BASE

BOTTOM-UP CLIMATE
ADAPTATION STRATEGIES
TOWARDS A SUSTAINABLE EUROPE

Experiences of bottom-up adaptation approaches in Europe and beyond

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BOTTOM-UP CLIMATE ADAPTATION STRATEGIES TOWARDS A SUSTAINABLE EUROPE

Title: D4.2 Experiences in bottom-up adaptation approaches in Europe and elsewhere

Summary: This report takes stock of adaptation planning and measures to date in Europe and globally. Case studies for assessment were selected based on criteria developed in line with the key principles and objectives of BASE. The report provides a general assessment of 136 selected case studies focusing on aspects including types of measure, stakeholder groups involved, sectors, decision support tools (participatory and economic), and funding sources. A further nine case studies are then explored in more detail in regard to measure selection and methods.

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Executive Summary

After the adoption of the 2013 EU Adaptation Strategy, the EU and its Member States have focused their efforts on adapting to climate change, especially with respect to promoting increased coordination, implementation and more informed decision-making. The shift from mitigation to adaptation is also apparent in the global context, with many countries recognising the need to increase adaptive capacities for preparation of expected future climate change impacts.

In this context, this report has collected examples, or case studies, of implemented adaptation measures from both Europe and internationally in an effort to characterise climate change adaptation. It aims to review the methodologies and tools used to analyse and assess adaptation options, with a focus on participatory and economic methods and tools. Participatory methods are those which utilise knowledge and input from stakeholders or participants in workshops, questionnaires, forums, etc. Economic methods utilise results generated from analyses, such as cost-benefit analysis, cost-effectiveness analysis, analytic hierarchy processes, multicriteria analysis, etc. Furthermore, this report covers various grey, green and soft adaptation measures, as well as combinations of these measures, in line with the European Environment Agencies (EEA) classification (EEA, 2013):

- Grey Measures: technological and engineering solutions
- Green Measures: nature-based or ecosystem-based solutions
- Soft Measures: managerial, legal and policy approaches

A set of criteria was developed to identify and select case studies for inclusion into a matrix (mix of geographic region, adaptation measures, applied methodology, status, data availability) and to conduct a general assessment of case studies. Another set of criteria was developed for the selection of case studies for in-depth review and assessment, including a focus on methods used, cost availability, sufficiency check, and public availability of information. In this regard, a ‘case study’ as understood within this report is an example which provides a particular instance of implementation of climate change measure(s) that can be studied for the purposes of this exercise.

The case studies selected represent a mix of grey, green and soft adaptation measures, as well as combinations of these measures; a mix of urban and rural focus; and a mix of different geographical regions, both developing and developed nations. In total, 136 global case studies are included in the general assessment, originating from 19 selected countries. The general assessment and collection of case studies in this exercise showed that soft measures are the type of measure most often implemented in both Europe and elsewhere. Public administration bodies on different levels are the stakeholders that are mostly included in the case studies, while local and regional scales are the most common scales for the case studies. A sectoral analysis shows that most case studies are focusing on biodiversity and ecosystems and coastal marine systems, and the least represented sectors are transport and tourism. The general assessment also shows that a significant amount of the case studies used, during the implementation process, participatory methods while economic evaluation methods are used much less. It was also identified, that public funding is also the main source for financing European adaptation.

Using the developed criteria, nine case studies were selected for in-depth assessment, and the vast majority incorporated participatory elements into adaptation decision-making processes. These participatory methods mainly include workshops and forums, where people are invited to speak and discuss adaptation options for a case study area. Conversely, only two case studies integrated economic methods into the decision-making process, and only one case study had a combination of both participatory and economic methods. A trend identified in the nine selected case studies is the focus on adaptation to the climate change threats of water scarcity and increased frequency and intensity of extreme storm events. Other themes identified in case studies focused on addressing the climate threats associated with coastal flooding or erosion, as well as higher temperatures and heat waves.

In regard to funding for adaptation measures, a variety of sources are identified in the nine case studies reviewed in-depth. These funding sources range from research (i.e. government), to national ministries, local municipalities, and private companies. Of the nine case studies reviewed, one case study had a single funding source, while in seven case studies mixed sources are used, and one remains unknown. Mixed funding sources can also be further diversified considering they come from different government sources (e.g. national and local sources), both government and public sources, and combined public sources. Mixed funding sources enable the funders to spread and, therefore, minimise the individual risk of the investment. It also helps to ensure that opinions and decisions are not linked to one funding source.

Despite the shift of focus from mitigation to adaptation, it was difficult to identify examples of implemented climate change adaptation measures. This could be due to terminology and the lack of identifying or highlighting an implemented action as one addressing a climate threat, or the lack of some existing adaptation databases which fail to provide implementation information. Additionally, those examples of implemented adaptation measures often lacked information regarding the decision-making process, especially in the case of economic methods and tools, as well as the cost (i.e. implementation and maintenance) of the adaptation measure itself.

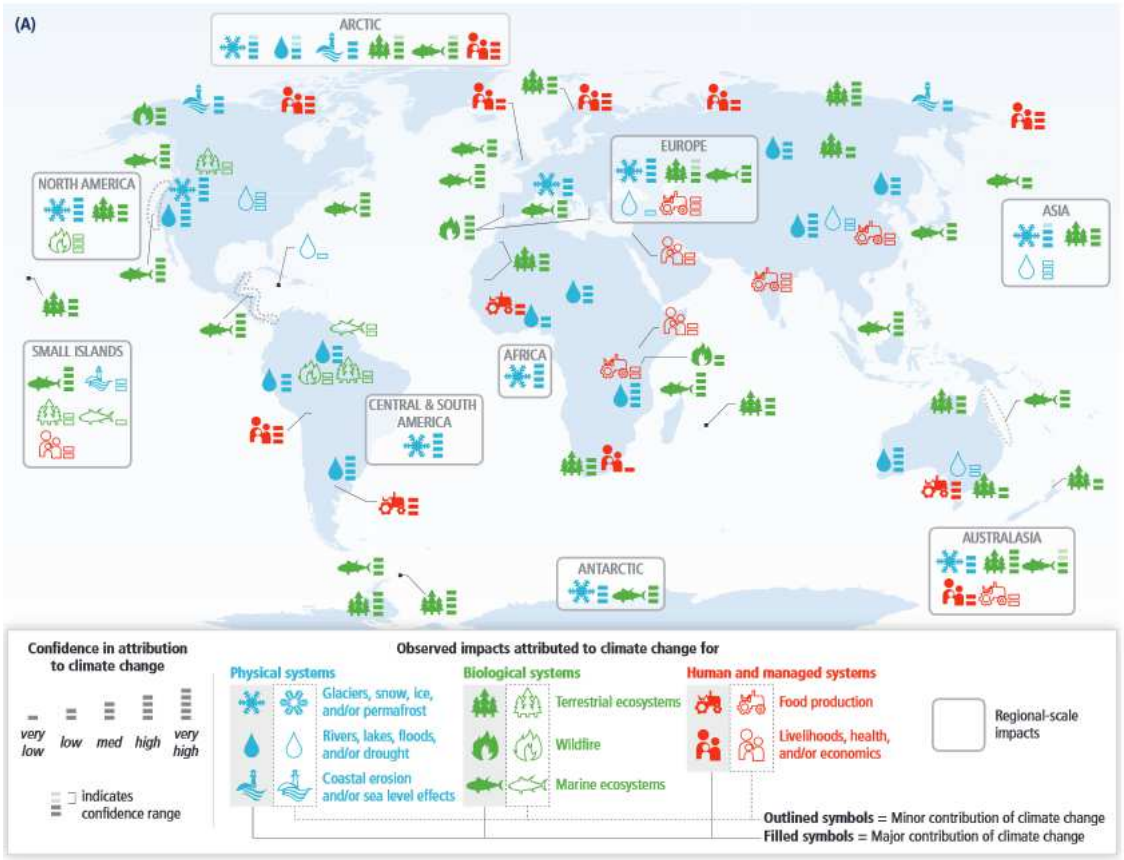
The main messages and lessons learned coming from this assessment are:

