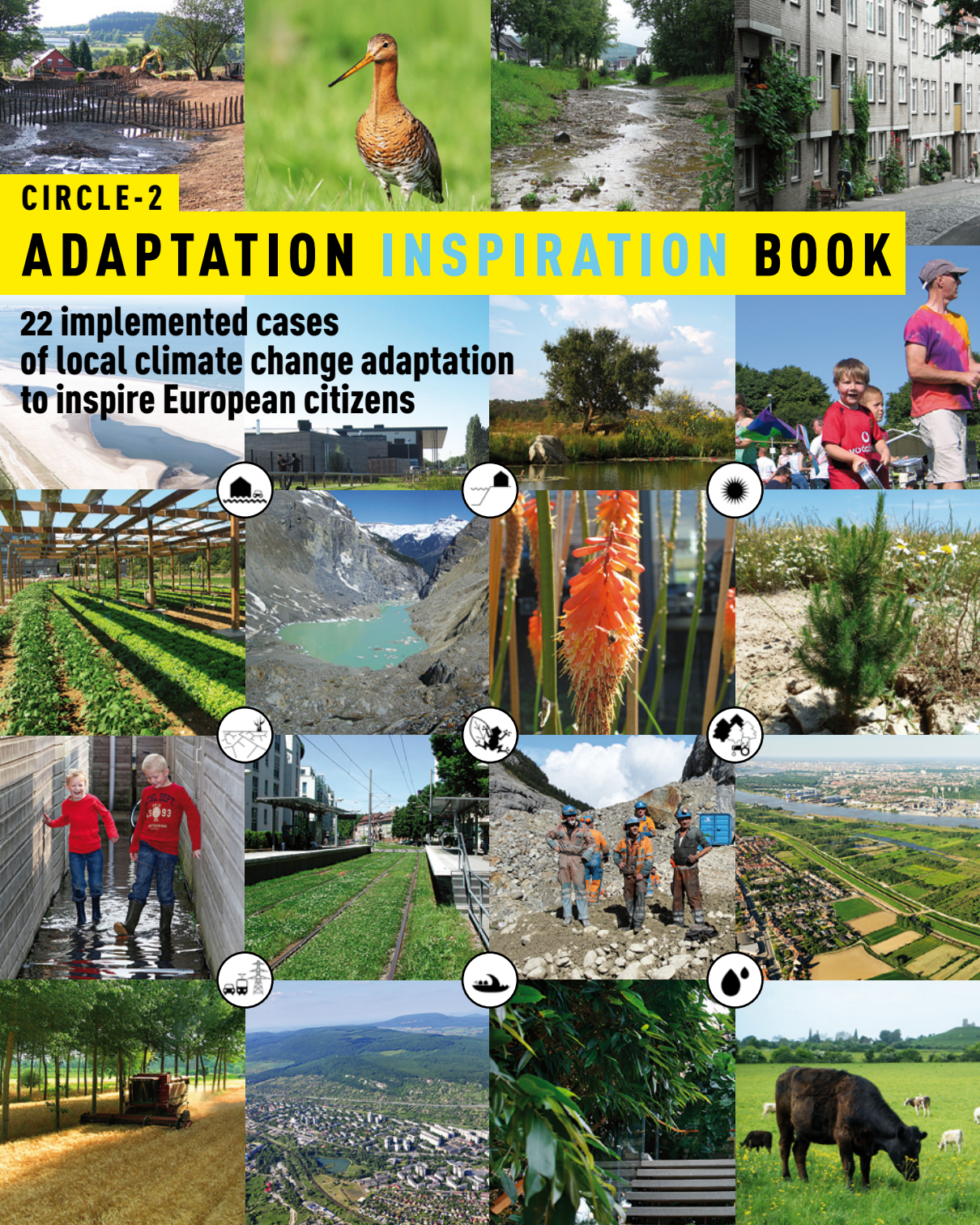

CIRCLE-2

# ADAPTATION INSPIRATION BOOK

## 22 implemented cases of local climate change adaptation to inspire European citizens

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## 22 implemented cases of local climate change adaptation to inspire European citizens

CIRCLE 2

CLIMATE IMPACT RESEARCH
& RESPONSE COORDINATION
FOR A LARGER EUROPE
EU FP7 ERA-NET

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European Environment Agency

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## ICONS CLIMATE RISKS

- flooding
- sea level rise
- heat
- drought

## ICONS SECTOR

- agriculture and forests
- coastal areas
- health
- infrastructure
- disaster risk reduction
- water management
- biodiversity and nature
- city planning and buildings

## BUDGET

€€€€ > 500.000 euro
€€€ 100.000 – 500.000 euro
€€ 10.000 – 100.000 euro
€ < 10.000 euro

# FOREWORD

From Jacqueline McGlade, Executive Director
of the European Environment Agency

**Climate change is a reality around the world, and the** extent and speed of change is becoming ever more evident. A recent EEA report [1] has shown that climate change is affecting all regions in Europe, causing a wide range of impacts on society and the environment, and further impacts are expected in the future, if no action is taken.
Observations show higher average temperatures across Europe as well as decreasing precipitation in southern regions and increasing precipitation in northern Europe. The Greenland ice sheet, Arctic sea ice and many glaciers across Europe are melting, snow cover has decreased and most permafrost soils have warmed. Furthermore, climate change is projected to increase river flooding in various parts of Europe, as the local water cycle is influenced. A lack of water will be a problem in some areas - in southern Europe, as river flow droughts are projected to become more severe and frequent. Rising sea levels raise the risk of coastal flooding during storm events.

**As Europe warms, the effects are becoming visible** in the natural world. Plants are flowering earlier in the year, while in freshwater plankton blooms are also appearing earlier. Some animals and plants are moving northward or uphill as their habitats warm.

**These environmental changes have many varied** implications for human society. For example, several studies show that parts of the continent will become more suitable for disease-carrying mosquitos and sandflies. There may be less water available for agriculture and yields may fall due to droughts, but growing conditions may improve in other areas. Demand for heating has fallen in parts of Europe, but this must be balanced against higher energy demands for cooling during hotter summers.

**Heat waves, floods and droughts have caused rising** damage costs across Europe in recent years. While more evidence is needed to discern the part played by climate change in this trend, growing human activity in hazard-prone areas has been a key factor. Future climate change is expected to add to this vulnerability, as extreme weather events are expected to become more intense and frequent. If European societies do not adapt, damage costs are expected to continue to rise. Some regions will be less able to adapt to climate change than others, in part due to economic disparities and different institutional settings across Europe. The effects of climate change may deepen these differences. Every part of society thus needs to adapt, while also reducing greenhouse gas emissions. The European Commission has initiated various actions to integrate and mainstream adaptation into EU sectoral policies. Many countries, regions and cities have also started the adaptation process. The European Commission will propose further actions to adapt in its European Adaptation Strategy, to be adopted later this year.

**Despite the wealth of information on climate change**, it can be hard to find the right information to help adaptation. The European Commission and EEA have developed the European Climate Adaptation Platform (Climate-ADAPT) [2], a website that aims to help Europe adapt to climate change. Users can access and share a wide range of information including adaptation case studies, potential adaptation measures and tools that support adaptation planning.

**The CIRCLE-2 Adaptation Inspiration Book provides a** great overview of practical and early examples of actual adaptive actions already taking place across Europe. These actions can make a region or city less vulnerable to the effects of climate change, enhance resilience or provide new opportunities. Many of the innovative solutions, generally improve the quality of the environment and the quality of life of citizens. As the benefits of such examples become clear, I hope this book can indeed inspire people to adapt.

[1] Climate change, impacts and vulnerability in Europe 2012, EEA Report No 12/2012

[2] Climate-ADAPT: climate-adapt.eea.europa.eu



# ABOUT THIS BOOK →

Tiago Capela Lourenço and David Avelar,
CIRCLE-2 coordination, www.circle-era.eu

**The idea of supporting an inspirational book on** practical climate adaptation first appeared in 2011 during the preparations for a CIRCLE-2 workshop called 'From National Adaptation Strategies to Concrete Adaptation Actions'.

**Right from the start the challenge was to answer** fundamental questions such as 'what does a practical adaptation example look like?' and 'what exactly does it mean to be inspirational?' Fortunately, and thanks to the vision and knowledge of our partners and in particular of our editors and contributors, an (inspirational) answer was soon to be found: 'a practical adaptation example has to be something that can be photographed' and that 'inspires others to see adaptation as an opportunity rather than a response to a problem'. Well, that is easier said than done. Adaptation remains a complex and often elusive concept. In practice, both in Europe and around the world, it is still dealt with from a strategic perspective rather than an effective one (hence the title of that workshop back in 2011). And for many, adaptation is tangled so tightly with other areas of science, policy and practice that it becomes difficult to understand and clearly define its frontiers. But CIRCLE-2 thrives precisely in this interface were science meets policy.

**Our experience shows us that adaptation is the** ultimate trans-disciplinarily challenge and one that will only succeed through original, imaginative and inspiring solutions. This is how decision-makers and communities across Europe and the world will be inspired to adapt to a changing climate. Or how they will perceive that there is more to adaptation than a very distant future. This book is designed to inspire science, policy and practice. It is one out of the several CIRCLE-2 contributions to something we aim and expect to see in the coming decades: the branding of adaptation as a positive approach to face climate change.
Please enjoy this marvellous set of adaptation examples. We hope that you too, like us, feel inspired by them!

# Overview of 22 inspiring case studies that helped adapt a region in Europe to the impacts of climate change.

Adaptation is adjusting to an uncertain future which will change dramatically according to climate and socio-economic scenarios.
The things that have to change are partially spatially defined, such as higher flood defences, flexible storm surges protection, water retention areas and cooling measures in cities, but also partially behavioural.
We have to change ourselves as well.

# INTRODUCTION

**What is adaptation to a changing climate? And can we call a measure 'adaptation' if the primary reasons for implementing are not related to climate change but climate change impacts are reduced and resilience enhanced? What observations can be drawn from the survey of 22 implemented adaptation measures in Europe?**

**Although most people may have a rough understanding** of climate change, the word adaptation often invites raised eyebrows. Policy makers, especially those at local level, tend to frame climate change as an energy problem, and turn to solutions such as energy efficiency and reducing greenhouse gases. For those not working in the field of adaptation to climate change, adaptation can remain an elusive concept. However, adaptation has become increasingly important. Even with a substantial reduction of the emission of greenhouse gases into our atmosphere, the average temperature on earth will continue to rise. Besides higher temperatures in Europe, climate change will likely cause local extreme weather events with high levels of precipitation potentially causing flooding, whereas droughts are also projected to become more prevalent. Sea levels will rise, causing flooding and saltwater intrusion, the yields of traditional crops are projected to decrease in some areas and new animal and plant species, some welcome, some harmful, will move northward and upwards. The heat islands within cities may become more intensive and cities may experience flooding challenges, both as a result of excessive rain and from the sea, rivers and waterways. At the same time we are facing global, political and social changes. Many (delta) cities require restructuring and introduction of  a more sustainable way of city planning, There is a need for greater social coherence, particularly during times of economic crises and more efficient energy use is a high priority as energy costs and oil reserves become scarcer. How than do you define adaptation and what does it look like?

**According to the IPCC adaptation to climate change is** the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC 2007, Glossary). Adaptation is adjusting to an uncertain future which will change dramatically according to climate and socio-economic scenarios. The things that have to change are partially spatially defined, such as higher flood defences, flexible storm surges protection, water retention areas and cooling measures in cities, but also partially behavioural. We have to change ourselves as well. In this book we consider adaptation as an action that reduces vulnerability to climate change, even if climate change was not the explicit driver of the project.

**To cope with the projected changes of climate change** several European countries have already developed, or are in the process of developing national adaptation plans, i.e. the Scandinavian countries, the United Kingdom, the Netherlands, Germany, Portugal and Spain. Publications containing good practices of adaptation are becoming available. Databases comprised of examples of adaptation measures are being established, most notably the European Climate Adaptation Platform (Climate-ADAPT), maintained by the European Commis-

sion and the European Environment Agency [1] which was launched in March 2012, and the CIRCLE-2 [2] Infobase. Looking closer at identified practices in many of these online databases shows that what is available are often theoretical case studies, or small scale pilots, rather than actual implemented, working adaptation measures. A reason often mentioned for this, is that adaptation implementation is not yet sufficiently advanced in Europe, or anywhere in the world for that matter. Therefore most 'best practices' are guidelines, adaptation options and policy plans for implementation, while implementation is still some years down the line. All this adds to the belief that adaptation, unlike mitigation, remains somewhat elusive, difficult to describe, and not as tangible. Many online databases provide short descriptions of projects, but seldom include information on efficacy and lessons learned.
Although implemented measures in Europe are limited in number, they are by no means absent. One just has to know how and where to look for them. Adaptation can be disguised as responses to increasing pressures or mounting risks and not necessarily identified as adaptation to a changing climate. Measures are often simply called by their direct effects, i.e. 'water safety measures', or measures to improve 'city climate'. The IPCC categorises these types of measures as autonomous adaptation, as opposed to planned or anticipated adaptation (IPCC 2007, Glossary). Autonomous adaptation does not constitute a conscious response to climate effects, but is triggered by other issues, such as improving quality of life in cities, tackling social issues or providing economic opportunities.

**Policy makers, practitioners, developers and scientists** could benefit from an overview of implemented adaptation measures and lessons learned. Policy makers can see what adaptation as implemented by others looks like in practice. They obtain a better impression of adaptation as the case studies can make those measures more real and tangible, and are able to draw lessons to improve their policies and practices. Developers can see how their actions and projects add to the adaptation to climate change of a particular region or city. Scientists can see how their research efforts are put into practice, how they can help develop evaluation methods to increase the efficiency of adaptation measures and can learn from implemented measures to further understand knowledge and evidence gaps.

**To provide policy makers and professionals with a** sense of what climate change adaptation is and what lessons can be derived from current implementations, the ERA-net programme CIRCLE-2, a European Network of 34 institutions from 23 countries committed to fund research and share knowledge on adaptation to climate change, conducted a search to identify examples of implemented adaptation measures. For the Adaptation Inspiration Book 22 case studies on implemented adaptation measures have been identified to date. These case studies were identified by scanning databases such as Climate-Adapt scanning research programmes of CIRCLE-2 countries and other EU countries, such as BRANCH, MEDIATION, ADAM, ESPACE, PROVIA [3] and CLIMSAVE [4], and scanning research programmes of CIRCLE-2 countries and other EU countries, such as Knowledge for Climate (Netherlands), CC-SnowII (Austria), Finadapt (Finland) and Klimzug (Germany) [4]. During the CIRCLE-2 workshop entitled 'From National Adaptation Strategies to Concrete Adaptation Actions' held in Vienna (October 2011), participants (including many policy makers and practitioners) were encouraged to offer their own examples of implemented adaptation measures. When cases were identified project leaders were asked to provide information about climate effects, costs and benefits through an online questionnaire. The data in this book reflect the knowledge and interpretation of the project leaders responsible for the case studies.

**The online questionnaire was also distributed among** CIRCLE-2 partner countries and contributors to allow for open submissions of projects not affiliated to any of the European or national research programmes.
The geographic scope of the Adaptation Inspiration Book is Europe. The measures did not necessarily have to be labelled as adaptation to climate change, as long as it led to a significant increase in the capacity to cope with climate change or a decrease in susceptibility to the negative effects of climate change. In other words, the adaptation measures identified had to make an existing situation or region less vulnerable to the effects of climate change, enhance resilience or provide new opportunities. It is our intention that these case studies provide inspiring, creative, innovative solutions that improve the quality of the environment and the quality of life of the people living there.

**The Adaptation Inspiration Book provides detailed** information on each identified measure: to which sector it belongs, (i.e. water safety, agriculture, cities), specific climate effects adapted to, length of the project and costs and benefits, including the proportion of the budget project leaders indicated was allocated specifically to adaptation. Their comparison yields some insight into success factors of the project, and into what are additional benefits of these case studies. Although specific attention has been paid to find case studies from all over Europe, due to the Northern and Western European's leading role in climate change adaptation research, these countries are responsible for the majority of case studies included in the Adaptation Inspiration Book. The identified measures tend to focus on water management (19 percent), biodiversity (19 percent), city planning (14 percent) and disaster risk reduction (14 percent) and most often tend to find adaptation solutions for flooding (72 percent). In 14 of 22 case studies, adaptation to a changing climate was the main motivation. Flood prevention and erosion were examples of triggers for measures in those case studies for which climate change was not the main driver.

**Most projects that are the subject of the case studies** were either publicly funded (12) or benefited from a combination of public and private funding (8 projects). Only 2 projects were fully financed from private funds. Half of the projects had budgets that exceeded 500.000 and only one was less than 10.000. For some only a small part of the budget was allocated specifically to adaptation (less than 5 percent) and for others the whole budget (5 projects), although others were unable to specify the specific portion of the budget allocated to adaptation. This difficulty is linked to the challenge of differentiating adaptation measures from those directed at other measures (e.g., where does ecological restoration stop and adaptation to a changing climate begin?).

