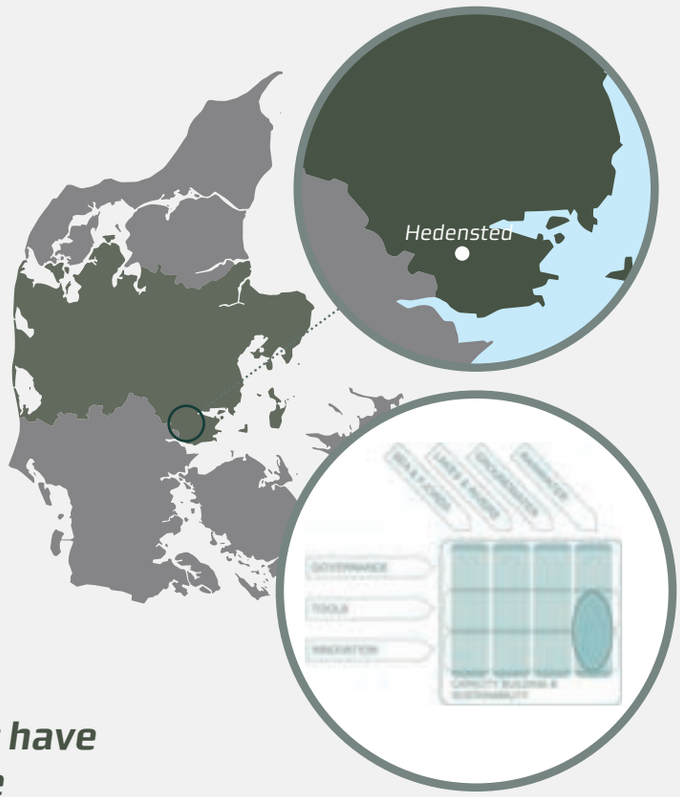
Moreover, a similar road project is established in New Zealand based on their version of the C2C CC project C21: Climatorium.

RELATION TO OTHER C2C CC PROJECTS

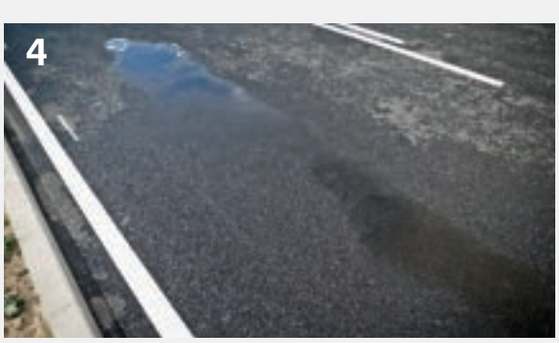
The project has included knowledge from other C2C CC projects: C3: Groundwater, C4: Rainwater, C6: Tools, C7: Innovation and C23: Potential for increased infiltration. This stresses the value of the overall knowledge generated in the C2C CC project and how this knowledge can be applied in different settings.

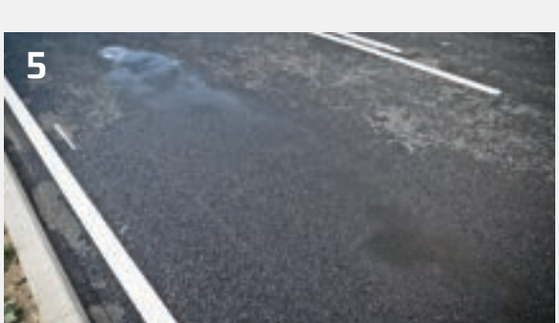
C22: PERMEABLE ROAD SURFACES

The starting point of the project was the development of a method to manage rainwater. The result was a system combining climate adaptation and green transition by merging water management with CO_2 neutral sustainable production of heating and cooling systems for housing. This system can be implemented in established residential areas.



> ***Sometimes you just have to do things and see where things end. When we started, we never thought that it would be such a huge success professionally, collaboratively and communicatively*** *(Project manager)*





Serious storm surges and prolonged periods with rain have become more common in Denmark. The traditional sewerage systems in the cities are under pressure, because the systems do not have adequate capacity to manage and direct the large amounts of water. This constitutes a risk of flooding with sewerage water on streets, roads and low-lying buildings, and the huge amounts of rain constitute an unnecessary strain to wastewater plants. Thus, it is very interesting to develop alternative ways to manage rainwater in urban areas.

One method, which has gained popularity, is to imitate nature's way of managing rain by local infiltration of water into the soil. This method is, however, not entirely unproblematic. Infiltration can transport polluted substances from the surface of the soil to the water level and further to the groundwater. Moreover, infiltration can dissolve and spread pollution. The increasing problem with high groundwater levels makes infiltration difficult or impossible.

However, infiltration has potential and is a relevant element in the continued work with managing rain in climate adaptation. Infiltration can build up water reserves in the soil, which can relieve areas during dry periods.

The purpose of this project was to uncover the connection between local geological conditions and the potential of infiltration of rainwater. Drillings have been made in selected urban areas in Horsens Municipality and infiltration tests was used to develop a geological infiltration map. Infiltration systems have been installed in the urban areas to locally manage the rainwater.

C23: POTENTIALS FOR INCREASED INFILTRATION

Management of large amounts of water from storm surges or heavy rain in the cities requires systems to relieve the traditional sewerage system. One way is to imitate the way nature handles rainwater. The project has focused on developing methods which makes infiltration a useful supplement to other rainwater systems.