- Despite the significant number of databases focusing on climate change and climate adaptation, in many instances the databases vary in the amount of information provided and are often lacking information, such as on the decision-making process or assessment tools used which makes it difficult to share and analyse success factors and further experiences during the selection and implementation phase of adaptation measures.
- Through the case study assessments it is shown that participatory methods are often very fruitful and can be critical to the success of projects, providing added value for the implementation. These can be an innovative way to include knowledge from local stakeholders, research partners and clients in the design of adaptation actions and ensure future business activities.
- Very little information in regard to economic methods and their application is available.
- Corresponding to the literature, a mix of measures seems to be for many circumstances implemented and advantageous e.g. the combination of grey infrastructure measures and green infrastructure for flood protection.
- In most instances adaptation projects rely on a mix of funding sources (e.g. government, private companies, etc.). This helps funders to spread and therefore minimize the individual risk of the investment and also helps to ensure that opinions and decisions are not linked to one funding source. But it also increases the effort for the applicant or the institution which connects the different funders.
- To disseminate lessons learnt of the selection and implementation of adaptation measures, documentation of adaptation projects and the methods used to select, design and ultimately implement adaptation measures should provide a clearer description of the reasons why a specific measure was selected by a local/regional community.

1 Introduction

Climate change is impacting different regions of the world in various ways, including extremes such as heat waves, droughts, floods, cyclones and wildfires, as well as exasperating other pressures on the environment or affecting human health. In addition, climate change leads to negative impacts on human livelihoods and socioeconomic systems (see Figure 1) (IPCC, 2014b). Human and natural systems are able to cope with adverse circumstances such as increasing climate change and adaptation measures are needed to maintain this capacity (IPCC, 2014a). For the last two decades, European climate policy has focused almost exclusively on mitigation of climate change. Only after 2000 with the impacts of climate change increasingly being registered, that adaptation was added to the policy agenda and EU Member States started to develop national adaptation strategies (Biesbroek et al., 2010). Adaptation measures help to reduce risk and vulnerability from climate change; seek opportunities; and build the capacity of nations, regions, cities, the private sector, communities, individuals and natural systems to cope with climate impacts, as well as mobilise that capacity by implementing decisions and actions (Tompkins et al., 2010). The EU adopted an adaptation strategy in 2013 to promote greater coordination and information sharing between Member States and ensure that adaptation considerations are addressed in all relevant EU policies. The strategy focuses on three main aims: promoting action by Member States, 'climate proofing' action at the EU level and better informed decision-making (EC, 2013a). It will be necessary to develop and implement adaptation strategies across all levels of government: local, regional, national, EU and also the international level. Within Europe, adaptation initiatives will most likely be taken at regional or local levels due to the varying severity and nature of climate impacts between the different regions (EC, 2015a).

Figure 1: Global impacts of climate change



Source: IPCC, 2014b

This report is produced as part of the BASE project, titled 'Deliverable 4.2 Experiences in bottom-up adaptation approaches in Europe and elsewhere'. BASE aims to foster sustainable adaptation in Europe by improving the knowledge base on adaptation and making this information easier to access, understand and act upon. The project is funded under the EU's 7th Research Framework Programme (FP7). The report aims to take stock of adaptation planning and measures to date in Europe and globally. It also aims to yield a review of methodologies and tools used (such as participatory ones) and analyse adaptation options (e.g. Cost Benefit Analysis, Multicriteria Analysis, Impact Assessments, etc.).

Thus, the goal of this work is to collect examples, or case studies, of implemented adaptation measures used both globally and in Europe in which lessons learned can be extracted for the broader adaptation and research community. It is, therefore, not the goal of this exercise to develop a new database or evaluate already existing databases such as INFOBASE, Global Adaptation Network, Climate-ADAPT. The goal is to characterize adaptation measures and methods for measure selection and development by "randomly" selecting case studies. A secondary aim is to analyse the existing adaptation measures reported in the major EU and Global Adaptation platforms. This report focuses on understanding how grey, green and soft measures, as well as combinations of these can improve or enhance adaptive capacity. This follows the European Environment Agency's (EEA) classification of measures (EEA, 2013). In this regard, grey measures are defined as technological and engineering solutions, while green measures are ecosystem based solutions and soft measures are managerial, legal and policy approaches. Future studies should improve and expand both this study as well as its geographical representation.

To conduct this study, a set of criteria was developed in order to help identify and select case studies for review and assessment. In this regard, Deliverable 4.2 intends to create a baseline to understand the state of climate change adaptation case studies in Europe and globally, with a particular focus on participatory and economic assessment methods. Participatory methods are those which draw on knowledge of participants or stakeholders, such as through workshops, questionnaires or information dissemination. Economic methods are those such as cost-benefit analysis, cost-effectiveness analysis, multicriteria analysis, analytic hierarchy process, etc.

This report aims to support overarching objectives of BASE by:

- Compiling and analysing data and information on adaptation measures and their effectiveness towards a publicly available, comprehensive and integrated knowledge base.
- Identifying conflicts and synergies at different policy levels, as well as between and within sectors, to highlight strategies for improving policy coherence and effectiveness.
- Promoting the understanding of grey, green and soft measures for adaptation to climate change.
- Propagating the use of participatory and economic methods into policy planning.

In this report, section 1 provides an introduction and review of the different types of climate change adaptation measures. Section 2 provides an overview of the approach and methodology taken and is followed by section 3 that starts with a general assessment followed by an in-depth assessment of the selected case studies. Finally, section 4 draws conclusions and makes recommendations.

2 Types of climate change adaptation measures

In the following chapter the three types of adaptation measures – grey, green and soft – are described in general. Definitions, examples, strengths and weaknesses are elaborated.

2.1 Grey adaptation measures

According to the European Commission (2009), “grey” infrastructure approaches are physical interventions, construction measures or the use of engineering services to make buildings and infrastructure essential for the social and economic well-being of society more capable of withstanding extreme events. These approaches are focused on the direct impacts of climate change on infrastructure and buildings (e.g. changes in precipitation, sea level rise, floods, temperature, etc.), and target exercising a degree of control over the environmental threat itself or preventing the effects of climate change and variability (EC, 2009). Grey measures include specific technological and infrastructural changes involving capital goods that consider specific climate change risks in planning and design (Agrawala et al., 2011; EEA, 2010; Jones et al., 2012; Sovacool, 2011).