**In general positive effects on sustainability, business** development and quality of the environment were reported more often than negative effects. 14 Percent reported negative impacts on business as opposed to 41 percent of projects reporting business opportunities arising from the adaptation measures. 9 Percent of adaptation measures resulted in a decrease in environmental quality while 77 percent of projects resulted in an increase in environmental quality. Prevention of damage (86 percent), increased sustainability (68 percent) and social benefits (68 percent) were also mentioned as positive side effects of the adaptation measures.
The case studies in the Adaptation Inspiration Book often do not limit themselves to action in one sector or tackling one challenge. For example, they combine adaptation to a changing climate with educating children by building a showcase sustainable school that can also be used in biology classes. Or they link adaptation to improving ecological conditions and quality of the environment by replanting forests and renaturalising waterways. Combining multiple sectors or goals in one project often improves cost effectiveness, as it did with a newly built sustainable school in the United Kingdom (page 36) and the Dutch Sand Motor project (page 84). When a longer term view is incorporated, measures are more likely to be sustainable and they are less likely to need revisiting in the near future. However, exact costs for adaptation are difficult to pinpoint.
As these case studies demonstrate, adaptation implementation is at an early stage in Europe and people implementing measures often do so in the context of 'learning by doing'. The focus is on learning yourself.
The cases in this Inspiration Book are early examples of actual adaptive action in Europe. Over the coming years, some of these and other cases will be included in the European Climate-ADAPT information platform to inspire others. If you have an equally inspiring case, please propose to include it in this online information system at climate-adapt.eea.europa.eu.

**Most case studies in this book are monitored by** researchers or communities to provide the information needed to evaluate whether the measures are achieving that for which they were implemented - contributing to reducing vulnerability to climate change. Monitoring is an important aspect of the process of adaptation to climate change. The only true test of whether or not a measure indeed reduces vulnerability is performance over time. As part of this monitoring, it is important to keep track of the latest climate scenarios and whether or not adaptation measures such as Sand Motors, agroforestry schemes and heat alert systems are still adequate as implemented. Are the implemented adaptation measures achieving the intended results? Is there a need to introduce improvements and, if so, how should they be introduced? As adaptation is a continuous learning process, are there lessons that can be shared and can the implemented measures and lessons learned be used elsewhere?

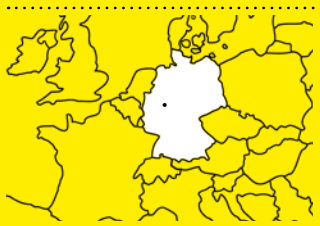
footnotes
[1] climate-adapt.eea.europa.eu
[2] www.circle-era.eu/np4/10
[3] www.provia-climatechange.org
[4] www.climsave.eu
[5] www.klimzug.de

# flooding

# Small streams, big floods

climate risks

sector



**Location**
City of Arnsberg, Germany

**Total budget**
€€€€

**Non-financial costs**
environment, nature and sustainability

**Non-financial benefits**
environment, business, social and nature

**Project partners**
District government of Arnsberg, District Hochsauerlandkreis, Environmental Bureau of Arnsberg, Consulting engineers, Local residents

**Public or private project**
Public

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Photo: ©Umweltbüro, Arnsberg

Within just two years 2.7 kilometres of the streams were successfully renatured, arranged in a more natural and ecologically sound way.

# Renaturing of small waters as a means of climate change adaptation

Photo: ©Umweltbüro, Arnsberg

**When thinking about adapting to future flood risks, it are often the large rivers that come to our minds first. Most of us are unaware of the fact that smaller water courses, such as streams or brooks, can also develop mighty powers during flood or intense rain events. The city of Arnsberg in Germany learned that the hard way: after two extreme rainfall events in 2007 it had to conclude that small streams can be dangerous as well. Within four hours, a downpour of about 130 litres of rain per square metre led to the flooding of four streams causing serious damage to the build-up area.**

Photo: ©Umweltbüro, Arnsberg

Those floodings caused unrest among the citizens, as Gotthard Scheja from the Environmental Bureau of the City of Arnsberg explains. For some time after the flood, as soon as the weather forecast predicted stronger rains, citizens would call the Environmental Bureau, fearing that another extreme rain would lead to reoccurred flooding. Under the influence of climate change flooding events are likely to occur more often. The frequency of extreme events, including heavy rain falls that can lead to major flooding, is expected to increase. This led the city administration and citizens to decide that the four smaller streams flowing through the municipality needed more room. Room to overflow, without flooding the villages. Within just two years 2.7 kilometres of the streams were successfully renatured, arranged in a more natural and ecologically sound way. This quick operation was made possible by the fruitful cooperation between municipality and local inhabitants, and fuelled by the prevalent fear that such an extreme event might cause serious harm again in the near future. As part of the renaturing measures, stream banks in and - very importantly - outside of the villages were enlarged and flattened. Water obstructing elements, such as stairs close to the stream bed were removed, reducing the power of the water. In an urban area where space is limited, providing a stream with more room can be a challenging measure.

In Arnsberg the involvement of local inhabitants from the very beginning of the planning process made all the difference. Several times citizens agreed to give up parts of their properties to allow the streams to expand again. In practice this meant that two to three metres of property and gardens were given back to the streams. Little garden houses were voluntarily given up twice, as they were located too close to the streams. Interestingly, most citizens were more than willing to cooperate, as the flood adaptation measures led to a higher safety level: an extreme flood, that statistically happens every hundred years, can now pass these brooks by Arnsberg without causing major damages.

Nowadays, local inhabitants feel relieved that their concerns for heavy rain and floods have been taken seriously. The measures led to increased biological diversity through nature (re)-development, improvement of the city landscape and increased touristic value of the city of Arnsberg. One other co-benefit that Gotthard is especially proud of is the fact that the adaptation measures undertaken for the four smaller streams in combination with the large measures at the river Ruhr contributed to the EU Water Framework Directive WFD in time (2012), as one of a few towns in Germany. The WFD commits the Member States of the European Union to achieve good (ecological) status of all water bodies by 2015.

**What does renaturing, rehabilitation and ecological reconstruction of rivers and streams mean?**
Renaturing a river, or a stream, basically means restoring the structure and functionality of a water course. By doing so, the water course is brought back as closely as possible to its original natural state before human interference occurred. Often, such measures enhance the water retention capacity of river and stream surroundings and therefore lead to the reduction of flood risks. Ecological restoration can include a diverse array of measures, including letting the river or stream meander again, giving the stream more room, enlarging and flattening the stream banks, enhancing erosion control, replanting formerly disturbed areas, allowing more daylight to reach the stream, reintroducing native species, and removing non-native species and weeds.

The two primary causes of flooding are climate change, resulting in increased severity and intensity of rainfall, and new developments on floodplains, which are themselves at risk of flooding, and which increase the risk of flooding downstream.

# When glaciers melt, what happens to the water?

climate risks

sector

**Location**
Grindelwald, Switzerland

**Total budget**
€€€€

**Non-financial costs** none

**Non-financial benefits**
Business

**Project partners**
Chief Engineer District 1
Department of civil engineering
Berne, Corporation of Riverbed
Constructions of Grindelwald,
Corporation of Riverbed
Constructions of the Region
Interlaken, Community of
Grindelwald, Federal Office of the
Environment

**Public or private project**
Public

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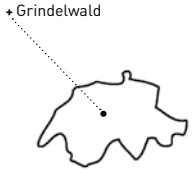
Photo:
©Chief Engineer District 1
Canton Bern,
Nils Hählen

The construction of the drainage tunnel was initiated in 2009, the year when during May the glacial lake reached its highest level.

# Drainage tunnel for glacier lake on Lower Grindelwald-Glacier



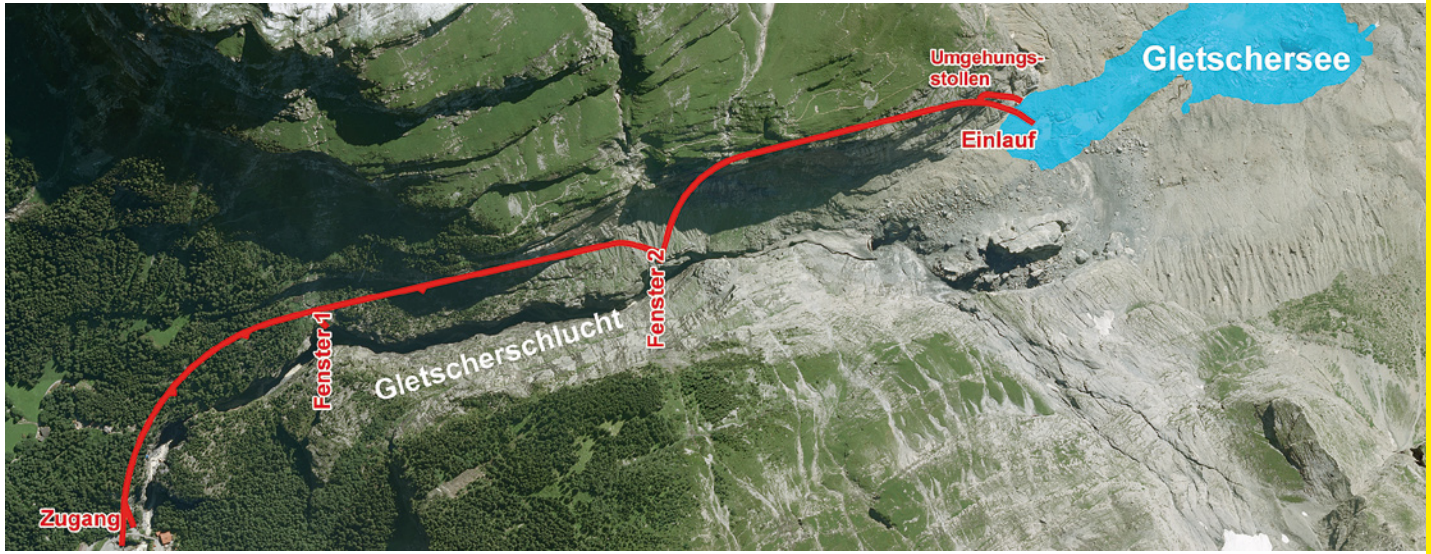




Photo: ©Chief Engineer District 1 Canton Bern, Nils Hählen

**Retreating glaciers are probably one of the most visible clues that our climate is changing.** The alps are predicted to be one of the regions most strongly affected by climate change in Europe. Over the course of the last century, the alpine region has witnessed increasing average temperatures and glaciers have lost almost two thirds of their volume since 1850 - and are continuing to do so at an increasing rate. The retreat of the glaciers not only changes the way the alpine landscape looks but also strongly impacts the water balance and levels of risks in the surrounding areas.

One risk related to glacial retreat is the formation of more glacial lakes than normal. The glacial lakes at the Lower Grindelwald-Glacier, a retreating glacier in the central part of Switzerland, form the biggest risk in the Bernese Oberland. Glacial lakes form when snow slowly starts to melt during spring. Glacier lakes naturally belong to glaciers, no matter whether they retreat or advance.

With the fast retreat due to climate change, more glacier lakes form - more often too - and therefore they are to be observed. When snow melts the melt water streams into the lakes very quickly and accumulates in vast water quantities. For example in July 2008 the almost empty glacial lake filled overnight to approximately 300.000 cubic metres – that's 120 Olympic-size swimming pools filled with water!

Rising temperatures during the summer months can then lead to the dangerous situation where the glacial lake is at risk of flooding the surrounding area at any time, as soon as the water has found a way of draining through the frozen bed of the lake – an event that is difficult to predict exactly and even more difficult to control. The Chief Engineer of the first district of the Canton Bern and the Corporation of Riverbed Constructions Grindelwald decided that the yearly growing lake volume was posing an unbearable risk to the region, as sudden outbursts would cause extensive flooding and severe damage. This meant that reliable protective measures were necessary to reduce the risk that the melting glacier posed.

To mitigate the risk of the lake breaking through and flooding the region a drainage tunnel was proposed.

The construction of the drainage tunnel was initiated in 2009, the year when during May the glacial lake reached its highest level recorded with 2.400.000 cubic metres. During spring 2010, the drainage tunnel became operational after eleven months of construction. An artificial drainage gallery was created as close to the bottom of the lake as possible. The tunnel leads into the gorge down the valley and the water can run through the river Lütschine. As a result, the water level can no longer rise beyond this point and the glacial lake is prevented from having large volumes of water. Now that that the volume of the lake cannot surpass 500.000 cubic metres, a sudden outbreak, if it occurs, is not expected to lead to major damages. As it is estimated that the bottom of the lake gets lower from year to year, it is likely that also the intake of the drainage tunnel needs to be lowered correspondingly.

Nils Hählen from the Oberingenieurkreis I explains that because most of the drainage tunnel is below ground it has a rather small effect on the surrounding landscape. Tourists are visiting the area again without having to fear flooding at the Grindelwald and the tunnel allows for dangers of high water level in the glacier lake to be quickly mitigated.

**Glacier melt – dangers and opportunities**

The result of glacier melt is a new landscape. The main risk is that on the way to a new landscape the formation of glacier lakes can increase the risk of heavy flooding. Instable moraines and melting permafrost around the former glaciers can cause an extreme bed load input to the valleys. The land use of valley floors in many alpine regions has to be changed because rivers will need more space. On the other hand opportunities due to new depressions occur when glaciers retreat. These depressions can be used to store water for power production, for protection against flooding or for the irrigation of valleys. Some glaciers bear risks, others opportunities, and sometimes risk and opportunities can appear at the same glacier.

Photo: ©Chief Engineer District 1 Canton Bern, Nils Hählen

# Working with nature in a real life laboratory for flood protection

climate risks

sector

**Location**
Kruibeke, Belgium

**Total budget**
€€€€

**Non-financial costs**
social costs

**Non-financial benefits**
Enviroment, social and nature

**Project partners**
Agentschap voor Natuur en Bos, Local partners: Kruin, Bedrijfsgilde, Boerenbond

**Public or private project**
Public

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(Photo: ©Afdeling Zeeschelde, Waterwegen en Zeekanaal)

The dynamic flow allows the creation of typical tidal landscapes, attracting hundreds of birds like the kingfisher and avocet.

# Kruibeke retention area

(Photo: ©Afdeling Zeeschelde, Waterwegen en Zeekanaal)

**Kruibeke is a small municipality in Flanders, across the river from harbour city Antwerp. It is located in a flood prone area of Belgium, once reclaimed from the river Scheldt.** The inhabitants of this region face a substantial flood risk when a spring tide occurs with a North Western storm. On average twice a year such an event causes a big storm surge to be pushed from the sea into the river Scheldt. This causes high water levels and a severe pressure on the Scheldt dykes.

The safety of the area around the river Scheldt needed to be improved to address the existing risk, a matter all the more urgent taking projected climate change into account. By lowering the dike of the Scheldt along a distance of 8 kilometres, the top of the storm wave is cut off, allowing the water to flow into the designated area (600 ha) in a controlled manner. The creation of this flood control area is part of the Sigma Plan that will support safety, environment, shipping and recreation along the Scheldt river.

But safety is not the only benefit of this project. The entire area will become an accessible nature area, harbouring a vast and unique swamp forest area, 150 hectares of grassland bird area and 300 hectares of tidal plain. Waterwegen en Zeekanaal N.V., the organisation managing part of the navigable waterways in Flanders, implemented an innovative method to allow the creation of mud flats and marshes in a low-lying polder. An inlet construction mimics the natural tidal movement. Twice a day, during high tide, the raising river water reaches 'tubes' in the inlet construction, that allow a reduced part of the flood water to flow into the area. At low tide, the water leaves the area though the outlet construction. This dynamic flow allows the creation of typical tidal landscapes, attracting hundreds of birds like the kingfisher and avocet.

In anticipation of this large scale project, Hamme Lippenbroek, an area of ten hectares, serves as a real life laboratory for this ingenious environmental scheme. Several universities monitor the testing site and are wildly enthusiastic about the speed and quality of the natural development in this experimental area. All lessons learned will be put to good use when fine-tuning the inlet- and outlet constructions in Kruibeke.

**Why is so much effort going into the creation of tidal plain habitat?** Mud flats and salt marshes are important parts of the river as they support the self-purification of the river system. The vegetation filters excess nitrogen from the water and allows for the uptake of oxygen into the water. At the same time, it enhances the development of plankton. Accordingly, flood control areas with tidal systems help to restore the basis of the food chain for innumerable plants and animals. Thanks to the promising and positive pilot results at Lippenbroek tidal habitats are now being constructed in other Sigma-projects beside the one in Kruibeke. Creating flood plans hopefully leads to a revitalization of the biodiversity in the river Scheldt.

(Illustration: ©Afdeling Zeeschelde, Waterwegen en Zeekanaal)

**The Sigma Plan**
Protecting Flanders from flooding from the River Scheldt and its tributaries, is the main goal of the Sigma Plan. When first implemented after the storm surge of 1976, the main targets where building higher and safer dikes, create controlled floodplains, and the building of a storm surge barrier in Oosterweel. In total 260 kilometre of rivers is affected by the Sigma Plan. New insights during the early 2000s have adjusted the plans. The original measures were no longer adequate to ensure safety when taking into account climate change, sea level rise and more extreme precipitation. New insights in river management led to the principle of 'room for the river' and combining safety measures with natural development. The new Sigma Plan in 2005 includes these principles. A chain of floodplains provides more room for the river and Flanders is committed to restore natural processes along the River Scheldt, while at the same time ensuring safety for inhabitants.