CONTINUATION

In addition to the mapping of the infiltration potential, the project has initially highlighted the potential challenges of groundwater close to the soil surface. The project group continues with a new project on the management of the shallow groundwater within the water technology project Fyrtårn Midtjylland.

RELATION TO OTHER C2C CC PROJECTS

The project is part of the projects C3: Groundwater, C4: Rainwater and C7: Innovation.

RESULTS

The mapping of the underground has shown that climate adaptation can be optimised in new urban development by including infiltration in the planning to optimise local geology and hydrology.

Results from the mapping have been compared to 30 other mappings of urban developments in Central Denmark Region to explore if general infiltration maps could be developed. This is, however, not possible due to geographical variation in geology and hydrology.

READ MORE ABOUT THE PROJECT RESULTS:

kortlink.dk/2gnh7

Our way of life is conditioned by the climate, and it always has been. Many of the settlements from the Stone Age now lie on the seabed for the simple reason that 10,000 years ago, the sea level was 20 metres lower than today. The climate has changed and the people of the time moved and adapted to the changes. Humans have done this throughout history, and we now face that challenge once again. Past adaptations did not come without costs, but they often offered new opportunities. This is another thing that the past has in common with the present and the future.

Whereas the usual climate adaptation project begins with the consequences of climate change and therefore focuses mainly on protection, this project reverses the problem and instead takes human adaptation to the changed conditions as its starting point. Not at the general level, but in a particular local area, specifically the area of the project C8: Håb to Håb on the east coast of Jutland, north of Juelsminde.

The area includes summer cottages, small towns and agricultural properties with scattered fields. Parts of the area is low-lying. Especially along the local river, Skjold Å, and several smaller streams but also towards the coast, where one of the cottage areas already lies behind a dyke as protection against the rising sea.

A combination of higher sea levels and increased rainfall could, in the worst case, mean that parts of the area would be more or less permanently flooded, which would significantly change the landscape and the conditions of use of the area.

The project was based on how climate change in the past had affected the area and the living conditions in it, as well as how human occupation of the landscape has left its mark over time. Traces of human settlement along the coasts coupled with meteorological, geological, archaeological and historical records have been reviewed and translated into elements that was able to feed into the ongoing work.

Based on this, local citizens in the area were involved in a dialogue to put climate change and the human impact on the local area into a broader perspective. While emphasising the concrete and local, the future of an area becomes easier to relate to as you stand in the middle of it. From here you are able to imagine where and how the water might spread in the future.

The main theme of the project is that each place has a climate story to tell. The intention of the approach is to strengthen the dialogue between the municipality and the citizens and create an understanding and acceptance of the changes that citizens might have to face as a result of local climate adaptation.

The result of the project was high and sustained commitment among the local citizens in the future development of the area. A commitment that practically turned the whole process around. Instead of a debate on the three drafts for local climate adaptation proposed by the municipality, the citizens challenged the municipality and came up with a fourth and much more comprehensive proposal, which is now incorporated in a new project.

CONTINUATION

In general, the results of the project will feed into further work to implement climate projects as widely as possible.

Locally, the efforts to adapt the area to climate change is being continued in a new project, BioScape. Read more about this and the area under project C8: Håb to Håb.

C24: CLIMATE HISTORY – CULTURE HISTORY

What happens in a climate adaptation project if the technical solutions and the management by the authorities take a back seat and the local community is given more space? Is it possible to get a better understanding of climate adaptation if it is placed within the framework of local history in order to compare it to the many changes in living conditions and landscape that have taken place over time? These considerations were at the heart of this project.

RELATION TIL ANDRE C2C CC-PROJEKTER

It has proven more difficult than expected to connect to the different projects in C2C CC to facilitate new collaborations. However, in a few places it has been possible to some extent.

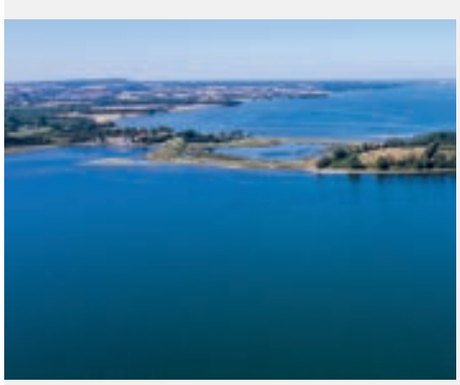
RESULTS

Climate history is a powerful platform to raise awareness, interest and debate as well as engage citizens and stakeholders in climate adaptation. In relation to the C8: Håb to Håb project, the model has proven very useful and has produced good results.

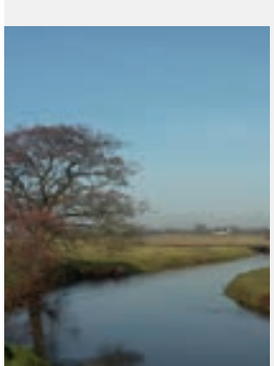
The general assessment of the process is that such work should be made in closer connection to the individual projects and carried out in a collaborative way between, for example, the municipality and the local museum or others with an insight into local and historical matters.

Coast to Coast Climate Challenge
– the 24 subprojects







C2C Coast to Coast Climate Challenge