Despite the acknowledgement and identification of climate change threats, little has been done in the form of on-the-ground implementation. National strategies for adaptation and risk reduction, if they exist, have yet to be incorporated into planning practice and tend to focus on grey measures (Wamsler, 2014). In general, grey measures are used to improve transport, energy, IT-infrastructure, housing, water supply and sanitation (Wamsler, 2014). For example, grey measures that are directly implemented or advocated through guidelines or legislation include breakwaters to reduce erosion, floodwalls and dams, improved drainage systems, road surfaces that resist higher variations in temperatures and precipitation, the construction of flood-prone infrastructure on higher ground, upstanding kerbs as a flood retention device, the use of buildings as windbreaks, subterranean electric wires, blinds or insulation to keep the inside cool, architectural design that optimises natural ventilation in buildings, and construction material that increases the reflectivity (i.e. albedo effect) of building facades, roofs and streets (Wamsler, 2014).

Overwhelmingly, grey measures are used or mentioned in conjunction with water management and disaster risk reduction, and coastal adaptation (Agrawala et al., 2011; EC, 2009; EEA, 2012; Jones et al., 2012; Sovacool, 2011; Wamsler, 2014; Wamsler and Brink, 2014). Much of the literature focuses on the use of grey measures to combat the risk of flooding and storm damage in relation to climate change. These grey infrastructure measures include temporary overflow areas or by-passes, updating storm water drainage and sewage systems (through source control), building designs which increase wind-resistance, decentralising energy systems and placement of electricity cables underground, as well as reconstruction of vulnerable buildings (EEA, 2012). Adaptation to individual buildings can range from minimal changes and retro-fittings (short-term) to highly innovative constructions which aim to climate-proof buildings (long-term) (EEA, 2012). References also highlight the use of shoreline hardening and engineered defences to address increased risk of coastal and flood hazards (Andrade Pérez et al., 2010; EEA, 2010).

Grey measures are also used to address the climate threats of increased temperatures and heat waves. Insulating buildings not only provide the benefits of reducing energy consumption and mitigating climate change, but also adapting to changes in temperature (EEA, 2012). Other options include active cooling of buildings through energy efficient air conditioning systems and district cooling (which prioritises absorption cooling over compression cooling). Examples of these can be found in Austria, Italy and Germany where district and local cooling have been combined (EEA, 2012).

Associated with rising temperatures but mainly with changing precipitation patterns, water scarcity and drought can also be addressed with grey measures. At a larger scale, re-allocation of water resources from relatively water-rich regions to water-stressed regions as well as the construction of desalination plants are options used to ensure sufficient water supply. Local measures include retro-fitting with water-saving technology and devices in individual and industrial buildings, in addition to proper maintenance of the

supply system to reduce leaks and sources of water loss (EEA, 2012). Table 1 below lists some common grey measures used to address impacts of climate change.

Table 1: Grey adaptation measures for various climate change impacts (adapted from EEA, 2012)

Heat	Flooding	Water Scarcity and Droughts
• Building insulation to keep the inside cool • Blinds to provide shade • Passive cooling of buildings • Urban designs providing shade • Ventilation of urban space by intelligent urban design • Emission reduction of air pollutants, e.g. NO_X	• Make new buildings and infrastructure flood proof by appropriate design and material use. • Maintenance/upgrade of drainage system. • Temporary water storage in basins or fascines. • Separate treatment of rain water, disconnected from sewage, improved ground drainage. • Innovative design of buildings and areas such as elevated entrances, building on poles, floating houses, temporary water storage. • Dams, flood defences.	• Water saving devices • Grey water recycling systems • Ground water recharge systems • Rain water harvesting systems • Supply from more remote areas (pipelines) • Desalination plants

There is a long-observed practice in adaptation studies to select grey or "hard" adaptation measures such as sea walls, dams, irrigation projects and other infrastructure over soft adaptation, which includes less visible changes in practices, planning and individual behaviour (Fankhauser and Burton, 2011; Jones et al., 2012; Narain et al., 2011; Parry et al., 2009; World Bank, 2010). This focus on grey adaptation structures such as sea walls, irrigation infrastructure and dams have been employed, sometimes for political reasons, such as wanting to be "seen to be doing something" (Linham and Nicholls, 2010). Additionally, the rationale behind many coastal adaptation infrastructures alludes to the fact that these structures provide tangible and visible protection, therefore instilling trust in the local population (Linham and Nicholls, 2010). As such, grey measures have the main advantage of being relatively easy to identify and appraise analytically, with many adaptation assessments focusing on grey measures due to this characteristic (Fankhauser and Burton, 2011; Narain et al., 2011; Parry et al., 2009; World Bank, 2010). Grey measures are also particularly relevant for industry sectors which rely on long-term fixed assets (e.g. water utilities, mining companies, energy producers and utilities, etc.). This reliance can require companies to consider the future impacts of climate change and implement relevant measures.

A study by Agrawala et al. (2011) looked into private sector engagement in climate change adaptation. The results found that 75% of companies consider physical risks arising from climate change, of which only 17% assess and take further actions to manage these risks. Of these companies, 84% implement soft adaptation measures, 45% implement grey (or hard) adaptation measures and 29% implement a combination of both soft and grey measures. Companies that chose to implement grey measures tend to be more vulnerable to climate change impacts, have restricted operational flexibility and rely on fixed assets. The main examples of these companies are regulated utilities, which rely on long-term fixed assets and could better finance adaptation investments by passing on costs to their customer base more easily than other companies.

This study also touched upon some of the identified disadvantages of grey measures. A common theme in the literature is the concern regarding the high costs of grey adaptation measures (EEA, 2013, 2012; Linham and Nicholls, 2010; Parry et al., 2009). As implementation of adaptation measures are most often left to cities and regional authorities, grey measures, like sewage systems, dams, dikes and desalination plants, are frequently beyond the financial capacities of local actors and must be addressed at national scales (EEA, 2013, 2012; Wamsler and Brink, 2014).

In addition to high costs, other concerns regarding grey measures include permanence, structural inflexibility and higher investment risk (Agrawala et al., 2011; Jones et al., 2012; Sovacool, 2011; Voskamp and Van de Ven, 2015). For example, re-allocation of water and the construction of desalination plants have a higher risk of mal-adaptation due to increased energy demand and the inherent vulnerabilities these projects may have to climate and other stressors (EEA, 2012). Moreover, few grey infrastructures provide additional benefits beyond the singular adaptation function rationalised for their construction (Jones et al., 2012; Voskamp and Van de Ven, 2015). For example, the construction of a seawall can also provide a space for a coastal promenade and improve access to beaches, as envisioned in the coastal reconstruction project in Blackpool, UK[1]. However, as ecosystem valuation methods and the ability to incorporate ecological co-benefits improve, cost-benefit ratios for alternative green or soft adaptation measures are increasingly more favourable than traditional grey measures (Jones et al., 2012).