Flood control areas with tidal systems help to restore the basis of the food chain for innumerable plants and animals.
(Photo: ©Afdeling Zeeschelde, Waterwegen en Zeekanaal)

# Teaching sustainability by being sustainable

climate risks

sector

**Location**
Leicestershire County (Melton Vale), UK

**Total budget**
€€€€

**Non-financial costs** none

**Non-financial benefits**
Enviroment, social and nature

**Project partners**
Willmott Dixon (main contractor), A+G (Architects), ARUP (Civiland Structural Engineers), DSA E+D

**Public or private project**
Public

**Contact**
DSA ENVIRONMENT + DESIGN LTD
David Singleton
e-mail: d.singleton@dsa-ed.co.uk

Especially constructed swales lead the water to a detention basin where specific plant species can filter and clean the water

# Melton Vale school SuDS

Photo: ©DSA Environment + Design

**The Melton Vale Post 16 Centre (MV16) takes teaching the next generation about sustainability and vulnerability to climate change to a whole new level.**
The Melton Vale Post 16 Centre is a school in Leicestershire in the United Kingdom that educates adolescents from the age of 16. When a new school building had to be constructed, the school board decided it had to be sustainable – and that the school had to become an instrument in teaching the students about sustainability. The building is situated on an east-west axis thereby maximising exposure to natural daylight and decreasing the demand for artificial lightning. Beehive style ventilators at roof level provide the school with fresh air. A wind turbine on site generates electricity and the school's heating system incorporates a biomass boiler, which uses wood pellets. Even more elaborate is the storm water runoff, a so called SuDs (Sustainable Drainage system) that effectively collects rain water runoff in a central detention basin. Large areas of new grass- and wetland are used to attenuate storm water. At the same time, this drainage scheme is providing a considerable increase in biodiversity across the site.
A rainwater tank collects water from the roof for recycling in the building. Any excess is directed into the basin. The western side of the school car parking and access road drain via a swale to the main attenuation basin. Nested wetlands carry storm water to one main detention basin. Especially constructed swales lead the water to a detention basin where specific plant species can filter and clean the water. The design prevents flooding even under a 100 year rainfall event with an extra allowance for climate change. The water leaves the school site via a gabion headwall. It then connects into the original (and conventionally piped underground) system of the wider school campus, which will receive much less water during an extreme rain event, due to the storage capacity at the school site.
Besides reducing the risk of floods, SuDS are also cheaper in installation compared to conventional underground drainage systems because there is no need for pipework, connections, tanks and gullies and, importantly, expensive excavation for these hard engineering measures. In addition swales and basins are easier and cheaper to maintain. They do not block easily and any problems (such as spillages of potential pollutants) are generally visible and can be fixed quickly.
To make maximum use of the innovative techniques the curriculum of the school has been modified to allow students to use the SuDS landscape for their studies. This offers students the chance to be involved in the monitoring and evaluation of the SuDS. Students are helping to collect data on the performance of the system. The art, geography, biology and chemistry departments use the school environment in their teaching programmes. Dave Barton, a biology teacher at the school, and his students have completed a field survey of the school landscape. They are comparing species diversity across various areas to see whether changes in management (such as frequency or type of grass cutting) alter species diversity. Additionally, Jon Sherwin, the school Principal, has noted that students' focus on learning has very much improved .

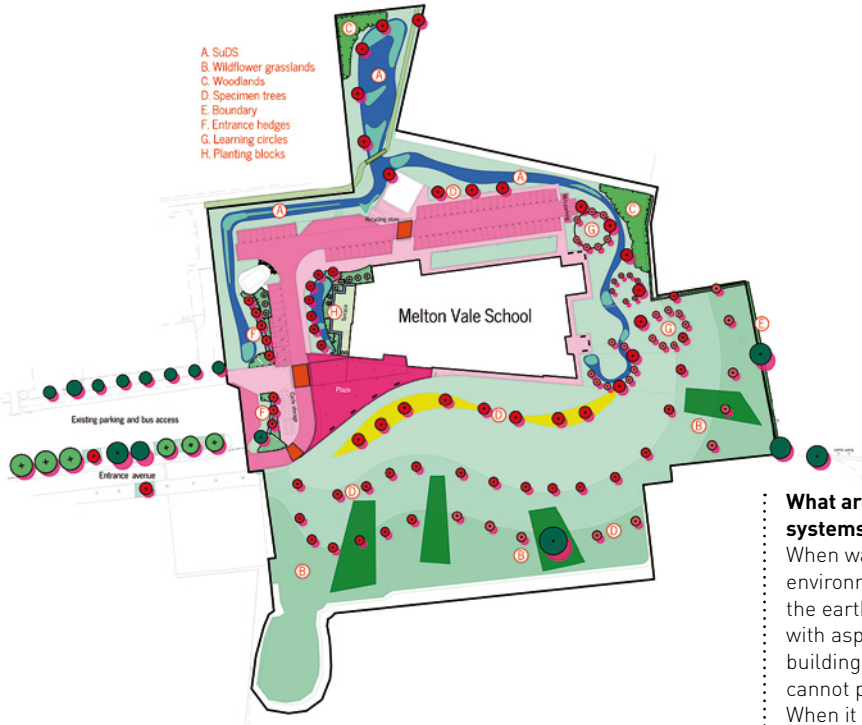


Photo: ©DSA Environment + Design

**What are Sustainable Drainage systems (SuDS)?**
When water falls on a natural environment, water is taken up by the earth. In our modern societies with asphalt parking lots, concrete buildings and paved streets water cannot permeate the ground.
When it rains the water is directed to local watercourses or the sewerage system. In Europe sewers and local watercourses overflow in case of heavy rains, events that are projected to occur more often with climate change. Overflowing sewers cause inconvenience, damage to buildings and pollution of the environment as wastewater is released to the environment. SuDS (Sustainable Drainage systems) alleviate those problems as they are designed to store or re-use surface waters at the source.
They do this by collecting surface water, or even polluted water, for instance water mixed with petrol or oil from the streets, and provide natural pre-treatment of the water before it is slowly released back into the environment. SuDS may include ponds and wetlands, swales, permeable surfaces, filter strips, infiltration trenches and underground storages.

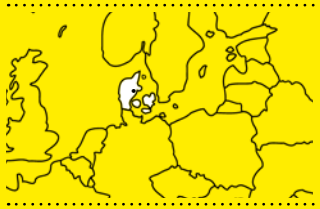
Large areas of new grass- and wetland are used to attenuate storm water.

(Photo: ©DSA Environment + Design)

# Creating new lakes to prevent flooding

climate risks

sector



**Location**
Aarhus, Denmark

**Total budget**
€€€€

**Non-financial costs**
none

**Non-financial benefits**
Enviroment, social and nature

**Project partners**
The private landowners in the area, Danish Nature, Local pumping society, Councillors in the City's Board, The former County Council of Aarhus

**Public or private project**
Public- private partnership

**Contact**
Nature and Environment, Municipality of Aarhus
Mogens Bjørn Nielsen, Head of Department
e-mail: moni@aarhus.dk

The lake attracts many different bird species in high numbers, with 169 species registered up to 2010.

# Wetlands reduce flood risks in Egå Engsø

**In Denmark climate change is projected to lead to more intense rainfall and rising sea levels. This prospect makes the provision of flood protection, especially for low-lying and densely populated areas, increasingly urgent.** An inexpensive and intelligent solution is to create what Mogens Bjørn Nielsen from the Nature and Environment department of the municipality of Aarhus calls 'time and space for water' in rural catchments.

Egaa Engsoe, a lake of 115 hectares surrounded by 165 hectares of wet meadows, is an example of creating 'time and space for water'. It is located in the densely populated and low-lying valley of River Egaa close to Aarhus. In 2006 the old river dikes were removed and the drained and pumped area was flooded. The created lake stores water during heavy rainfall, which reduces the risk of flooding. Additionally, the lake reduces nitrogen leaching from surrounding agricultural areas.

The main motivations of the Municipality of Aarhus to create Egaa Engsoe were to obtain a cleaner water environment that enhances the recreational uses and serves to adapt the region to projected climate change. The water level of the lake can rise by about one metre, depending on seasonal rainfall conditions. A dynamic flow model for the area shows that the lake has reduced the flood risk of the densely populated areas in the lower part of the river valley.

Mogens Bjørn explains that initially it was difficult to sell the idea of a new wetland because this was a new idea and concept. But when the area first became flooded, many people asked: "Why haven't we done this before?" – followed by expressing their appreciation of the beauty of the lake and its surroundings. This shows that the project was successful in terms of managing the many interests of the involved stakeholders and to find a solution that is technically wise, from a flood risk reduction point of view, as well as financially convincing. Interestingly the Egaa Engsoe is now one of the most popular recreational sites in the municipality. Every day the site is visited by many hundreds of citizens and it has become an important green-blue area in the region.

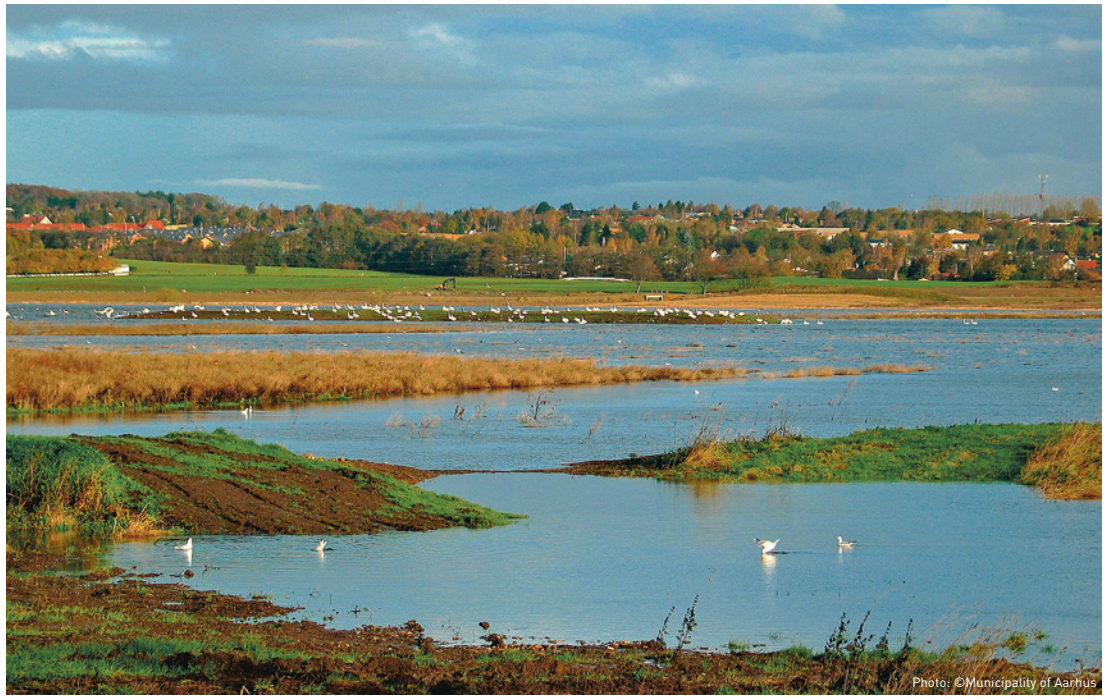


Photo: ©Municipality of Aarhus

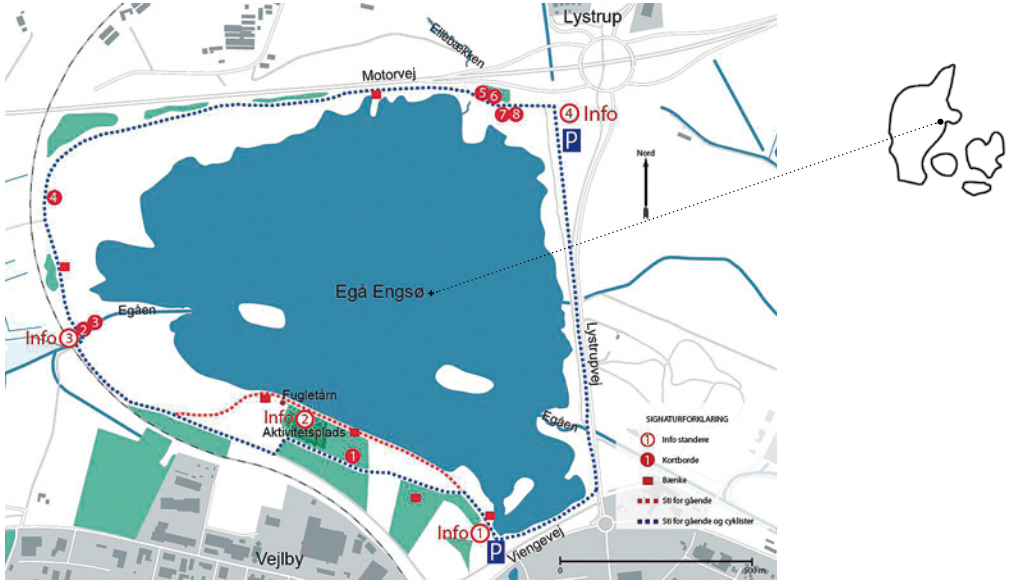


Photo: ©Municipality of Aarhus

**Proof that the reservoir works**

"On August 26th 2012 we had a once in 50 year thunder storm with heavy rain fall in Aarhus," Mogens Bjørn explains. "That day 500 houses in Aarhus were damaged by flood water. But downstream of Egaa Engsoe no houses were flooded along the river. Because of the reservoir capacity in the new lake several hundreds of houses were prevented from being flooded. Our data shows that during the flood the discharge to the lake was 6.5 $m^3$ per second and the discharge out of the lake to the low laying section of the river downstream was only half of that. During the period of the flood 650.000 $m^3$ water was stored in the lake and not discharged to the river downstream. In hours and days after the flood, the water from the lake was slowly discharged to the downstream reach of the river without causing any harm."

The main motivations of a municipality to create a lake, is to obtain a cleaner water environment that enhances the recreational uses and serves to adapt the region to projected climate change.

Woodland can help to sequester carbon, reduce the emission of greenhouse gases and support in the adaptation of areas to inevitable changes of the climate in the future, including extreme rainfall events and flooding.

read more → next page

# Community woodlands managed by the people

climate risks

sector

**Location**
Somerset County, United Kingdom

**Total budget**
€€€€

**Non-financial costs**
none

**Non-financial benefits**
Enviroment, social and nature

**Project partners**
**UK Partners:** Somerset County Council, Environment Agency, Somerset Drainage Boards Consortium, Somerset Wildlife Trust RSPB, Farming and Wildlife Advisory Group (FWAG)
**European partners:** WRD – Waterboard Regge & Dinkel (Netherlands), WVER – Wasserverband Eifel-Rur (Germany), WGS – Waterboard Groot Salland (Netherlands), VMM – Vlaamse Milieumaatschappij (Belgium), IAV – Institution d'Amenagement de la Vilaine (France)

**Public or private project**
Public

**Contact**
Somerset County Council
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(Photo: ©Phil Stone)

It is only a sense of local ownership that the development of a new woodland is possible and involvement of local inhabitants.