Often cited are the unsuccessful cases of grey measure implementation and subsequent failure or mal-adaptation, as well as the negative impacts of grey measures on biodiversity (Andrade Pérez et al., 2010; Hallegatte, 2009; Jones et al., 2012; Parry et al., 2009; Wamsler, 2014). For example, levees and sea walls can have negative side-effects as channel sediment and freshwater to deeper ocean waters, potentially fundamentally changing and degrading coastal ecosystems and their ability to act as natural storm barriers (Jones et al., 2012; Linham and Nicholls, 2010; Sovacool, 2011). More extreme views claim that infrastructure development utilises taxpayer money, encourages the development of industries and housing in at-risk areas, necessitates continued investment in maintenance and upgrades, and ultimately increases the number of individuals who will rely on future tax-funded disaster relief (Leichenko and Thomas, 2012; Linham and Nicholls, 2010).

Grey infrastructure may also create a false sense of security on the landward side of defences (Linham and Nicholls, 2010; Wamsler and Brink, 2014). As Hurricane Katrina demonstrated in New Orleans, Louisiana, traditional grey infrastructure can fail when local levees broke and locked in the flood waters they were meant to withstand (Hallegatte, 2009; Jones et al., 2012). Sovacool (2011) warns that developing countries and their elites may advocate implementing grey measures for similar reasons: tempted by the sophistication and scale of grey infrastructure; taking comfort in the belief of human engineering and advanced technology; or believing grey measures will benefit the economy through the creation of export markets, distributing intellectual property or accruing economic rents. A study by Wamsler (2014) also concludes that southern countries have a bias towards grey measures, as they are seen as more advanced than green or ‘natural’ solutions.

2.2 Green adaptation measures

Hulsman et al. (2011) describe that in the past, many concepts have been developed to focus on soft solutions that combine multiple functions: green adaptation, ecological engineering, building with nature, eco-technology and eco-dynamic design. There might be some variation in the focus of these different concepts, but they all aim at improving natural and socioeconomic values of an area through the effective utilisation of natural processes and ecosystem services. Cross-cutting keywords within these concepts include “multifunctional use”, “nature development”, “integrated approach”, “sustainability” and “ecosystem services” (Hulsman et al., 2011). According to the European Environment Agency (EEA, 2013) ‘green actions’ are “ecosystem-based approaches that use the multiple services of nature.’ Ecosystem based approaches include action such as reinforcing natural defences such as dunes or wetlands, maintaining and restoring healthy ecosystems, and removing man-made obstacles so that indigenous plant and animal species can move across landscapes. Green infrastructure involves integrating multiple green adaptation actions into a spatially organised plan (EEA, 2013). In urban areas green measures cover water retention in green spaces and blue spaces (parks, green roofs, water ponds, etc.) providing cooling and shade as well as cover from harsh wind provided by trees and other vegetation, in streets, parks, back yards of housing

[1] http://www.m-tec.uk.com/project-new-sea-wall-moulds-blackpool.html

blocks etc. Foster et al. (2011) stress the use of green roofs, hard and soft permeable surfaces, green alleys and streets, urban forestry, green open spaces such as parks and wetlands, and adapting buildings to better cope with floods and coastal storm surges.

Besides urban areas, green adaptation measures are also used in coastal areas. Green coastal defences seek to provide space to water and using natural landscapes, e.g. allowing the sea to invade former dune slacks in certain parts of the coast, reef construction along a coastline can reduce coastal erosion, etc. A UK example, the Wallasea Island: Wild Coast Project uses the restoration of a flood plain area along the coast as coastal flood protection (Naumann 2011a). Furthermore, the restoration of riparian areas and mangroves is especially relevant for Asian, African and Latin- and South-American coasts. With Integrated Coastal Zone Management (ICZM) efforts focus on finding a good combination between grey and green infrastructures for costal protection measures.

In the agricultural sector, many green adaptation measures can be implemented, e.g. focusing on cropping practices such as change of crop-mix, crop rotation, residue management or change to conservation soil tillage. Measures also include those which have the objective of reducing soil erosion, such as buffer strips with permanent vegetation, planting winter cover and maintaining permanent grassland. Furthermore, measures like buffer strips especially at rivers and lakes also have a positive effect on water erosion and quality (Hjerp et al., 2012).

Green adaptation measures can also be used to reduce flood risk from rivers. Sometimes interlinked with dikes and other grey measures, such as flood gates, green measures have a great potential for flood protection. Flood plains and flood meadows can also have a positive effect as a buffer zone for agriculture runoff. One ongoing and important activity is the “Room for the River”-programme in the Netherlands[2], which aims to achieve flood protection, improve landscaping and environmental conditions around rivers in Holland. In Germany, several restoration projects for flood meadows are implemented or planned to be implemented, such as: the Lenzener Elbtalaue, with 420 ha, at the river Elbe[3].

Furthermore, green measures are relevant for the forestry sector – including afforestration activities as well as establishing agro-forestry systems (i.e. growing tree crops, hedgerows, shelterbelts and alley cropping) (Hjerp et al., 2012).

Green adaptation measures are also applied for water management purposes. Actions to improve water purification and regulation, such as recovery of riparian vegetation and wetland restoration, can have positive effects on available water quality and quantity (Naumann 2011b). Additional benefits of river restoration beyond improving water quality and quantity also include reductions in flood damages.

The green measures included in adaptation policy at national and local level embed advantages as well as disadvantages for adaptation. Generally, green measures offer a range of co-benefits which especially in cities and at the aggregated level promote their inclusion in adaptation policy. These additional benefits fall within four categories; provisioning, regulating, cultural and supporting services. Examples with different characteristics are (Arnberger and Eder, 2012; Foster et al., 2011; Gill et al., 2007; Petersen et al., 2011):

- increased quality of life and well-being: e.g. recreational spaces, improved urban spaces such as ‘cities for people’;
- public health (mental and physical health): e.g. vegetation has air filtering functions, green spaces provide stress relief, spaces for sports and active recreational activities;
- increased social cohesion: e.g. common practices around gardening, green spaces are meeting places and sites for social activities, builds community identity;
- increased land value: e.g. proximity to green spaces increases attractiveness and thus real estate prices;

[2] More information can be found here: http://www.ruimtevoorderivier.nl/english/.

[3] More information: http://www.naturschutzgrossprojekt-lenzen.de (only in German).

- increased compliance with regulations (especially water and building): e.g. co-benefits improves motivation for compliance;
- hazard mitigation: e.g. flooding and heating risks reduced;
- environmental benefits: e.g. increased biodiversity, climate mitigation.

Green measures such as urban green spaces or willows in wetlands often represent a lower investment than grey measures; the renovation of a sewer system enhanced with additional capacity depends on long-term and costly investments in built infrastructure whereas water reservoirs in urban parks requires relatively lower investments in land and green infrastructure. Some studies suggest that green measures such as green streets, rain barrels and planting trees are 3-6 times as effective in managing cloudbursts and storm surges than grey methods (Foster et al., 2011). It must, however, be noted that the full advantages require integration of green measures in urban development, strategic rural/urban development and agricultural policy, and the full benefit of green measures can only be realised by a comprehensive accounting of their multiple benefits. Most green infrastructure is generally acknowledged to increase the liveability of urban areas and provide more social and amiable urban spaces and communities. Furthermore, the local design and location of green infrastructure provide issues for public participation to which citizens often can relate immediately and experience ownership to, due to e.g. direct impact on everyday life and local environment.

The inclusion of green measures can also have some disadvantages. These include:

- competition for land, especially in urban areas, this may lead to contested planning initiatives;
- risk of drying out of vegetation and green cover in cases of drought;
- strong roots of trees that may permeate built infrastructure;
- requirement of strong human resources in local government institutions to gain the full benefits, through integration of green measures in planning and development initiatives;.
- green infrastructure that involves slowly growing plants, may also have an issue of time, i.e. delay in provision of services relative to the demand for shelter or water detention.

2.3 Soft adaptation measures

Adaptation to climate change involves taking practical actions to reduce vulnerability to climate risks. This involves either through a reduction to the exposure to climate stress or the sensitivity to the impacts, in other words increasing adaptive capacity (Adger, 2006) and exploiting positive opportunities. This has been the definition of adaptation put forward by the Intergovernmental Panel on Climate Change for adaptation (McCarthy et al., 2001; Parry et al., 2007). Nevertheless, adaptation has equally evolved as a concept to account for incremental or transformative changes in social, ecological systems (IPCC, 2014a).

‘Soft’ or non-structural approaches**,** correspond to the design and application of policies and procedures, as well as land-use controls management strategies, information and dissemination programs, or economic incentives to reduce or prevent disaster vulnerability. They require careful management of the underlying human systems (EC, 2009).

The notions of “soft” versus “grey” adaptations are so embedded in the adaptation science discourse that it becomes difficult to find accurate descriptions and robust studies on what soft measures are. Most official documents refer to soft adaptation measures as being those which do not involve hard constructions, such as dikes or seawalls, but are mostly about sharing information, awareness raising and dissemination activities on adaptation issues (EEA, 2013). This designation is also used to refer to instruments for policy and strategy developments, as well as new institutional, governance and social learning arrangements which support advancements on adaptive capacity (UNDP, 2004; Olsson et al., 2006).

Spatial and land-use planning may be considered fundamental soft adaptations, which are often overlooked in case study research, since they involve a wide scope of public and private actors and are mostly integrated in long-term planning activities (Biesbroek et al. 2009; Wilson, 2006). In addition, economic instruments, such as the role of market and regulatory mechanisms, could play a particularly key role in facilitating adaptation to climate change. This is particularly critical because the scope of the adaptation challenge will most likely far exceed the public budgets available to address it. The scale and/or efficiency of many adaptations typically undertaken by governments could be enhanced through engagement with the private sector. Policy instruments need to be put in place to catalyze such engagement and to ensure that it leads to the desired outcomes. These instruments can be directed at using markets, creating markets, regulation and legal arrangements, and engaging the public. A range of policy instruments are relevant to adaptation in many sectors, including insurance schemes, price signals/markets, financing schemes via Public Private Partnerships (PPPs), regulatory incentives and research and development incentives (Agrawala and Fankhauser, 2008, 2008).

Table 2: Examples of 'soft' adaptation (EC, 2009)

Soft Adaptation
• Gathering and sharing information (undertaking research on new technologies, new methods of adaptation and positive feedbacks; collecting and monitoring data, communication education and training initiatives to increase awareness, buy in and behavioural change).
• Creating a supportive institutional framework (changing standards, legislation, best practice guidance and developing appropriate policies, plans and strategies).
• Creating supportive social structures (changing internal organisational systems, developing resources to deliver the adaptation actions and working in partnership).
• Economic instruments, which could play a particularly key role in adaptation (Agrawala and Fankhauser, 2008 2008): insurance is a recurring instrument within the context of adaptive responses in a number of sectors, particularly agriculture; price signals and environmental markets, meanwhile, might be critical to adaptation within the context of many climate sensitive natural resources including water and ecosystems; public private partnerships could potentially play a very critical role in the financing and enhancing the climate resilience of infrastructure, where the costs of adaptation are high.

Insurance can play a prominent role in any adaptation strategy, covering risks, such as crop failure, snow coverage and the impact of freak weather events (e.g. floods, storms, hurricanes and heat waves). However, insurance cover is by no means universal. It is especially uneven among poor households and in poor countries. Public policy measures will likely be needed to overcome these market imperfections. For example, they may take the form of publicly funded adaptation measures to bring risks down to an acceptable level. Alternatively, government could subsidize the most extreme layer of risk to cover low probability high consequence events. Public policy should not, however, subsidize systemic risks, as it may reduce incentives to move from activities that become progressively less viable under the changing climate (Agrawala and Fankhauser, 2008).

Climate change might also pose risks to the global supply chain for many products, and might consequently need to be reflected in business planning (e.g. through public private partnerships). Even beyond the state of firms and businesses, adaptation considerations may be integrated in the co-management of resources (material and human), available to local communities (Olsson et al., 2006). For instance, this could take place through the co-management of water resources in responding to risks of desertification. Other forms of managing available resources, such as investments, on climate-proofing of homes and purchase of insurance, might influence the vulnerability of individuals and households to climate change impacts (Agrawala and Fankhauser, 2008).

Therefore, soft measures can equally refer to local engagement in participatory approaches to planning, creating opportunities for dialogue and exchange among different systems of knowledge (Nelson et al.,

2006). Scholars have addressed as well the role of social capital (Adger, 2003) and collective action (Adger et al., 2013) in building local adaptive capacity. Social capital refers to the relations between diverse groups and networks, and how they establish interdependencies and integrate different types of knowledge in adaptive governance (Adger, 2003; Folke et al., 2005). Thus, activities that proactively promote social capital and collective action may be also considered soft approaches.

Adaptation studies have addressed the importance of local knowledge and traditional systems for resource management (Amaru and Chhetri, 2013). Some communities facing serious environmental challenges have survived over the years by having traditional strategies for coping with external pressures (Folke et al., 2005; Nelson et al., 2007). Therefore, adaptation projects that focus on tapping into local traditional systems of knowledge and promote social learning processes can be also considered soft approaches (Olsson, 2006; Milligan et al., 2009; Hobson and Niemeyer, 2011).

Soft measures can refer to a much broader set of adaptation strategies and measures than merely to measures that do not entail hard constructions. Moreover, soft measures are thought to be more easily integrated in long-term adaptation plans and strategies, than hard adaptation strategies, since they can potentially account for uncertainty in planning and provide no-regret solutions and co-benefits to local communities and stakeholders (EEA, 2013). They are often characterised as being cheaper, though this may not always be the case.

Soft approaches may provide various sources of social resilience (Folke et al., 2010) and promote sustainable futures for social and ecological systems dealing with persistent problems regardless of climate change (Nevens et al., 2013). For instance, coastal zones facing erosion and flooding today, will probably still have to account for at least the same level of environmental pressure in the future, regardless of future climate impacts. Therefore, by addressing persistent problems already felt, through deliberative modes of governance and effective institutional responses to managing and governing local resources, groups, communities or nations will have built in sources of resilience to both current and felt, as well as future and uncertain changes. Consequently, the biggest argument for integrating soft measures in adaptation strategies is their potential for no-regret outcomes that promote more sustainable and resilient societal systems.