# WAVE Community Woodlands and Climate festival in the Somerset County

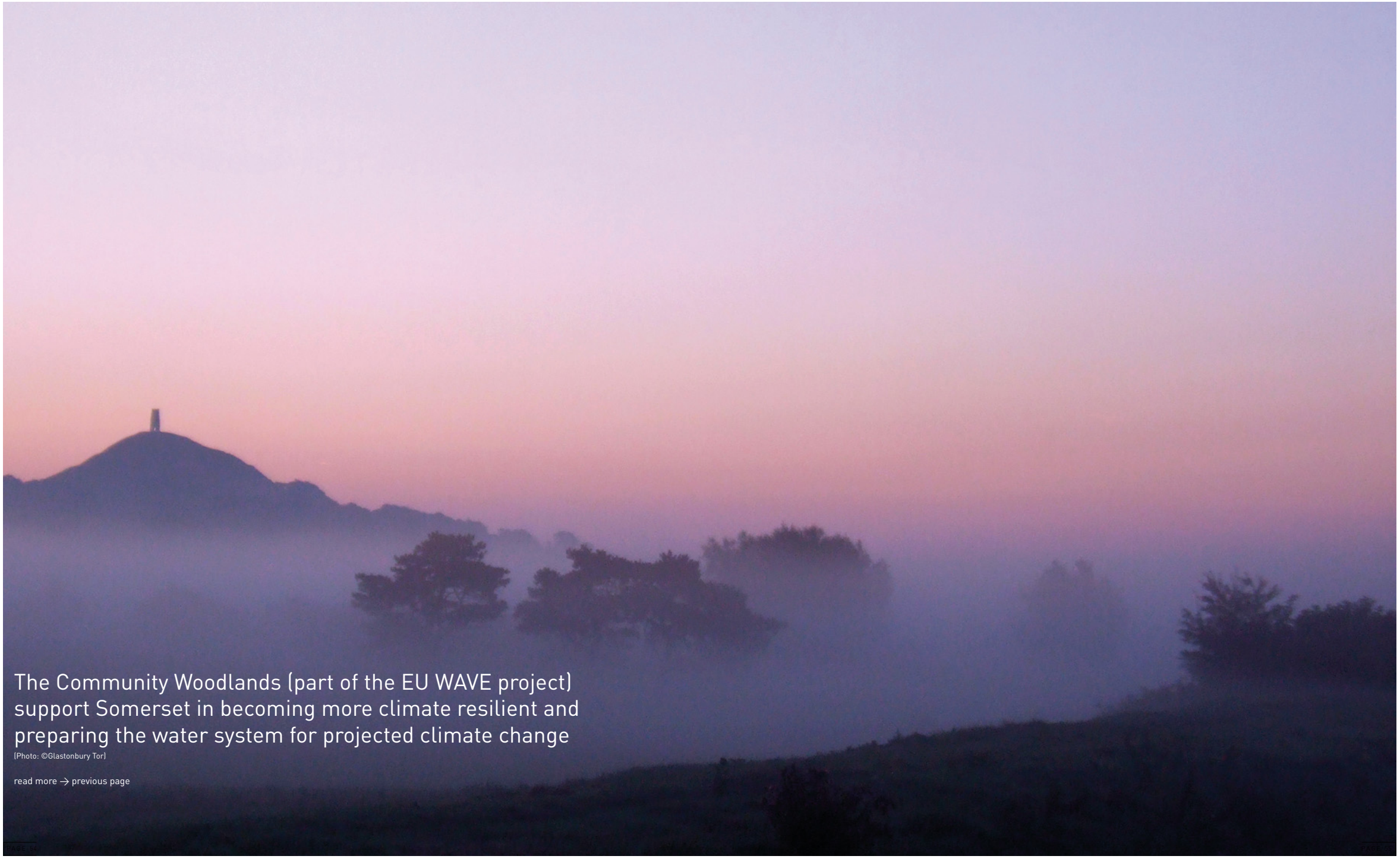
(Photo: ©Steve Dury)

(Photo: ©Steve Parker)

(Photo: ©WAVE)

**The county of Somerset is one of the counties in the United Kingdom with the lowest woodland cover.**
Woodland can help to sequester carbon, reduce the emission of greenhouse gases and support in the adaptation of areas to inevitable changes of the climate in the future, including extreme rainfall events and flooding. This triggered Somerset County Council six years ago to encourage the development of so called Community Woodlands. Since then, twelve Community Woodlands have been established with local residents.
The woodlands are usually between a quarter and five hectares of managed (semi) wild areas with trees and shrubs located within a short walking distance to the next village or town. The Community Woodlands (part of the EU WAVE project) support Somerset in becoming more climate resilient and preparing the water system for projected climate change. Somerset intended to work with natural processes to manage excess water in a sustainable way, for instance by providing more space for water in the environment, while at the same time minimising the impact on communities and landowners, and maximising opportunities for wildlife and other local interests. Trees can alleviate the severity of flooding because they increase the water-holding capacity of the ground and slow down water runoff.
Phil Stone, the lead officer from Somerset County Council, points out that planning a new woodland and gaining local support is not always easy. An important, yet also critical first step, is to find an owner who is willing to give up land that can be developed into a Community Woodland. It is only a sense of local ownership and therefore local interest and involvement that the development of a new woodland is possible and involvement of local inhabitants guaranteed. Local councils with an interest in creating a woodland in their municipality published the initiative to the public. For towns where volunteers stepped forward new woodland schemes were planned. There have also been cases where individual landowners were the main instigators of the projects and there was little involvement of the local Councils.
An incredible 161 volunteers have contributed an estimated 21.760 hours to the WAVE project, mainly on habitat management, wardening of reserves and botanical surveying, for Somerset Wildlife Trust (SWT). SWT has completed 222 advisory visits to landowners and 31 agri-environment scheme applications (part of the current Rural Development Programme for England (RDPE)), that provides funding to farmers and other land managers in England to deliver effective environmental management on their land. These activities will inject almost £2.9 million into the economy of the Somerset Levels and Moors over the next ten years.
Within the WAVE project, Somerset organised a Water Festival, which was attended by 6.000 people.

**Water festival to inspire visitors**
Water or River Festivals have been held in Somerset since 2003 with the first event attracting 2.000 people. Water Festivals are all about the people of Somerset celebrating their local rivers, as a way of raising awareness of their value and the importance of conserving water. It is estimated the 2009 Water Festival attracted approximately 6.000 to 7.000 people throughout the course of the day. The event has rotated between three venues: Bridgwater, Langport and Taunton. The Festival was intended to serve as an event that would bring together the communities of the Bridgwater and River Parrett catchment areas. As in past events it was agreed that a family focused fun day would be the best method of attracting a wide audience and greater numbers together with the fact that admission to the Festival would be free of charge. Without doubt, the event was a huge success, and enjoyed by all. There was a good turnout of boats of all types, good attendance by members of the public, a good feeling of community spirit, live bands, and happy traders who reported lots of activity.



The Community Woodlands (part of the EU WAVE project) support Somerset in becoming more climate resilient and preparing the water system for projected climate change

[Photo: ©Glastonbury Tor]

read more → previous page

# Let it rain, let it rain, let it rain

climate risks

sector

**Location**
Trondheim, Norway

**Total budget**
unknown

**Non-financial costs** none

**Non-financial benefits**
Enviroment, business, social and nature

**Project partners**
The project is led by the Norwegian Water Resources and Energy Directorate (NVE)
Cooperators: EU Interreg 4b project SAWA, Norwegian Cities of the future project (Framtidens byer), Norwegian research project ExFlood , Technical university Trondheim, NTNU, City of Trondheim

**Public or private project**
Public-private partnership

**Contact**
Norwegian Water Resources and Energy Directorate (NVE)
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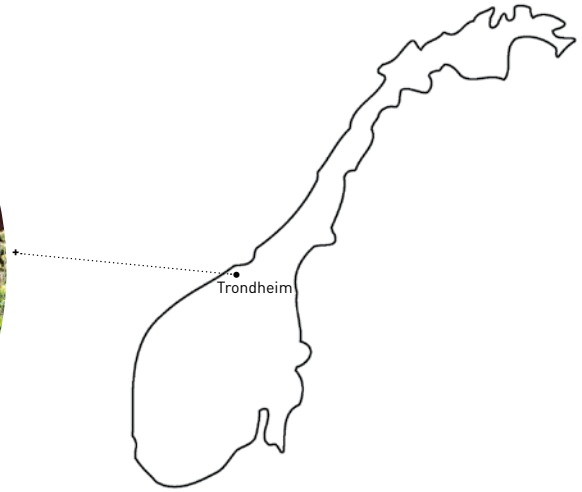
e-mail: bcb@nve.no

Rain gardens or bio retention areas have been used to manage extreme events for decades, and inspired the people of Trondheim

# Rain gardens to manage extreme rainfall events

(Photo's: ©Arvid Elke)




**The Norwegian city of Trondheim is building rain gardens to reduce the water load on the sewers and retain water on the site where it falls as rain.** These rain gardens are inspired after an American example. In the United States rain gardens have become a popular storm water management practice. Rain gardens or bio retention areas have been used to manage extreme events for decades, and inspired the people of Trondheim to build their own. Rain gardens are constructed as shallow planted depressions and facilitate a local management of storm water through collection, retention and infiltration of water.
A pilot rain garden in Trondheim was constructed in 2010, in the city borrow Risvollan, with help of landscape and construction company Anlegg & Utemiljö. To create a rain garden the clay soil had to be excavated and refilled with sandy soil. When it rains heavily storm water will enter the rain garden and slowly seep into the sandy soil and finally into the drainage layer which includes a drain that directs excess water away. The pilot rain garden in Trondheim is 40 square metres large and has a water retaining capacity of approximately 13 cubic metres including the filter media. These rain gardens were designed and built under an initiative led by the Norwegian Water Resources and Energy Directorate (NVE) with the aim to adapt cities to climate change.

To test the effectiveness of the rain garden a model was created to simulate the hydrological performance of the Risvollan rain garden. The model contains real data that was measured since its instalment in 2010. The results indicate that the rain garden can reduce a 15-year peak flow (26 mm in three hours) with up to 90 percent for a large rain garden, which covers 7 percent of a catchment area. The infiltration rate was 10 cm/hour, and the water depth 20 cm. Peak reduction was 22 percent for a smaller rain garden, which covers 4 percent of the catchment area. Furthermore, the results show that a standard rain garden, which covers between 5 to 7 percent of the catchment area, should be capable of managing as much as 90 percent of the annual runoff in Trondheim. The infiltration rate is essential for the rain garden performance. In two smaller rain gardens about 7 m2 in size, a 30 year flood peak in Oslo (24 mm in 20 min) can be reduced with 77 and 100 percent when the infiltration rate was 17 and 104 cm/hour respectively.
Besides the promising water retention capacities, rain gardens improve the quality of their environment, as they increase the amount of green - and blue structures in cities. A functioning rain garden requires a certain amount of maintenance, for example weeding and irrigation, that needs to be taken into account when planning a rain garden. Bent Braskerud, from the Norwegian Water Resources and Energy Directorate (NVE), indicates that investing in rain gardens leads to lower costs for water management. "Using pipelines for storm water are actually not the wisest investments. Open storm water systems, on the contrary, give the population more value for money as they create green and blue structures in the urban environment - nature in the city." Creating more room for water and ecological niches might even increase biodiversity.

**Rain gardens**
Rain garden are lower areas in the landscape that allow rain water runoff to be absorbed into the ground. A rain garden looks just like any cultivated garden and may attract birds, butterflies and wild flowers. Rain gardens in cities serve a double purpose: they reduce the water load on the sewer system in case of heavy rains and serve as green havens for animals ánd humans. Rain gardens can be used everywhere human structures such as asphalt and pavement prevent infiltration, and were vegetation can be planted. It is a flexible tool to store water and to create a more diverse landscape in the city. An extra benefit is that polluted surface water will be purified to some extend when it infiltrates the filter media.

One of the difficulties in raising awareness of climate change is that it is perceived as a global problem, with large scale impacts, but huge uncertainties in terms of exact local effects. Some adaptation measures have to be taken locally, and for people to understand and accept these measures, climate change has to be made local and tangible

# Teach the children – and make it fun

climate risks

sector

**Location**
Tiel, the Netherlands

**Total budget**
€€

**Non-financial costs**
none

**Non-financial benefits**
none

**Project partners**
Municipality of Tiel, TekstPerfect, Vissia, Made by Mistake, Stichting Duurzaam Rivierenland

**Public or private project**
Public

**Contact**
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Annemieke Spit
e-mail: aspit@tiel.nl

Photo: ©Municipality of Tiel

While raising awareness of climate change in a fun way, the programme also creates understanding for the water measures that will be taken in Tiel.

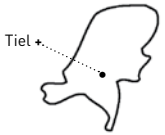
# Educational programme climate change and water

Photo: ©Municipality of Tiel

**Educating children and raising their awareness of climate change is important and can help to make future generations more knowledgeable and thus more informed about adapting to climate change.** The municipality of Tiel, in the Netherlands, created the educational programme 'Wie, Wat, Water' (or: 'Who, What, Water') on climate change and water for the city's primary schools. The programme gradually narrows its scope from global to local effects in the eastern part of Tiel and it highlights the green and water measures that are being taken there. While raising awareness of climate change in a fun way, the programme also creates understanding for the water measures that will be taken in Tiel.

One of the difficulties in raising awareness of climate change is that it is perceived as a global problem, with large scale impacts, but huge uncertainties in terms of exact local effects. Some adaptation measures have to be taken locally, and for people to understand and accept these measures, climate change has to be made local and tangible. In Tiel, school children are educated about climate change, which builds a bridge between understanding the need for adaptation to climate change and accepting local adaptation measures.

Tiel East is an area that has to deal with a lot of water nuisance, such as flooding. The district lies between the dikes of the Waal and the Amsterdam-Rijn Canal. Problems with seepage water occur everywhere along the Waal, especially at high water levels. As a result of projected climate change and higher water levels more seepage water will be created in the future. To keep the district liveable the water nuisance must decrease. The search for solutions started with a 'the more the merrier' adagio. From resident to water expert, from historian to urban developer, from dike warden to project developer, everyone was welcome. A motley group of people started looking for ideas to make Tiel East drier and nicer. By combining the knowledge of many different people the best results are created. Each group has made a new map of Tiel East. They include operations that can make the district better able to cope with water nuisance and add quality to the environment. Jointly the groups have collected dozens of ideas. All kinds of things are included: permeable streets, a super-wide climate dike, new canals and ditches, green roofs and water squares.
Tiel East features as a case study example in the school children's teaching programme. The educational programme starts with one of the teachers leading a group discussion about climate change: what do the children already know about climate change? After the introduction the children learn to work with a special 3D water map of the Netherlands in which floods can be simulated. They actively experiment with water to see the effects of different water levels on the Dutch lands.
The programme is quite popular amongst schools in Tiel, kids and their teachers appreciate the playful way they learn about the subject.

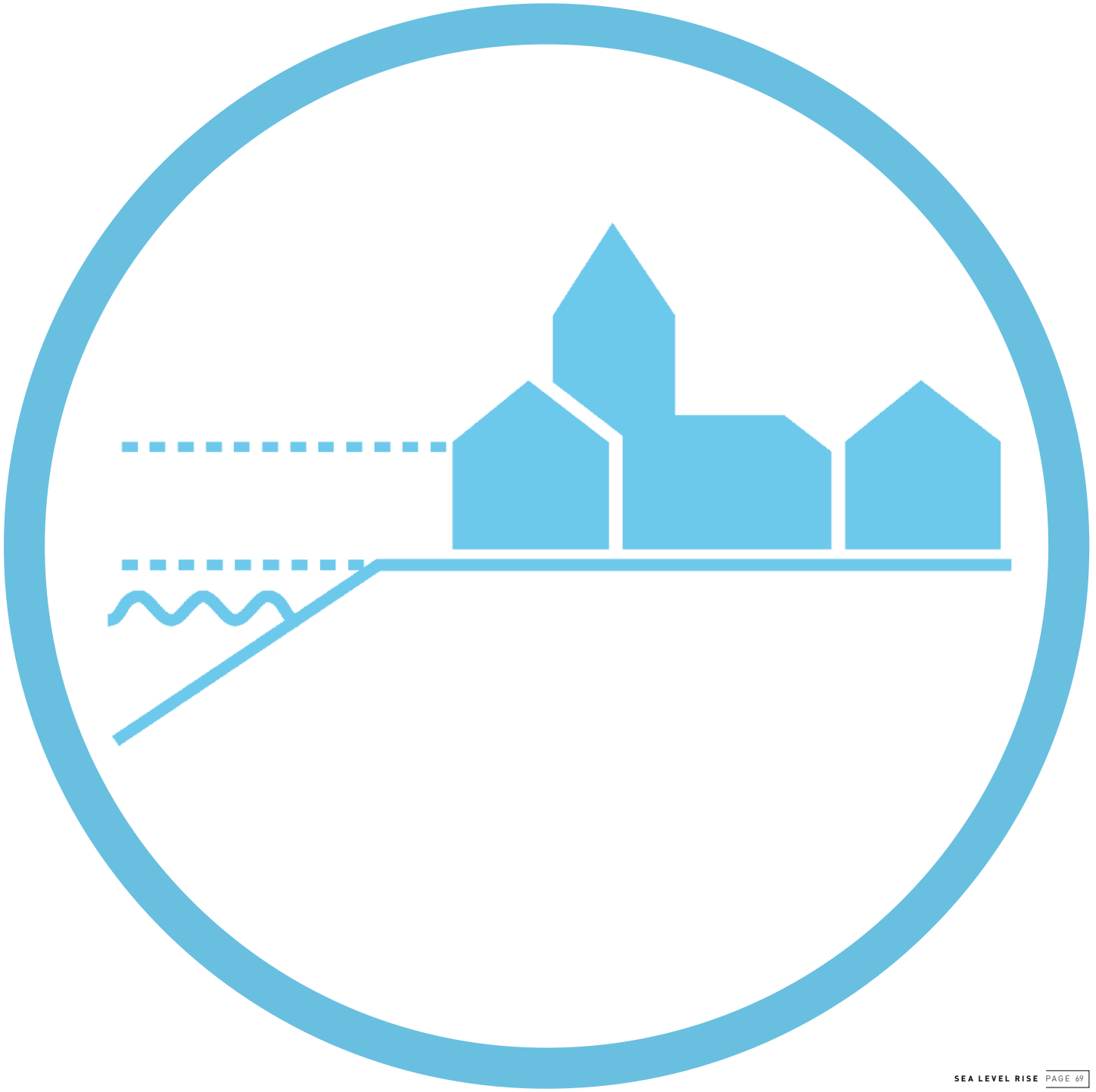



**Watergame: playing in a virtual world and finding real life solutions**
Communication tools like the educational programme have proven their value in Tiel East. The Watergame is another example that was developed to improve the process between local stakeholders in the area: project developers, water board, municipality, housing associations and citizens. It's a multiplayer game in which several circumstances are simulated, for example heavy rainfall, high river levels, effects of extra paved surface due to new developments and the effects of water measures. It was a fun way to gain more insight in each others interests and learn about the benefits of looking for solutions together. It had a positive effect on the actual process. The Watergame led to a scenario that combines solutions for short term issues, such as water storage, with solutions for long term issues such as adapting to climate change with multifunctional dikes.