Conversely, the biggest challenge in implementing soft approaches is their complexity, since they often mean the engagement of a wide set of policy makers, stakeholder groups and communities and a long-term planning perspective (Nevens et al., 2013). Overall, these various types of soft measures may mean a restructuring of dominant rules and structures, altering the dominant development pathways of a society deliberatively adapting to present and future external pressures (Pelling et al., 2014).

3 Methodology

This section describes the methodology used to gather and select case studies for assessment. As a first step, a matrix was developed to collect case studies. The gathering of case studies started with a review of European and international databases[4] focusing on climate change adaptation case studies. These databases were selected based on several criteria (described below in section 2.2) so that the most relevant portals considered by the involved researchers were reviewed. This review was complemented with a general internet search, focusing on specific countries selected for analysis. Furthermore, national databases were screened for relevant countries. The countries reviewed were selected to cover a wide geographic spread, spanning Europe, North America, South America and Singapore taking into account the European and other world regions already covered by BASE and its partners.

Case studies included in the matrix and selected for in-depth analysis should not be viewed as a comprehensive and complete representation of implemented climate change adaptation measures, but rather a selection of available examples within the selected ones and that provide us with a wide spectrum of the diversity found, mainly regarding the typology of the measure (green, grey or soft), the geographical location, the use of different participatory methods and funding sources. All local currencies have been converted to EUR based on June 2015 exchange rates.[5]

3.1 Case study matrix and general review

A matrix (i.e. excel spreadsheet) was developed to characterise and select case studies. It focused on covering the aims of this research as described in the Description of Work to review and assess methodologies and tools for economic assessment and participation used in climate change adaptation (i.e. selection of measures). To this end, it also aimed to link to participatory and economic methods used in decision-making processes. The layout of the matrix and the six main information categories are described in more detail below.

To remain consistent and organised, the first information category, *ID (Number, Name of Case Study, Location, Description, Specific Studies)* and *Types of Measures (Grey, Green, Soft)*, refers to the identification information as well as the type of measure implemented in a specific case study. Descriptions for grey, green and soft measures (based on EEA 2013) were created to help partners fill in this section.

The second main information category, *Involved in Case Study (NGOs, Transition Initiative, Ecovillage, Informal Groups, Consortiums, Companies, Social Enterprises, Public Companies, Research and Education Centres, Public Administration)*, aims to identify the key actors and stakeholders and their subsequent roles within relevant adaptation case studies. This section makes a distinction between the major types of actors involved from informal groups. Regarding the roles of how these actors contribute to these initiatives we considered support, authoritative body, major funder, information dissemination, etc…

The third information category, *Typologies of Adaptation Measures*, expands upon the initial classification of adaptation measures as grey, green or soft into more specific information considering the geographical location of case studies: coastal, urban, rural, river basin and other. Each typology has additional options to better identify which climate impacts these adaptations are targeting.

Similarly, the fourth information category, *Dimensions of Characterization*, expands upon the initial ID information to account for geographical scale, major sectors involved, time period of adaptation implementation, temporal perspective and process direction. The scale range varies from local to

[4] List of international databases focusing on climate change adaptation case studies: INFOBASE http://infobase.circle-era.eu; Global Adaptation Network http://ganadapt.org/; Climate-ADAPT http://climate-adapt.eea.europa.eu/web/guest; CAKE http://www.cakex.org/case-studies; weADAPT https://weadapt.org/; UNFCCC https://unfccc.int/adaptation/knowledge_resources/databases/items/6996.php; MEDIATION http://mediation-project.eu/; and Web of Science http://wokinfo.com/; www.klimatilpasning.dk and www.klimaanpassung.at.

[5] http://ec.europa.eu/budget/contracts_grants/info_contracts/inforeuro/inforeuro_en.cfm

European/global. Sectors refer to the major industry sectors the adaptation measure or case study impact or affect. Years of implementation refers to the time period in which an adaptation measure was actually being implemented, while the temporal definition refers to the perspective of analysis (e.g. retrospective for past/completed case studies; prospective for on-going and future actions). Lastly, the process direction refers to the initiative direction for the adaptation measure: bottom-up, top-down or both (T-D and B-U).

The fifth information category, *Decision Support Tools Used in the Implementation Process*, directly links to the participatory (Stakeholder and Public Workshops, Questionnaires, Information Dissemination, Participatory Add-ons to Adaptation Pathways, Other) and economic methods (Cost Benefit Analysis, Cost Effectiveness Analysis, Multi Criteria Analysis, Analytic Hierarchy Process, Participatory Cost-Benefit Analysis, Participatory Add-ons to Multi-Criteria Analysis, Other) used in climate change adaptation decision-making processes. The major participatory and economic methods were used to fill out the matrix options, while the 'other' column provides a 'catch all' category to collect lesser used methods.

Lastly, the sixth information category, *Funding* and *Additional Information*, aims to identify financial aspects of adaptation measures (i.e. funders, cost of implementation and maintenance costs), as well as any additional information deemed important or useful.

3.2 Case study selection and in-depth characterisation

This section details the criteria used in the collection and selection of case studies of adaptation measures for the matrix. The methodology followed a two-step process. The first step generated a set of criteria used to select and gather global case studies for inclusion into the matrix. The second step generated a set of criteria used to select case studies for in-depth analysis (see case studies in section 4.2).

3.2.1 Criteria for inclusion in matrix

A list of initial characteristics were used as criteria to establish and aid in the selection of case studies for the matrix. Examples were drawn from Europe and internationally in an effort to collect a wide range of diverse adaptation case studies (i.e. implemented adaptation measures). The objective of this first step is to collect a range of case studies that provide a mix of sectors, geographic regions (within countries), ecosystems, methodologies and measures. The collection and inclusion of case studies to the matrix depended upon the display of key characteristics, which have been identified as criteria for inclusion into the matrix. The following descriptions provide more detail of these case study characteristics criteria:

1) *Geographic Region*—case studies should originate from countries selected to provide a broad geographic, cultural, socioeconomic, and political scope. These include: Australia, Austria, Brazil, Denmark, Finland, France, Germany, Norway, the Netherlands, Portugal, South Korea, Spain, Sweden, United Kingdom and the United States of America.
2) *Type of Measure*—case studies need to clearly display a focus on one or more concrete measures for climate change adaptation. These measures can be categorised as green, grey and/or soft according to the case study matrix. In this regard, case studies can include one or more measures for adaptation to climate change. If a measure is not clearly identifiable it was not included in the matrix.
3) *Applied Methodology*—case studies should indicate the application of a clearly defined methodology either in the choosing and/or assessing an adaptation measure. This methodology should be categorised as either a stakeholder participation/engagement and/or an economic method within the case study matrix. Those case studies without a defined methodology were excluded from the matrix.
4) *Status*—case studies should clearly indicate the status of implementation of the identified adaptation measure(s). This status must be categorised as either retrospective, prospective, or retro-and prospective within the case study matrix. Measures that are only virtual (suggested or proposed), with no indication for implementation, were excluded.