Future climate change is expected to add to vulnerability, as extreme weather events are expected to become more intense and frequent.

If European societies do not adapt, damage costs are expected to continue rising.

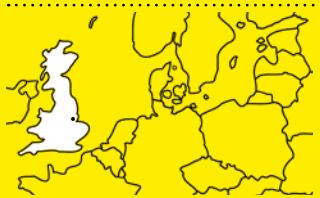
# sea level rise



# Nature as an ally in coastal defence

climate risks

sector



**Location**
Freiston Shore,
United Kingdom

**Total budget**
unknown

**Non-financial costs**
Business

**Non-financial benefits**
environment, social and nature

**Project partners**
Department for Environment Food and Rural Affairs (Defra), Royal Society for the Protection of Birds (RSPB), Environment Agency, Natural England

**Public or private project**
Private

**Contact**
Environment Agency
Philip Staley
e-mail: philip.staley@environment-agency.gov.uk

Photo: ©The Environment Agency (UK)

One of the largest managed realignment sites in the UK is located at the Freiston shore on the north-western bank of The Wash bay and estuary.

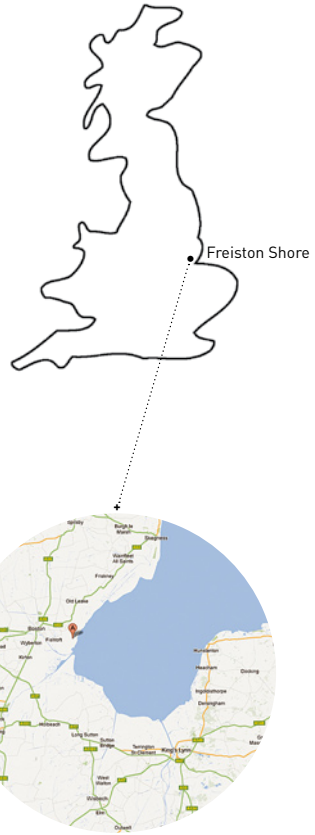
# Freiston shore managed realignment

Freiston shore through the years
(Photo's: ©The Environment Agency (UK)

**What is the best way to protect the European coast? Most people would probably answer that they know about dikes, dunes and embankments to protect the land from powerful storms and waves of the sea. Another approach to coastal zone management and coastal protection is managed realignment.** Managed realignment is where the original coastal defence line, for instance an embankment, is breached and a new defence constructed elsewhere. One of the largest managed realignment sites in the United Kingdom is located at the Freiston shore on the north-western bank of The Wash bay and estuary. Managed realignment schemes along the United Kingdom's coastline provide a sustainable flood defence solution that incorporates a functioning ecosystem and compensates for habitat loss by traditional flood defence and other human induced works.

Photo: ©The Environment Agency (UK)

Managed realignment schemes introduce a new way of thinking about flood defences, which traditionally focused on built structures. Instead of resisting the impact of water, for example with a sea wall, this method manages the tidal inundation and wave impact. Using nature or natural powers plays an important role in this new thinking. At Freiston the primary defence, an embankment, was breached at three sites. Through the three breaches, tidal currents are now able to flow freely into the enclosed marsh land and create a new habitat from what had previously been reclaimed agricultural land. The newly created salt marsh provides a natural habitat for birds and plants and serves as a sustainable sea defence. It also breaks the incoming waves and reduce their energy. This leads to less impact on the sea defence, for example, a dike that is lying further inland. These objectives are linked to the requirements of the Habitats Directive and the UK Biodiversity Action Plan (BAP) targets. The targets for salt marshes and mudflats are incorporated into UK Shoreline Management Plans. The Royal Society for the Protection of Birds (RSPB) manages the site and has created a wetland habitat with a brackish lagoon that is used by birds, juvenile fish and birdwatchers.




The project is successfully delivered through partnerships between the Department for Environment Food and Rural Affairs (Defra), the Environment Agency, the RSPB and others. It has raised the standard of coastal defence and therefore reduced the flood risk to the surrounding area. In addition, a bird reserve has been created where many species of wildfowl and waders such as brent geese (Branta bernicla) and redshank (Tringa totanus) feel at home. The area is now a valuable nursery habitat for juvenile fish. The nationally significant species of birds and wildlife that can be seen at the site and adjacent lagoon has made Freiston popular with visitors, and the RSPB receives approximately 60.000 visitors to the site every year.

**What is a managed realignment?**
Managed realignment is a method that works with nature instead of against it. Under a managed realignment the original coastal defence line, for instance an embankment, is usually moved inland or to higher ground; an area of inter-tidal habitat is therefore developed between the new defence and the old defence. In order to create this inter-tidal habitat, the old dike or sea wall needs to be breached or completely demolished. This allows a regulated tidal flow into the site and allows for the development of salt marsh habitat species. Managed realignment schemes can also reduce the maintenance costs of the coastal defences located further inland. As an adaptation strategy to projected climate change, the inter-tidal habitat stands as an important sea defence. The salt marsh effectively breaks the waves and reduces their energy and therefore constitutes the first line of flood defence against tides and waves. This can be important under stormy conditions nowadays but also for preparing (adapting) coastal areas for projected sea level rise.

What is the best way to protect the European coast?
Most people would probably answer that they know about dikes, dunes and embankments to protect the land from powerful storms and waves of the sea. Another approach to coastal zone management and coastal protection is managed realignment.

read more → page 12

# A hybrid solution: dike-in-dune

climate risks

sector

**Location**
Noordwijk, the Netherlands

**Total budget**
€€€€

**Non-financial costs**
none

**Non-financial benefits**
Business

**Project partners**
Rijkswaterstaat,, Province of Zuid-Holland, Community of Noordwijk, Waterboard Hoogheemraadschap van Rijnland

**Public or private project**
Public

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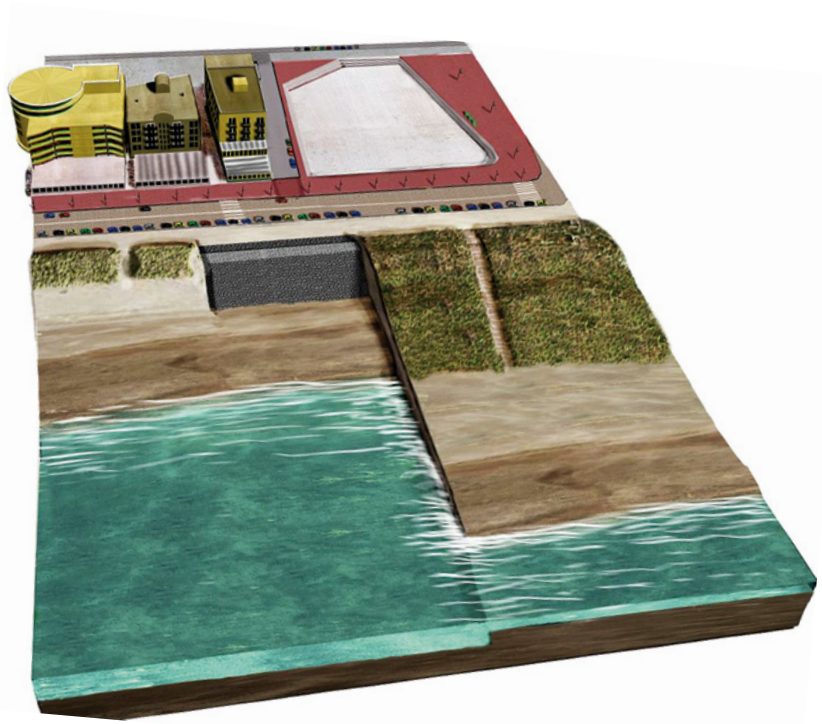
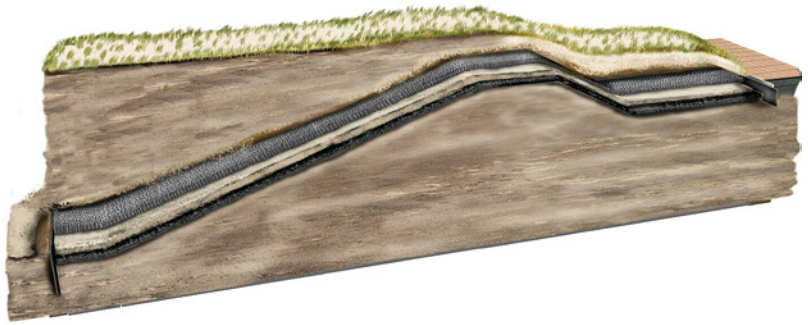
The dike was constructed first and covered with sand afterwards creating new dunes.

# Strengthening weak link Noordwijk





**The Dutch have centuries of experience guarding their coasts and protecting the land from the water.** The impressive piece of engineering ingenuity that are the Delta Works did a tremendous job in protecting the low lying delta country. Dunes and dikes protect the remaining coast line. The Dutch coastline has several weak spots that need urgent improvement. At the town of Noordwijk at the Dutch North Sea coast the dunes were deemed to be too low by one metre over a length of 100 metres. To improve one of several weak links in the Dutch coastal defence system, and in anticipation of projected climate change with higher sea levels and possibly more extreme storms, at Noordwijk a so-called dike-in-dune defence has been built.

Normally, either a dike or a dune forms the coastal defence. The location of the newly built dike in Noordwijk corresponds with the location of previously existing dunes and runs parallel to the boulevard.

old situation

new situation

A wide dune or a high dike would both have negative consequences on the activities on the boulevard and recreational activities in the area that form the backbone of Noordwijk's economy. The hybrid dike-in-dune was the perfect compromise. This way the view over the sea was mostly maintained, the area kept its natural dune landscape and Noordwijk would again be safe – and properly prepared for current and projected sea level rise.
The dike was constructed first and covered with sand afterwards creating new dunes. These new dunes have been connected to the existing dunes and broadened by about 40 metres towards the direction of the sea. The dunes are approximately nine metres above 'Normaal Amsterdams Peil' (NAP) – were around 0 NAP correspond with average sea level.

The dike-in-dune will effectively protect Noordwijk and its assets during a storm. If it's an extreme storm, the waves will first attack and erode the dunes. When all sand in front of the dike is eroded away by the storm, the dike at the core can withstand the rest of the storm.

The dunes are protecting the dike and the two protective measures complement each other. The dike-in-dune solution is unique, as it provides an alternative to traditional flood prevention strategies. This is of special importance when flood defences have to be built with limited space available.. Projected sea level rise is incorporated in the dike-in-dune principle.

The dike-in-dune measure has the additional benefit that it is a seaward solution of the defence strengthening measure. Therefore the formal boundaries for building restrictions along the boulevard were also moved seaward. This led to the removal of some building restrictions (especially underground parking garages) along the boulevard.

**Weak links in Dutch coastal defence**
The Dutch coast is constantly eroding. In 1991 the Dutch Government formalised the then current coastline. To sustain that coastline, the Dutch Government (Rijkswaterstaat) yearly adds 12 million m3 sand to the coast in beach and foreshore nourishments. This is a relatively cheap and robust way to keep the erosion at bay. In 2003 the Dutch coast was examined and ten locations where identified that were not meeting the norms for coastal protection. Taking into account climate change and sea level rise improving the dikes and dunes of the coast was deemed urgent. Since that time eight 'weak links' on the coastline have been improved, i.e. at Noordwijk, Scheveningen and the Delfland coast. At these locations the dikes were not traditionally improved by heightening or broadening them. Instead sandy solutions were chosen because of its sustainability and flexibility. At Noordwijk a dike was covered by dunes that naturally flow into adjacent the natural dunes. At other locations massive amounts sand was pumped onto the beaches, broadening the coastal area. Sand can easily be added to keep up with sea level rise.

As global temperatures rise, sea levels will also go up. Coasts will become more vulnerable to flooding and erosion, with significant consequences for the people, infrastructure, businesses and nature in these areas.

There is a long tradition of measures to protect coasts from the immense destructive power of the seas, but more will need to be done in the coming years with the increasing climate change impacts.

The Sand Motor is placed like a hook (one kilometre into the sea and two kilometres wide) with a maximum height of six metres and includes an inner lake.
(Photo: ©Rijkswaterstaat, Joop van Houdt)

read more → page 12

# Two cases of the Sand Motor concept: working with nature

climate risks

sector

**Location**
North Sea Coast and IJssel lake, the Netherlands

**Total budget**
€€€

**Non-financial costs**
none

**Non-financial benefits**
Envionment, social and nature

**Project partners**
**Sand Motor North Sea coast:**
Dutch ministry of Infrastructure and the Environment, Province of Zuid-Holland, Ecoshape (public-private partners), NGO's like Deltares, Universities, among others of Delft and Wageningen, several municipalities, environmental organisations
**Sand Motor Lake IJssel:**
It Fryske Gea, Building with Nature, Climate Buffer Coalition, Province of Fryslan, Water Board Fryslan, Ministry of Infrastructure and Environment

**Public or private project**
Public- private partnership
Public (National government, province, municipality; and Private (Boskalis, Van Oord)

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* Only for Lake IJssel

Photo: © Erik van Slobbe

The Sand Motor concept is not only applied along the Dutch sea coast, but also in the freshwater lake IJssel.

# Spreading sand along the coasts of the sea and lake IJssel

**The sea slowly but steadily gnaws off little bits of the Dutch coast. To counteract coastal erosion, the shoreline needs to be nourished, an activity that disrupts the local ecosystem every five years.** Keeping up with sea level rise requires an extra effort in sand replenishments. Dutch engineers came up with a less invasive and more nature friendly way of replenishing the sand and protecting the coast in a more sustainable way. The Sand Motor uses natural processes to help spread sand along the coast, leading to more sustainable coastal protection. The Sand Motor concept is as follows: a large amount of sand is deposited at a strategic location on the seabed. Wind, waves and currents transport the sea gradually northward along the coast. At Ter Heijde on the North Sea coast a total of 21 million cubic metres of sand have been deposited in 2011. Trailing suction hopper dredgers brought sand from the bottom of the North Sea and distributed it. The Sand Motor is placed like a hook (one kilometre into the sea and two kilometres wide) with a maximum height of six metres and includes an inner lake. On the highest point an observation mast of 40 metres high, with eight cameras was placed in 2012, to follow the development of the Sand Motor. Close to the Sand Motor restrictions for swimming may be in place, and rescue services keep a close eye on the Sand Motor.

The Sand Motor will gradually change shape and eventually diminish, when the waves and currents have transported the sand along the beach, supporting the formation of approximately 35 hectares of new dunes and beach. As a result of sand disposition, the coast will be wider and better able to withstand powerful storms and waves and is able to cope better with sea level rise. Other expected benefits of the Sand Motor, if the experiment proves to be successful, is the development of additional space for recreation and nature, as well as the natural maintenance of the beach over a long period of time. Additional vegetation has already developed The Sand Motor attracts a wide variety of animals, mainly birds and seals who tend to rest on the tip of the Sand Motor.

**The Sand Motor concept is not only applied along the Dutch sea coast, but also in the freshwater lake IJssel** (1100 square kilometres) in the heart of the Netherlands. Parts of the IJssel coasts of the province of Friesland have unprotected flood plains, which will submerge when the lake level rises as a result of sea level rise.

In 2009 the Dutch started experiments with the Sand Motor in Friesland, at Workummerwaard. The Sand Motor at Lake IJssel both enhances the level of security of the flood protection system and provides opportunities for natural development and recreation. The Sand Motor is initiatedby a broad coalition of regional and national actors and part of the national programme Eco Shape.
It took less than a year after the idea was conceived, to construct the Sand Motor at the Workummerwaard test site. In 2011, 20.000 cubic metres of sand were deposited 200 metres from the shoreline. A row of poles was constructed perpendicular to the coast. The poles reduce wave energy and facilitate sedimentation and they are the only visible element of the Sand Motor seen from the coast.

The Sand Motor attracts a wide variety of animals, mainly birds who tend to rest on the tip of the Sand Motor

Photo: © Erik van Slobbe

**The Sand Motor**
Authorities were keen to implement this experiment because of the need to adapt the management of IJssel lake level to the rising North Sea level. The Sand Motor was framed as an experiment contributing to the search for coastal adaptation measures. After a period of reconnaissance the Sand Motor was implemented as a learning object, with a heavy monitoring programme attached to it. The potential risk of failure was communicated to all those involved and actually only enhanced the willingness to participate because it fitted well in the partners' ambitions to innovate. "After all", says Erik van Slobbe, one of the accompanying scientific project partners, "we are working with nature here. There are no certainties with respect to the outcome. As steering the waves is simply not possible, it remains a matter of close study, good preparations and then letting natural processes take over."
The Sand Motor can then potentially be applied in other parts of the Netherlands, Europe and the rest of the world. Carola: "The Sand Motor has put the Netherlands back on the map as an innovative coastal defence specialist.

Other expected benefits of the Sand Motor are the development of additional space for recreation and nature, as well as the natural maintenance of the beach over a long period of time.

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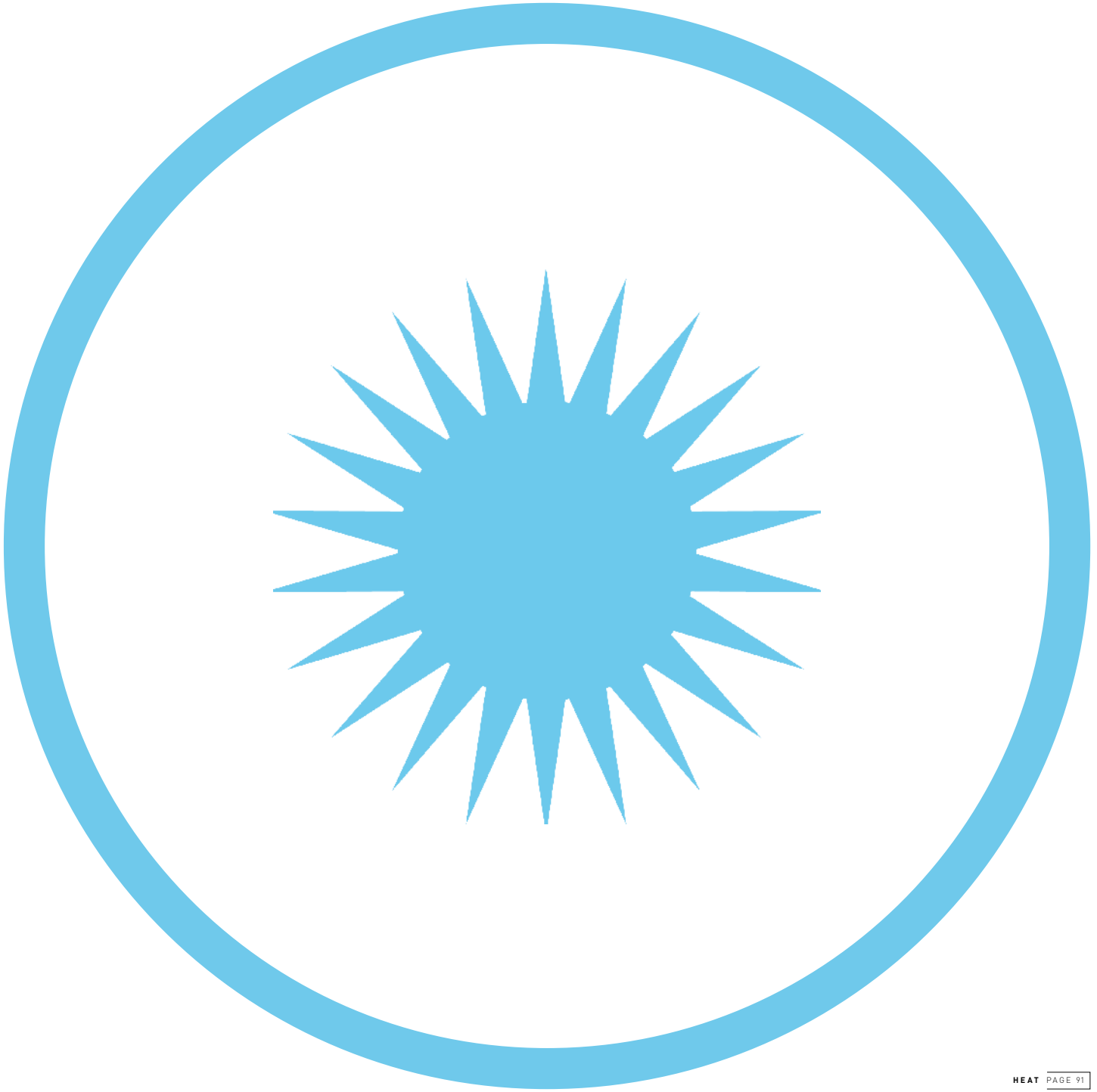
# heat



# A green alternative to air-conditioning

climate risks

sector

**Location**
Eferding, Austria

**Total budget**
€€€

**Non-financial costs**
none

**Non-financial benefits**
Enviroment, business, social and nature

**Project partners**
The private landowners in the Biohof Achleitner GmbH, EBP Preisack (construction and project management firm), Planning group AGSN, Danube University Krems

**Public or private project**
Private

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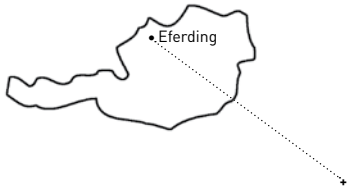
The plants and planter boxes in the Biohof Achleitner building are situated at different locations throughout the building.

# Biohof Achleitner: room acclimatisation with plants

Photo's: ©ebp

**Plants can be found anywhere: on the streets, in our homes and at work. Most people find plants pretty, or why else would they surround themselves with so many of them?** They might even say that plants have a positive effect on their well-being. This could be true not only from an emotional point of view, but also from a health perspective. Plants can help regulate indoor temperatures of buildings, when professionally installed in sufficient quantities. When the climate changes and temperatures rise cities are vulnerable, including as a result of enhanced warming through the heat island effect: because of the high density of buildings, roads and less green patches temperatures in cities tend to be higher - especially at night-time - than in the surrounding land. Installing air-conditioning might be a solution – but not a very sustainable one. On top of that: airconditioning can add to warming of the street as hot air is released to the outdoor environment. Could plants provide a (literally) greener alternative to energy consuming air-conditioning? This idea was tested in the Biohof Achleitner in Austria, a biological farm yard. The Biohof houses a whole sale, a marketing department, storage and processing sections, a bio-supermarket and a bio-restaurant. The building is a showcase for sustainable building design and is financially supported by the 'House of the future' initiative of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT).

The plants and planter boxes in the Biohof Achleitner building are situated at different locations throughout the building, including the foyer, cafe, hallways and in all the offices.



It's not a matter of placing a few potted palm trees here and there. Efficiently and effectively using plants for climate control requires meticulous planning, knowledge about the plants used, a suitable building architecture that allows sufficient sun light to reach the plants and an automatic irrigation system. The planning of the indoor plantation was done by a community of German architects from Tübingen who promote sustainable design, the Planungsgruppe AGSN. Scientists of the Danube University in Krems studied the effect of plants on the indoor climate of the Biohof Achleitner building for the first two years after the installation of the plants. Plants cool their environment by evaporating moisture through their leaves. Evaporation is a process that requires heat. Plants take this heat from their environment when evaporating. The surrounding indoor environment cools down subsequently. Evaporation rates of plants are linked to light intensities and vary throughout the day. The office plants start to evaporate water after the sun has risen and reach maximum evaporation rates around noon. Almost precisely at sun set evaporation rates slow down and come to a stop.

During the day plants are capable of increasing the indoor humidity 10-15 percent, presuming that 5-10 percent of the total indoor space is allocated to plants. In general, humidity during winter does not fall below 35 percent and during summer never rises above 60 percent. The results of the test have shown that the plants in the Biohof cool between 2.3 - and 16.2 watt per square metre. Or to put it in more familiar terms: a reduction in temperature of two degrees Celsius during the summer.
The associated costs of installing the plants are approximately 20-40 euro per square metre, although exact costs can vary. Maintenance, such as watering and trimming, is done by employees of the Biohof and demands about four working hours weekly. An interesting co-benefit pointed out by Eduard Preisack from the construction and project management firm EBP is, that since the plants have been installed six years ago, people called in sick less frequently than before: the humid air has positive effects on the human mucous membrane and may reduce susceptibility for a cold.

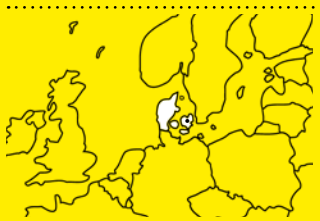
**Which conditions do plants need and what else can they do?**
Plants need sun light. When sun light is not sufficiently available, it has to be supported by artificial light. Plants located more than four metres from the facade, need additional sources of light, as shortwave length light can only be reflected to a limited extent. Long wave length light is important for the growth of plants and can be reflected by bright surfaces. The plants in the Biohof offices need light intensities between 1200 and 1800 Lux. To support the plants, additional ultraviolet light was installed. About two thirds of the lights can be switched off again after a short while. Plants demand regular watering, trimming and nutrition. Plants support the reduction of indoor air temperatures and improve the air quality to a certain extent by binding harmful substances from the air. Other positive effects, especially at the working place, include an impact on the mood of humans, the reduction of stress and tiredness and an overall positive impact on productivity.

Biohof Achleitner in Austria is a showcase for sustainable building design and is financially supported by the 'House of the future' initiative of the Austrian Federal Ministry for Transport, Innovation and Technology (BMVIT).
(Photo: ©ebp)

# The green roof philosophy of Copenhagen

climate risks

sector



**Location**
Copenhagen, Denmark

**Total budget**
€€

**Non-financial costs**
none

**Non-financial benefits**
Enviroment, business, social and nature

**Project partners**
The private landowners in the Biohof Universities, Municipalities, Waste water utilities, Suppliers of green roofs, Architectural companies

**Public or private project**
Public

**Contact**
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Dorthe Rømø
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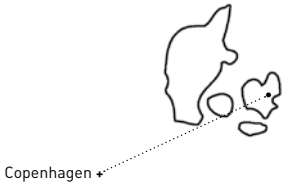
Illustration: ©Municipality of Copenhagen

Green roofs not only increase the quality of life in the city but can also help to adapt urban areas to projected climate change.

# Green Roofs in Copenhagen



**Looking out over the city of Copenhagen Dorthe Rømø, from the Technical and Environmental Administration of the municipality of Copenhagen, imagines a sea of green around her on the rooftops of the city.** Green, that's the new grey, is what you will also hear from many citizens in the lively metropolis of Copenhagen. Green roofs not only increase the quality of life in the city but can also help to adapt urban areas to projected climate change. Copenhagen is working hard on making this vision a reality. Green roofs in itself are no novelty, but the large scale implementation of it and supportive policies under Copenhagen's Green Roof Philosophy are.
Why let city roofs lie around useless? That was one of the questions that motivated Dorthe to raise the interest of many Copenhageners, including the city administration, for a more coherent green roof policy. Or rather: a green roof philosophy. Dorthe: "Green roofs are part of a new strategy to develop our cities, respecting nature and adding functionality to the cities, ultimately adding quality of live for all citizens. Green roofs will help the city to cope with climate change as green roofs decrease heat in the city."

Photo's: ©Dorthe Rømø

It all started with a renewable building demonstration project at a kindergarten, showcasing a diverse array of green roof solutions. To promote the green roofs philosophy in urban design and development, and to promote green roofs to Copenhagen residents, Green Roofs Copenhagen organises meetings, workshops, and conferences where interested citizens and business owners can get inspired and informed. Taking cooperation to the next level, new projects are initiated, where stakeholders from different sectors share their knowledge, experience and get inspired by each other. The initiative gave an immense boost to green roofs in the city planning in Denmark. In Copenhagen alone, 40 green roofs were designed and built over the last years, which are now providing approximately 40.000 square metres of functional green in the city. Very importantly, green roofs are mandatory in most new local plans, for houses with a roof slope of less than 30 degrees. Dorthe: "We have calculated that because we have been mandating green roofs in most new local plans we have more than 200.000 m2 of green roofs coming up the next years." In one of northern Europe's largest development sites, the so called North Harbour, new houses have to be built with green roofs. They all contain a rooftop angle of less than 30 degrees to facilitate the placement of plants on the roofs. Furthermore green roofs are integrated into various other guidelines such as guidelines for adaptation to climate change, guidelines to support Copenhagen's strategy for biodiversity, as well as the guidelines for sustainability in constructions and civil works.
"Today we have a least 40 green roofs with a total of 30-40.000 square meters. Since we have made green roofs mandatory in local plans drafted in 2010 and 2011 we expect to increase the amount of green roofs to 200.000 square meters in the coming years", says Dorthe, and she adds: "And that's only based on local plans approved in 2010 and 2011, so even more will follow as more locals plans will make green roofs mandatory."

The city of Copenhagen does not directly give funding to create green roofs, as other European cities do. Dorthe: "What we offer is a onetime reduction of 300 Danish Krone for each square metre you can cut off from the public sewer system. I believe that if we choose to create subsidies programmes for some years it could boost the green roof development further especially in retrofitting projects."
Among green roofs in Copenhagen you now find the Gyldenris Park: Nursery school with a 'garden of sensation' and playground made of nature materials on the roof, the green roof of the National Archives which includes an integrated cycle track and the green 'lid' on a basement garage in Sluseholmen.

**Recycling good ideas**
Traditional Scandinavian green roofs have been around for centuries in Scandinavia. The traditional sod, or turf roof, is a traditional Scandinavian type of green roof covered with sod on top of several layers of birch bark. It was the most common roof in rural areas until well into the 19th century. The heavy load of the roof (250 kg/m2) prevented leaking as the logs of the wooden house were tightly pushed together, making the walls more draught proof. The sod roofs also helped to insulate the house during cold winters. The water tight element of the roof was birch bark. Sod was mainly used to keep the birch bark in place. Today's green roofs are rather more sophisticated, using waterproof membranes, drainage layers, filter fabrics, growing medium, advanced irrigation and carefully selected plants.

Why let city roofs lie around useless?

(Photo: ©Dorthe Rømø)

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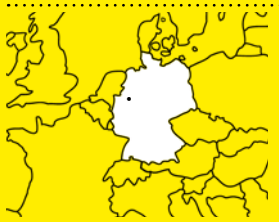
# Citizens mobilised: creating a blue-green corridor in the city

climate risks

sector



**Location**
Kamen, Germany

**Total budget**
€€€€

**Non-financial costs** none

**Non-financial benefits**
Enviroment, social and nature

**Project partners**
Citizens living along the Heerener Mühlbach, enterprises and owners of the properties alongside the Heerener Mühlbach, European partners of the Future Cities project, Waterboard Lippeverband, Municipality of Kamen, planning and construction companies

**Public or private project**
Public- private partnership

**Contact**
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Photo: ©Cordula Skrabaczewski, Lippeverband

The Heerener Mühlbrook was for a long time an open sewer system with steep, concrete banks which were dangerous for human life.

# Disconnecting storm water runoff from the sewer system

**What do you want us to do about climate change? Do we even have a problem? Citizens of the city of Kamen in Germany were not at all concerned about climate change when the city first came with a plan to adapt the Heerener Mühlbach (Heerener Mühlbrook), a tributary of the river Lippe, to climate change.**

Marie-Edith Ploteau of the water board Lippeverband was not surprised: "Climate change is a global problem, but for adaptation you need to involve people on a local level. You must go to the smallest scale to explain about climate change, or it remains an abstract problem." During public information sessions citizens learned about the urban heat-island effect, the chances of increased flooding and more severe flooding under projected climate change, for instance the overflowing of the sewer systems in the system after heavy rains. Especially appointed experts made house visits to talk to people in their homes about taking matters into their own hands and adapting to climate change.

The Heerener Mühlbrook runs straight through Kamen, but for a long time was an open sewer system with steep, concrete banks which were dangerous for human life. Fences prohibited approaching the brook. The sewer system flooded frequently – and was expected to do so more often in the future. An important aspect was to create separate trajectories for waste water and storm water (rain). To improve the water quality of the Heerener Mühlbrook an underground sewer pipe was constructed alongside the brook. In addition more room was created for the brook's water to flow, removing the concrete bed and the contaminated ground, creating natural banks and letting the water body meander again.

Photo: ©Anke Althoff, Lippeverband

As part of the European project Future Cities citizens were mobilised to help disconnect storm water runoff from the sewer system and help adapt Kamen to future climate change. The joint ecological improvement and the sustainable use of storm water will have a positive impact on the environment: higher resilience in case of heavy rainfall, better microclimate especially in summer and stronger ecological functions of the water body . Because future rainfall and temperature are not exactly known, it had to be done in a flexible and cost-effective way, and combine different urban functions.

Photo: ©Cordula Skrabaczewski, Lippeverband

The early adaptors of Kamen that showed interest after the first information sessions could expect visits from technicians who discussed their possibilities of disconnecting storm water from their homes and properties from the mixed sewer system. Technical support and financial incentives were available, but parts of the disconnection were paid for by the citizens themselves: 16-21 euro per square metre. More and more citizens realised the importance of the project and ultimately almost 80 houses and properties were disconnected from the mixed sewer system. Marie-Edith: "When one home owner was convinced, it was easier to convince the neighbours as well."The disconnected rain water from the 80 properties is being lead through the renatured Mühlstream.

Besides the ecological improvement of the water body and the disconnection of storm water from private properties, plants were added to the brook to attract flora and fauna wildlife and increase biodiversity. This way the green-blue corridor increases the quality of the environment by creating possibilities for recreation. A bicycle path and walking path was built connected to the city walking paths. During summer the area provides a cool refuge from summer heat. And in addition all dangerous signs and lots of fences have been thrown out, much to the pleasure of the neighbourhood.

The close collaboration of the water board and the municipality with the citizens living next to the water body led to an increasing awareness of the citizens regarding adaptation to climate change and what they can personally do to adapt.

**Never be sorry: no regret measures**

No-regret measures are often mentioned with respect to climate change adaptation. As the exact rainfall patterns are uncertain, it is wise to consider those options and measures that address today's problems and are flexible. This way they can be adjusted in the future as circumstances evolve or new insights provide better basis for action. No-regret measures also combine different functions so that several aspects at the same time receive benefits from a measure. It is also important that some functions receive immediate benefits, such as an improvement of the quality of the environment, or opportunities for nature or for businesses.