5) *Data Availability*—case studies and their respective methodologies should be categorised according to their respective data availability. This categorisation will influence the second round of case study selection for in-depth assessment. The categorisation of data availability can be considered as high, moderate, or low as described below. Those determined to be low were excluded from the matrix.

    a. *High*: case study website, contact person(s), referenced or mentioned in the media and other reports, and applied methodology is clearly explained in detail.

    b. *Moderate*: case study website, contact person(s), limited or few mentions in the media or in other reports, and applied methodology is not clearly explained but has enough information to seem viable.

    c. *Low*: no website, no contact person, limited to no mention in the media or in other reports, and applied methodology is not mentioned or vaguely referenced in an ad hoc manner.

3.2.2 Criteria for in-depth assessment

A list of further selection characteristic criteria is proposed to aid in the selection of case studies for in-depth assessment. This list, in addition to that of the initial criteria as described above, serves the purpose of identifying good practices. In order to develop this list of criteria, a review of relevant literature and publications was conducted in order to identify potential criteria for selection[6]. Based on this, criteria were selected which aligned with objectives of BASE Deliverable 4.2. The following descriptions provide more detail of the proposed case study selection characteristic criteria for in-depth assessment:

1) *Cost Availability*—case studies should indicate the costs associated with the adaptation measure targeted and clear indications of where this funding originated. Understanding the actual cost of an adaptation measure and the funding sources for its implementation can provide information regarding the economic feasibility of the adaptation measure as well as its economic efficiency. Additionally, many governments and public bodies are pushing for more transparency in decision-making processes as well as financial transactions. If information on costs is not available these examples were excluded from the in-depth assessment.

2) *Effectiveness*— information regarding the performance of the case study or adaptation measure in question should be checked to identify whether the adaptation measure was (in)sufficient in addressing climate change concerns. An example of this would be whether a constructed flood defence was sufficient in its performance to withstand flood risks. This criterion is included as a quality check, to ensure that poor performing measures or worst-case scenarios are also identified.

3) *Public Availability of Information*—case studies should have sufficient information available so that the context of the case studies and selected measures can be assessed. This criterion is both a quality and transparency check to ensure all relevant information is freely provided when searched or asked directly. This criterion relates to the Data Availability criterion listed in the initial criteria list (see above). If it is deemed by the reviewer that not enough information is available, than these examples were excluded from the in-depth assessment.

[6] List of reviewed documents for potential criteria for selection:

World Health Organization. (2008). Guide for Documenting and Sharing “Best Practices” in Health Programmes. *Brazzaville: WHO*. http://afrolib.afro.who.int/documents/2009/en/GuideBestPractice.pdf
Schipper L., Liu W., Krawanchid D. and Chanthy S. (2010). Review of climate change adaptation methods and tools. MRC Technical Paper No. 34, Mekong River Commission, Vientiane. http://www.mrcmekong.org/assets/Publications/technical/Tech-No34-Review-of-climate-change.pdf
Emmanuel Santoyo Rio and Philip Charlesworth. (2013). Study on Good Practices in Agricultural Adaptation in Response to Climate Change in Cambodia. SNV Netherlands Development Organisation. http://snv.org/sites/www.snvworld.org/files/documents/snvkh_agr_goodpracticesclimatechange.pdf
EEA. (2006). Set of Selection Criteria for Climate-ADAPT Case Studies. http://climate-adapt.eea.europa.eu/en/c/document_library/get_file?uuid=593659fe-c206-4ee5-9bc2-f819d803a7ac&groupId=18
EEA . (n.d.). Best practice – a method for dissemination and implementation of project results. http://ec.europa.eu/environment/life/publications/lifepublications/generalpublications/documents/bestpractice.pdf
MC3. (2011). Meeting the Climate Change Challenge (MC3)- Case Study Criteria. http://www.mc-3.ca/case-study-criteria
UCCRN. (2014). Urban Climate Change Research Network (UCCRN)- Call for ARC3-2 Case Studies. http://uccrn.org/2014/10/01/call-for-arc3-2-case-studies/

4) Finally, the ultimate selection of case studies should represent this diversity:
    a. A mix of grey, green and soft measures
    b. A mix of geographic regions
    c. A mix of rural and urban examples
    d. A mix of Top-Down and Bottom-Up Approaches
    e. A mix of methodologies, measures and ecosystems

4 Results

This section provides the results based on the previously detailed methodology. It is split into three sub-sections. First, a general assessment of the compiled global case studies is described. The general assessment summarises the main characteristics of the relevant case studies, e.g. how many case studies could be found per country, which stakeholders are involved in the case studies, how many contain green, grey and/or soft measures, etc. Second, the selected in-depth case studies are analysed. This section is further split into additional sub-sections of grey, green and soft measures in order to structure the examples. The in-depth assessment of the case studies focuses mainly on the methodologies and tools for economic assessment and participation used in climate change adaptation decision-making processes. Third, the databases, which were reviewed within this work, are described and a brief analysis based on the research team's experience and findings is provided.[7] This is done in an effort to highlight the type of information available in such databases and point to potential areas where they could be improved.

4.1 General assessment

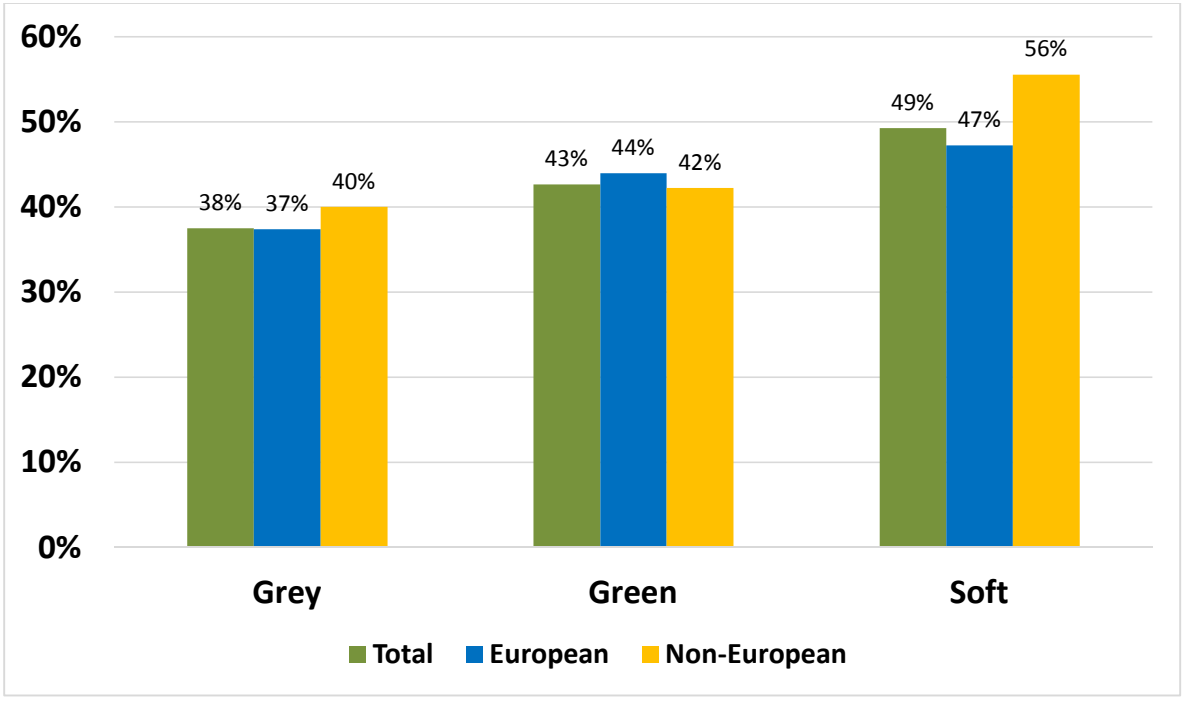
This chapter gives an overview on the main characteristics of the assessed case studies. The section describes the results of the database search in regard to where the case studies are located, which type of measures are implemented, which stakeholder groups are involved, at which scale (national, regional, local, etc.) the case studies are situated, which sectors are covered, which methods are used (participatory and economic) and which funding sources were available for implementation. In total, 136 case studies are included in the general assessment, originating from 19 worldwide countries. Most case studies found are from Germany (15), followed by the USA and Portugal (13). Of all the case studies, 91 came from Europe and 45 are non-European case studies.