To improve the water quality of the Heerener Mühlbrook an underground sewer pipe was constructed alongside the brook

Photo: ©Marie-Luise Pickel (Lippeverband)

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In Stuttgart, as in any European city, space is valuable and can only be used once.

Population growth and climate change will intensify the conflict between open (unused) space and economically interesting building projects.

Photo's: ©City of Stuttgart, Office for Environmental Protection

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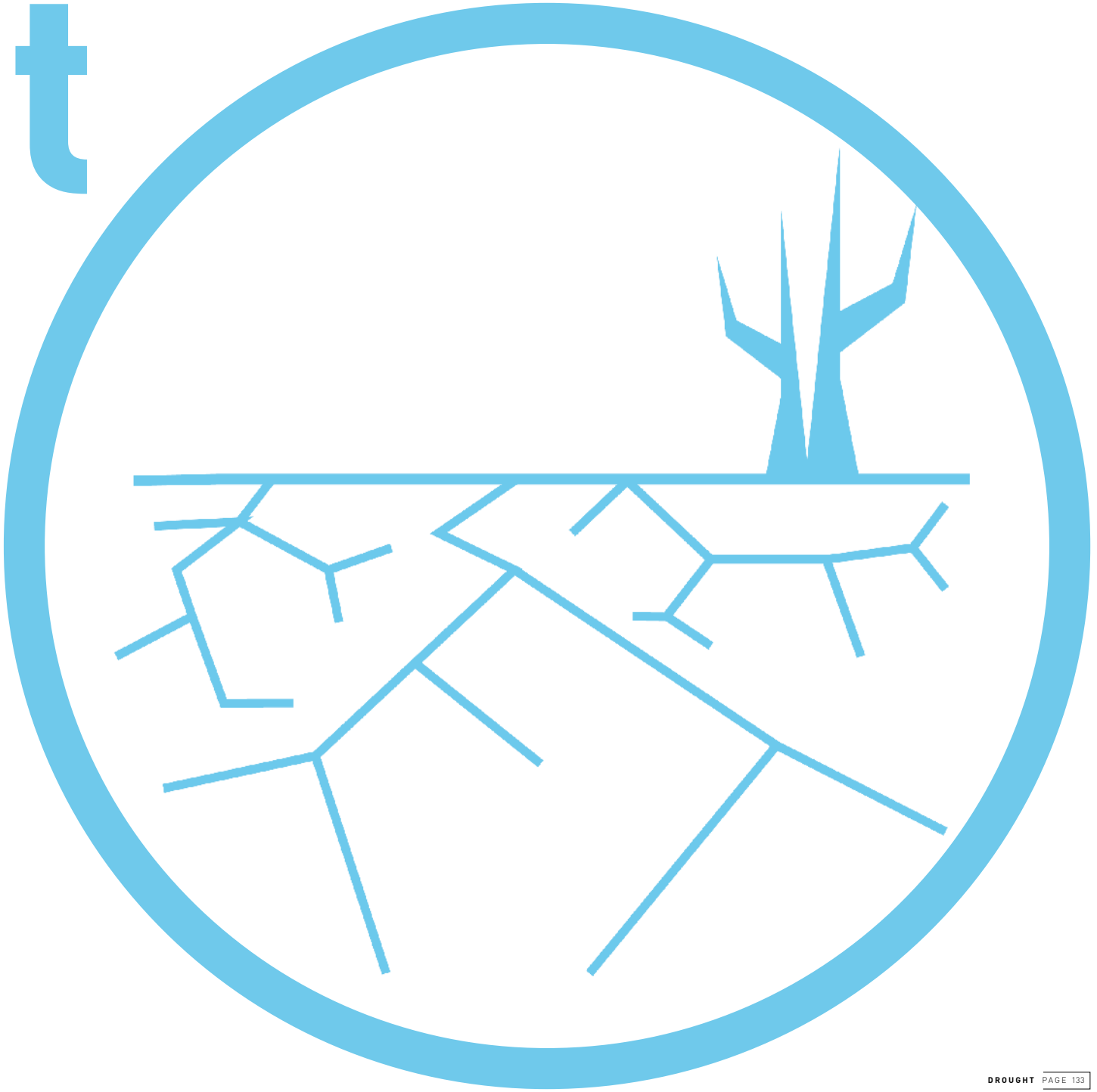
Photo: ©City of Stuttgart, Office for Environmental Protection

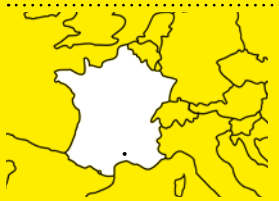
# drought



# Agroforestry: agriculture of the future?

climate risks

sector



**Location**
Montpellier, France

**Total budget**
€€

**Non-financial costs**
Business

**Non-financial benefits** Enviroment

**Project partners**
6 units of INRA are involved: UMR SYSTEM, Montpellier; UMR AGIR, Toulouse; UMR EEF, Nancy; UMR MISTEA, Montpellier; UMR LERFOB, Nancy; UMR BIOGECO, Bordeaux

**Public or private project**
Public

**Contact**
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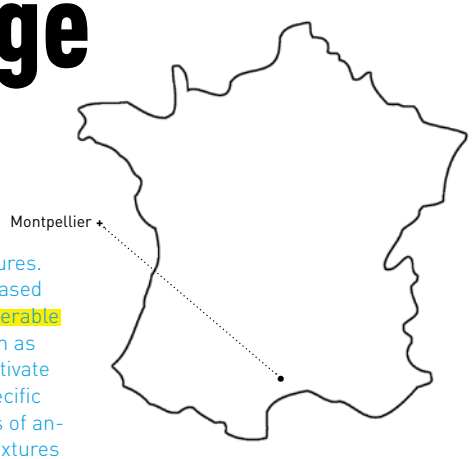
(Photo: ©Christian Dupraz)

Throughout France farmers have started experimenting with the concept of agroforestry.

# Adaptation of plurispecific systems to climate change




**We need new ways of farming to keep European food production efficient, make it more sustainable and able to cope with the projected effects of climate change.** Will we be able to keep or even increase current production rates under higher average temperatures, more frequent droughts, floods and heat waves? To prepare for the effects of climate change it is important that the agricultural sector takes appropriate adaptation measures. The current system, largely based on monoculture, is more vulnerable compared to alternatives such as plurispecific systems that cultivate a mixture of species. Plurispecific systems can include mixtures of annual crops (intercropping), mixtures of trees (plurispecific orchards or forest) and mixtures of trees and crops (agroforestry).
The time for rethinking agricultural practices is pressing, admits Christian Dupraz. Christian works for the French National Institute for Agronomical Studies (Inra): "The stagnation of yields of major crops in Europe over the last 15 years is well documented and that this stagnation is probably linked to a changing climate." With the project Adaptation of PlurIspecific systems to Climate Change (APICC), Inra intends to help agriculture in Europe adapt to projected climate change. The project assesses the resilience of plurispecific agricultural systems to effects of climate change, such as increasing temperatures or droughts, water and biotic stresses and more extreme events.

(Photo's: ©Christian Dupraz)

In Montpellier an agroforestry scheme has been implemented for 20 years. The scheme mimics some features of natural ecosystems, yet is driven by farmers and forest managers to deliver a range of goods and services. Tests have indicated that an agroforestry scheme with cereals and walnuts on 100 hectares of land has a land use return of 1.4 to 1.5. This means that the 100 hectares agroforestry of trees and crops together, provide as much as a field of 140 or 150 hectares would provide when the trees and the crops would be separated.

Throughout France farmers have started experimenting with the concept of agroforestry. In the Gers county (Midi-Pyrénées province) a farmer has 400 hectares of wild cherry, service tree and ashes with cereals or fodder. In the Hérault county (Languedoc-Roussillon province) some farmers mix walnuts or poplars with high value seed production for wheat, maize or sunflower. In the Picardie or Centre provinces, large cereal farms have started to introduce trees in a treeless landscape, using wide distances between tree rows to accommodate the large machinery.

Agroforestry systems can be less vulnerable to climate change. In an agroforestry scheme trees provide shelter to crops and reduce the risks induced by high spring temperatures. In France, about 3.000 hectares of agroforestry systems are now planted each year and it is expected that within the next 25 years, about 500.000 hectares of agroforestry schemes will have been implemented.

**What is agroforestry?**
Agroforestry is exactly what the word says: a combination of agriculture and forestry. Farmers combine trees or shrubs with crops and sometimes even livestock. Combining different plant species instead of having monocultures has several positive side effects. Biodiversity is increased by the usage of several plant, crop or tree species, as they create a more diverse habitat that is able to support a wider variety of wildlife species than a monoculture field. This can impact natural pest control or pollination. Landowners that use agroforestry schemes can diversify their products, increase their income and improve soil and water quality, reduce (wind) erosion and prevent damage due to flooding. Farmers might benefit from an enhanced provision of ecosystem services. Agroforestry sustains the resources of the land much better than conventional farming practices and therefore allows future generations to farm on highly productive land. It is important to consider the changing climate when selection trees and shrubs in an agroforestry scheme. Agroforestry schemes are a long term investment. It takes some time until trees mature and provide the functions and benefits described. Short term investments that aim at quick financial returns hardly ever support agroforestry schemes.

**To prepare for the effects of climate change it is important that the agricultural sector takes appropriate adaptation measures. The current system, largely based on monoculture, is more vulnerable compared to alternatives such as plurispecific systems that cultivate a mixture of species.**

(Photo: ©Christian Dupraz)

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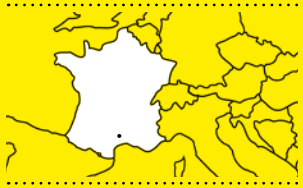
# Combining energy production and food production in one place

climate risks

sector



**Location**
Montpellier, France

**Total budget**
€€€

**Non-financial costs**
None

**Non-financial benefits**
Business

**Project partners**
6 units of INRA are involved: Sun´R a corporate business specialized in photovoltaic systems

**Public or private project**
Public- private partnership

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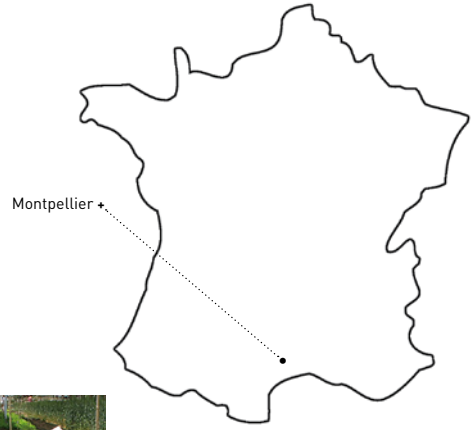
(Photo: ©Christian Dupraz)

Combining food production with energy production by solar panels in agri-voltaic schemes can increase crop returns.

# Solar panels produce energy and protect crops from excess heat



(Photo's: ©Christian Dupraz)

**Providing food for a growing world population is no longer the only purpose of agriculture. Modern farmers are counted upon to deliver crops and provide raw materials for bio based fuels and bio energy.** An additional stress factor for southern European agriculture is dealing with increasingly high temperatures, that can have a particular large impact in (already hot) summers.
The French National Institute for agronomical Studies (Inra) initiated a project where they designed so called agri-voltaic systems. These agri-voltaic systems provide shading for crops for food production while at the same time producing energy with photovoltaic (solar) panels at the same plot. The goal was to protect crops from excess heat, maximize agricultural land use return and mitigate climate change.
Christian Dupraz, from Inra, explains that combining food production with energy production by solar panels in agri-voltaic schemes can increase crop returns. The panels provide shading, which seems particularly beneficial for summer crops in case of excessive heats or droughts.
Preliminary results on salad, pea and wheat crops indicate that winter crops may not benefit from the new environment, while summer crops may take advantage of the protection against excess heat or evaporative demand. Christian Dupraz reasons that solar panels may provide shading as effective as trees and at the same time produce energy. In Montpellier a 2.000 square metre agri-voltaic test field has been build.
The measurement and modelling of the land use return for this solar panel field supports the idea of higher land use returns: a land use return of 1.6 has been calculated. This means that a 100 hectare field, with a combination of crops and solar panels, is as productive as a 160 hectare field where crops and solar panels are managed separately on distinct tracks of land. The great success of the agri-voltaic scheme was unexpected and surprised the whole team.

It seems that solar panels not only produce sustainable energy, but also may reduce heat stress in shaded crops and save water demand by crops because crops will evaporate less. Researchers are looking into the agri-voltaic system's adaptive aspect, that seems to lie in the mechanism of efficiently providing light and shade to crops. This can be achieved by optimal solar panel density for immobile panels, or time-adjusted solar panel position for panels on trackers. Tracking can be adjusted to protect crops against irradiation when needed, or conversely to provide enough light when the crops are light-deficit sensitive. Preliminary results show that in both agroforestry and agrovoltaic systems, protected crops perform better than full sun crops under projected climate change. This may be explained by reduced heat stress during flowering in spring, by a longer life of leaves, and by reduced nitrogen and water stresses in the shade.
Agri-voltaic systems combine energy production with food production, and at the same time increase the resilience of agriculture to climate change. The scheme can be particularly interesting for countries where suitable land for agriculture is scarce. In 2013 a two hectares large test site will be build. There are plans to test this scheme also at other sites in southern France.

**What is an agri-voltaic system?**
The agri-voltaic system consists of photovoltaic solar panels at a height of around four metres supported by a tensioned structure which enables agricultural machinery, such as tractors, to pass underneath and cultivate the land. The location of the solar panels higher above the ground lets wind cool the panels. This increases their efficiency compared to solar panels that have to operate under warmer circumstances, for instance, when built on a rooftop or close to the ground. The crops grown under the panels during the experiment included wheat, vegetables such as peas, cucumber and salad varieties. The design used for this system is non-standard: the optimal density of panels above the field was determined during the experiment. Another advantage of the system is that during winter or late summer, when crop production comes to a virtual standstill, the farmer can receive revenue from the electricity production

[Photo: ©Christian Dupraz]

Agri-voltaic systems provide shading for crops for food production while at the same time producing energy with photovoltaic (solar) panels at the same plot.

# Green deserts in Spain

climate risks

sector

**Location**
Northern provinces in Spain

**Total budget**
€€€€

**Non-financial costs**
Environment

**Non-financial benefits**
Sustainability, enviroment, business, social and nature

**Project partners**
Fundación General de la Universidad de Valladolid (E), AquaPro BV (NL), Sylma BVBA (BE), Universidad de Valladolid (E), Diputación Valladolid (E), Diputación Léon (E), City council of San Mateo de Gállego, Zaragoza (E), City Council of Riofrio de Aliste, Zamora (E), Transfer Latin Business Consultancy (E)

**Public or private project**
Public- private partnership

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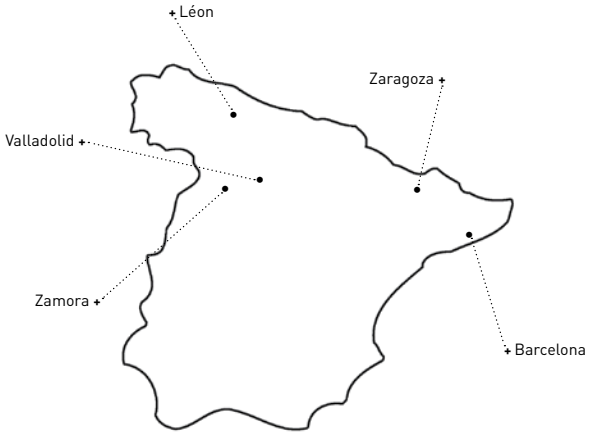
Sven Kallen, e-mail: sven@transfer-lbc.com

Photo: ©Life+ The Green Deserts team

Planting new and appropriate trees in dry areas of the Iberian peninsula can prevent desertification.

# Planting more trees in dry areas




**Over the course of the last century, southern Europe has witnessed decreases in annual precipitation and rising temperatures. In some parts of southern Europe, the decrease in annual precipitation is a staggering 20 percent. This makes southern Europe and in particular the Iberian peninsula, vulnerable to projected climate change.** Considerable rises in average and extreme temperatures are expected, notably during the summer. Planting new and appropriate trees in dry areas of the Iberian peninsula can prevent desertification and can help to increase the resilience of the area to the projections of climate change. However until now reforestation projects have only been partly successful because of the continuous need for water, extremely low survival rates of trees and high overall costs.

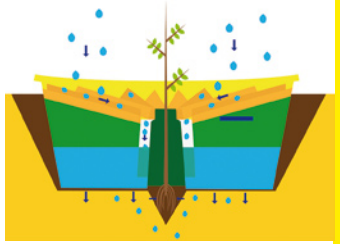
Explanation of the Waterboxx to children

The Green Deserts project in Spain found a way to overcome these problems and aims at converting 63 hectares of bare and dry land into forest by planting around 55.000 trees in the five Spanish regions Valladolid, León, Zamora, Zaragoza and Barcelona, with the use of an innovative invention called the Waterboxx. Sven Kallen from Transfer Latin Business Consultancy explains how this works. In the Waterboxx, rain and condensation is collected and a daily dose of water is directed to the saplings. By a smart system a single rainfall event can be used to distribute water to saplings over the course of a year (see text box for more information).

Currently, two thirds of the trees have been planted and the remaining trees will be planted in the remainder of 2012. In total 22.000 Waterboxxes will be used in which different combinations of trees and bushes will be planted (2 per Waterboxx). The test sites in the five regions have varying climatic conditions, altitudes, land uses, and soil compositions. Already they are affected by the changing climate and desertification, and no trees, plants or crops can be grown without artificial irrigation, if at all. This makes the Green Desert project special, as it aims at reforesting the areas without using artificial irrigation, a strategy that no one has attempted before, says Sven. The preliminary results of the tests are very positive and stakeholders react enthusiastically. Until now, approximately 90 percent of the young saplings have survived. In Zaragoza (Los Monegros desert) survival rates are higher, while in Catalonia it is lower based on the presence of wild boar. During droughts he boar tipped over the Waterboxxes in search of water. They managed to get the lids off and drink the water inside. They also destroyed quite a few of the young saplings.
Often, the young trees are planted by children from local schools. This creates awareness and interest in the community. Trees grown with help of the Waterboxx will, once matured, help prevent erosion and possibly flooding during strong rain events or increase the water-retention capacity of the land during dry periods. The realisation of the Green Deserts project open opportunities for more reforestation projects in Spain and create green jobs in small industries including maintenance, fruit picking and processing that are beneficial for local employment.

Planting with children in Viladecans, using the Waterboxx

Photo's: ©Life+ The Green Deserts team



**How does a Waterboxx work?**
In the Waterboxx, rain and condensation is collected. The standard Waterboxx is made of polypropylene, there are biodegradable versions and a reinforced paper pulp Waterboxx is currently in testing phase. The box is 25 cm high with a 50 cm diameter and stores up to 15 liters of water. The design and storage section of the box prevents evaporation of the water once taken up. With the help of a wick, the box distributes a daily dose of water to the roots of the young tree. In this way, a heavy rain shower of ten minutes, which might occur only once a year, can be apportioned to the plant over the next 300+ days - or until the next rain shower, the manufacturers, AquaPro promise. This capturing and apportioning of water gives the young plant enough time to search for natural capillary water, even in very dry soil. The hard soil underneath the box is constantly moisturized which slowly but steadily restores the capillarity of the soil. In these vertical water canals, the roots can find their way, even through stones and rocks. The costs per Waterboxx depend on the volume, but is on average Đ10. As the polypropylene version can be reused 10 times before being recycled, the yearly cost per 'round of plantation' comes down to about Đ1.

Southern Europe and in particular the Iberian peninsula, is one of the most affected regions of current and future climate change. Climate models support this outlook, as considerable rises in average and extreme temperatures are expected, notably during the summer.

# A vision of a thousand lakes

climate risks

sector

**Location**
Tamera, Portugal

**Total budget**
€€€€

**Non-financial costs**
None

**Non-financial benefits**
Enviroment, business, social and nature

**Project partners**
Sepp Holzer (Krametrehof, permaculture consultant)

**Public or private project**
Public- private partnership

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Photo: ©Tamera Archive

Retentionlakes are created by building earth dams, behind which rainwater is stored.

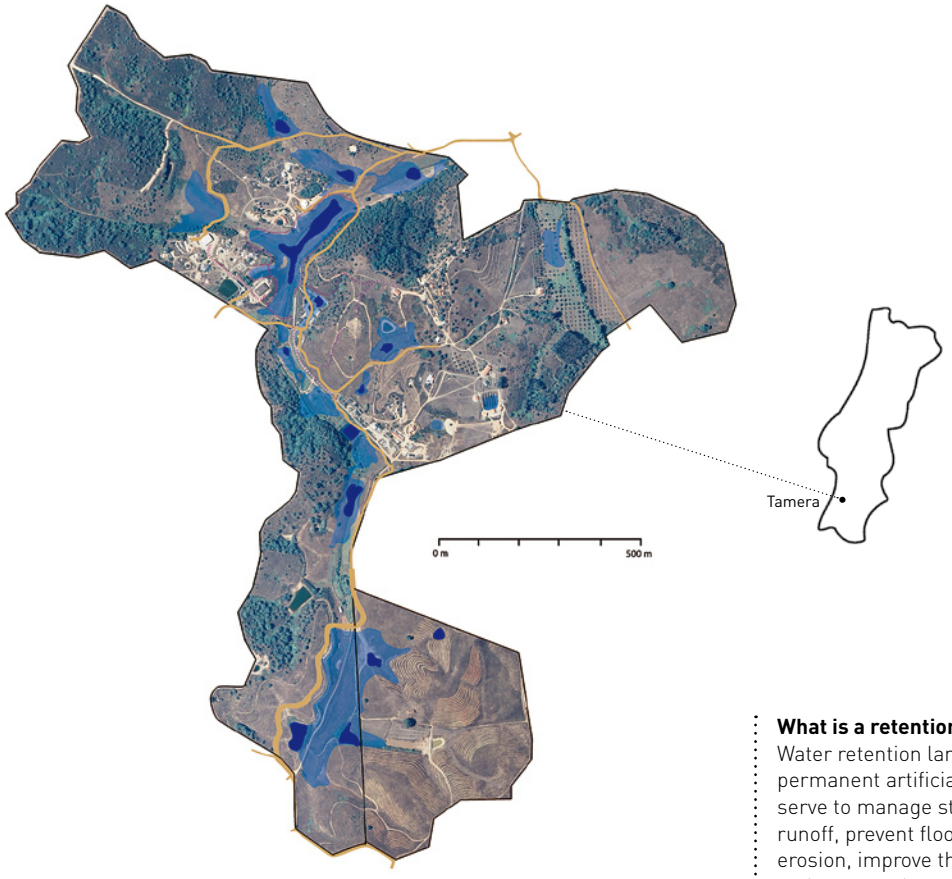
# Tamera Water Retention Landscape

Photo: ©Tamera Archive

**The water cycle in Portugal is affected by deforestation, overgrazing, deteriorated topsoil layers and a long history of unsuitable agricultural production in the area. In springtime Portugal heavy rainfalls cause water dames and flooding. Fertile top layers are washed away and the land is further eroded. Comes summer drought and forest fires bring harm to the land.**

Although Portugal has a similar average rainfall as that of Central Europe the soil is unable to hold on to nutrients and water. Projected climate change is expected to aggravate the drought already present in Portugal.
The province of Alentejo in the south of Portugal is one of the areas that face serious desertification problems. It is also the home of Tamera, an international training and experimental site founded by three Germans in the mid-90s. The site hosts a community of about 200 people who live, work and study there adhering to the philosophy 'think globally, act locally'. Tamera also works on solutions for the disturbed water balance in the region by creating water retention landscapes. These landscapes contain lakes that will provide a solution for desertification, water scarcity, flooding and rural de-population.

Retention lakes are created by building earth dams, behind which rainwater is stored. A total of 6 lakes has been built since 2007, and 10 more retention areas are planned. The lake grounds are not sealed, so the water can seep into and soak the surrounding earth-body. In addition, the lakes were built with deep and shallow zones, thereby connecting the lakes to the groundwater. Meandering shorelines ensure that the water is in constant movement, allowing for oxygenation and self-purification. Fish are now inhabiting the lakes and terraces are built around them to allow the organic cultivation of fruit trees, vegetables and other crops. Mixed aquaculture can be established in the lakes.
With enthusiasm Leila Dregger, from the Tamera Peace Research Centre, tells that local Park Rangers have animal tracks in the surrounding areas leading to the lakes in Tamera. The preliminary results are promising. Natural vegetation has recovered, around 10.000 trees have been planted, and much of the natural wildlife has returned. Around 100 species of birds now flock the shorelines of the five lakes and every now and then an otter strolls through the area. At the height of the 2011 summer drought farmers from the surrounding area arrived with water tanks at the Tamera lakes to receive water for their animals. The final vision is to have 1.000 lakes in the area to provide water for everyone – plants, animals and humans.




**What is a retention landscape?**
Water retention landscape are permanent artificial lakes that serve to manage storm water runoff, prevent flooding and erosion, improve the water quality and support the restoration of the water cycle by retaining the water in the areas where it falls as rain. In addition, they improve the quality of their environment and allow for groundwater recharge. Water retention basins are sometimes also referred to as wet ponds. A water retention landscape consists of a series of interconnected retention spaces, from pond-sized up to lake-sized, in which the rainwater can collect behind a dam constructed from natural material. The retention spaces themselves are not sealed with concrete or any artificial layer, so the water can slowly but steadily diffuse into the earth-body.

Meandering shorelines in the south of Portugal ensure that the water is in constant movement, allowing for oxygenation and self-purification.

Fish are now inhabiting the lakes and terraces are built around them to allow the organic cultivation of fruit trees, vegetables and other crops.

(Photo: ©Tamera Archive)

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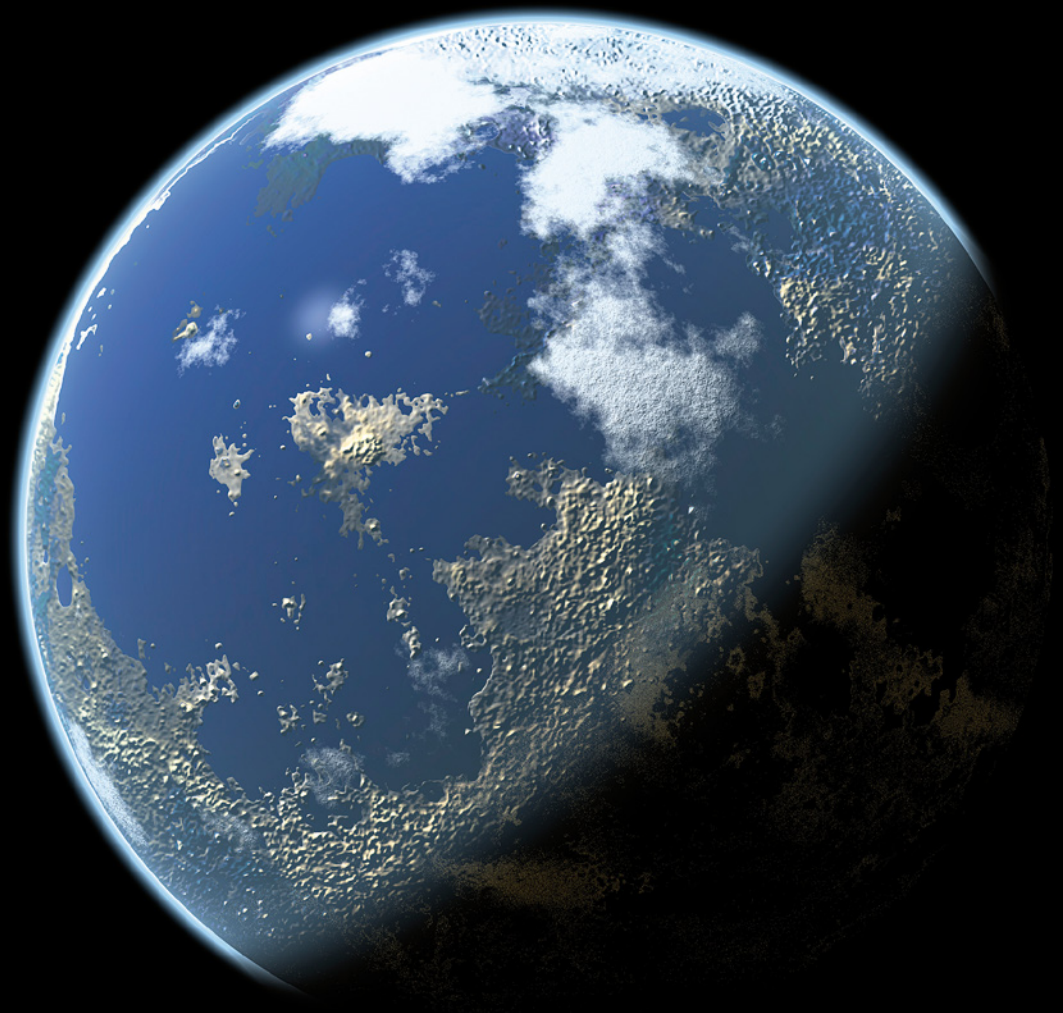
Climate change is a global issue.

At the same time adaptation solutions are found locally.

We must rebrand adaptation as something positive that can help create a better environment.



# What lessons can we draw from the 22 inspiring adaptation case studies ?

# How can these be translated to your specific country or adaptation challenge?

**In economic harsh times, adapting to future climate change is not always high on the agenda. Inspiring people and showing multiple benefits from measures can get unlikely projects off the ground, such as the Green Roof Philosophy in Copenhagen, where many people installed green roofs without additional funding. The Community Woodland in Somerset, United Kingdom, is another prime example where people helped to rebuild the woodlands to reduce flood risks. A Water Festival held to support this initative attracted more than 6.000 people and raised more local awareness of the need to adapt to climate change. Although the case studies described in this book are very diverse, when compared they yield some interesting lessons for all policy makers, professionals and scientists working on adaptation to climate change.**

## Right here, right now

**Adaptation has to be tailored to local challenges and needs**

There is no one size fits all approach when it comes to adaptation to climate change; no easy roadmap or list of instructions you can follow to automatically yield good results. Each situation is different; be it a school that needs to become more sustainable and deal with excess water or the coastline of an entire country that needs to be protected from sea level rise. Adaptation is very context specific and new insights and research in the future may very well change what we perceive as 'good' adaptation.

## A different angle

**Innovation doesn't always have to be 'new'**

To create an innovative adaptation measure, you do not always have to invent something new. New innovations such as the Sand Motor and the Waterboxx are interesting and promising, but sometimes reinventing old practices can bring about innovation too. It can be refreshing to look at traditional practices and apply them to a new situation, such as green roofs, drainage tunnels and wetlands. It is the context in which they are applied what makes them innovative. Furthermore, what is standard practice in one place, such as the rain gardens in the United States, is innovative in another.

## Make it real

**Make climate change local and urgent**

Climate change is a global issue. At the same time adaptation solutions are found locally. Adapting to climate change must be done in cities, municipalities, by local governments, companies and citizens. Climate change however remains an abstract concept. When citizens experience local disasters such as flooding (such as citizens in Arnsberg, Germany and Kruibeke, Belgium), heat waves (such as in France and England in 2003), and realise that these events can become more frequent in the future, climate change is no longer an abstract concept, but very real, and very here. That knowledge empowers citizens to take – and ask for, in the case of the Arnsberg floodings – adaptive measures.

## Power to the people

**Involve local stakeholders**

Almost all successful adaptation measures in this book have been implemented with the support of local stakeholders: policy makers, business owners and citizens. It takes time and energy to involve these groups from the very beginning, but that pays dividends later: many land owners next to the renatured waterway in Arnsberg, willingly give up part of their properties to prevent flooding of the waterway in the future, while those in Kamen, paid for part of the measures themselves. This wasn't possible without intense involvement of these groups, including meetings and house-to-house visits explaining the existing local effects and those projected as a result of climate change, accompanied by information about what these citizens could do to adapt to these effects. Involving stakeholders promotes a more sustainable approach, because citizens themselves take on responsibility.

## Good for you, good for me

**Create mutual benefits**

It is clear from the 22 case studies in this book that adaptation measures are rarely implemented solely for the purpose of adapting to climate change. Most measures have additional benefits, such as educating students in case of the sustainably built school in the United Kingdom, combining coastal protection with recreational development such as with the dike-in-dune in Noordwijk, the Netherlands, or creating a more attractive and climate resilient urban environment such as in Nijmegen in the Netherlands. This way benefits accrue and costs are lower than they would have been if adaptation measures had been carried out in isolation.

## Inspire!

**Inspirational, bold, daring and innovative measures go a long way**

The 'Al Gore' approach which instates fear of a changing climate into people's hearts no longer seems to work. On the contrary: knowing that a big threat is looming, but not knowing what you can do about it, leads more frequently to inaction, rather than to action. Notwithstanding the fact that initiatives like the movie 'An Inconvenient Truth' did a tremendous job putting climate change on the (political) agenda, we have learned that for people to take action, it is better to show them options, preferably as close to home as possible. It is important to inspire people and show how their own actions can contribute to the larger goal of adaptation to climate change. These contributions to reducing vulnerability to climate change can sometimes be small, such as a sidewalk garden, or sometimes have a much bigger effect, such as replanting woodlands in large parts of England or reforesting dry, erosion-prone areas of Spain.

## Learn by doing

**How can we improve?**

Many of the case studies involved active learning of participants. Citizens learn about climate change and how they can adapt to it. Policy makers learn to combine different goals with adaptation to climate change and make financially sound and sustainable decisions that are flexible enough to be adjusted in the future. Scientists learn to cooperate with public and private parties. Most case studies in this book are monitored by researchers or communities to see how much they actually contribute to reducing vulnerability to climate change. Monitoring is an important aspect of adaptation to climate change; an important prerequisite to see if we are learning and to find ways to improve what we are doing.

Use this book and its inspirational case studies to your own advantage. Learn from them to initiate adaptation projects or improve your current strategies and plans for adapting to climate change.

# COLOPHON

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# FURTHER READING

The European Climate Adaptation Platform (CLIMATE-ADAPT)
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Transition Network
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