4.1.1 Type of measures in reviewed case studies

Green, grey and/or soft adaptation measures were all identified in the case studies. As depicted in the following graph (Figure 2), all the different types of measures are represented in the gathered case studies. In total, most of the activities in the case studies are soft measures, representing 49% of all adaptation measures in the case studies, while green measures are involved in 43% of all assessed case studies. Grey adaptation measures are mentioned overall in 38% of the case studies.

For non-European case studies, the implementation of soft measures is higher at 56% of the case studies while Europe has 47%. The share of case studies with green measures does not differ that much between European (44%) and non-European countries (42%), similar to grey measures with 37% in European case studies and 40% in non-European case studies.

Figure 2: Type of measure in reviewed case studies

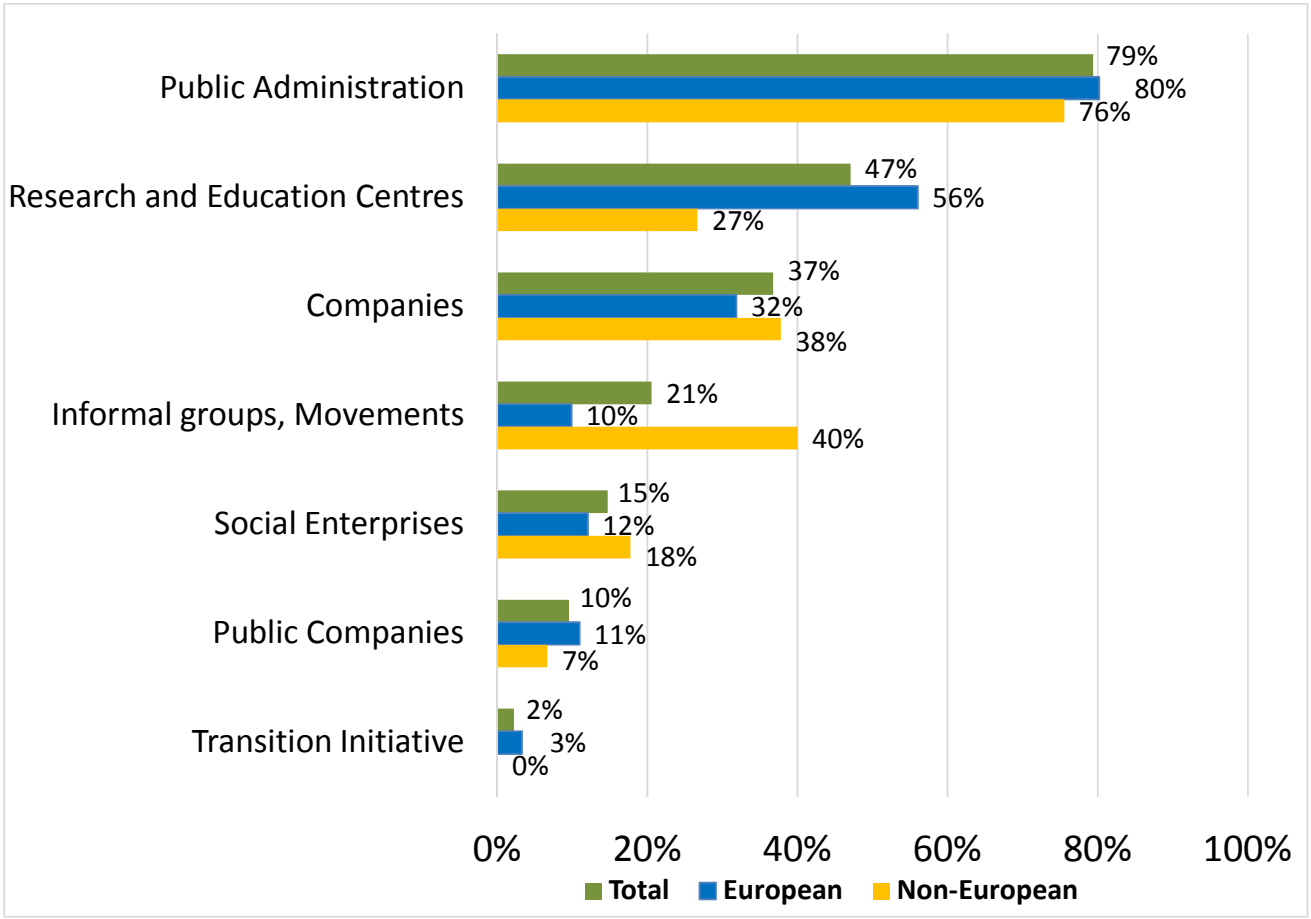


4.1.2 Stakeholder groups in reviewed case studies

For the reviewed case studies, it was identified which different stakeholders were active in the implementation of the measures, e.g. in giving advice or research for designing the activities. The screening of the case studies show (Figure 3) that public administration bodies on different levels (municipality, regional, national or European level) are the stakeholders that are mainly included in the reviewed case studies – with 79% representing this group. In 47% of all reviewed case studies, research and education centres were active, e.g. universities, research centres or schools. Private companies at different sizes (e.g. big businesses, SMEs or farmers) were involved in 37% of the case studies. Furthermore, other stakeholder groups identified include informal groups and movements (21%), social enterprises (e.g. non-profit companies, cooperatives) (15%), public companies (10%) and transition initiatives (i.e. grassroots projects) (2%) were involved.

In the non-European case studies, the stakeholder group of public administration bodies identified in the case studies reaches 76%. For the European case studies, over half of them include research bodies. In 27% of the non-European case studies, research and education institutions are active. Private companies at different sizes (e.g. big businesses, SMEs or farmers) were involved in 38% in non-European case studies and 32% in European case studies. A major difference between European (10%) and non-European case studies (40%) can be seen for informal groups and movements.

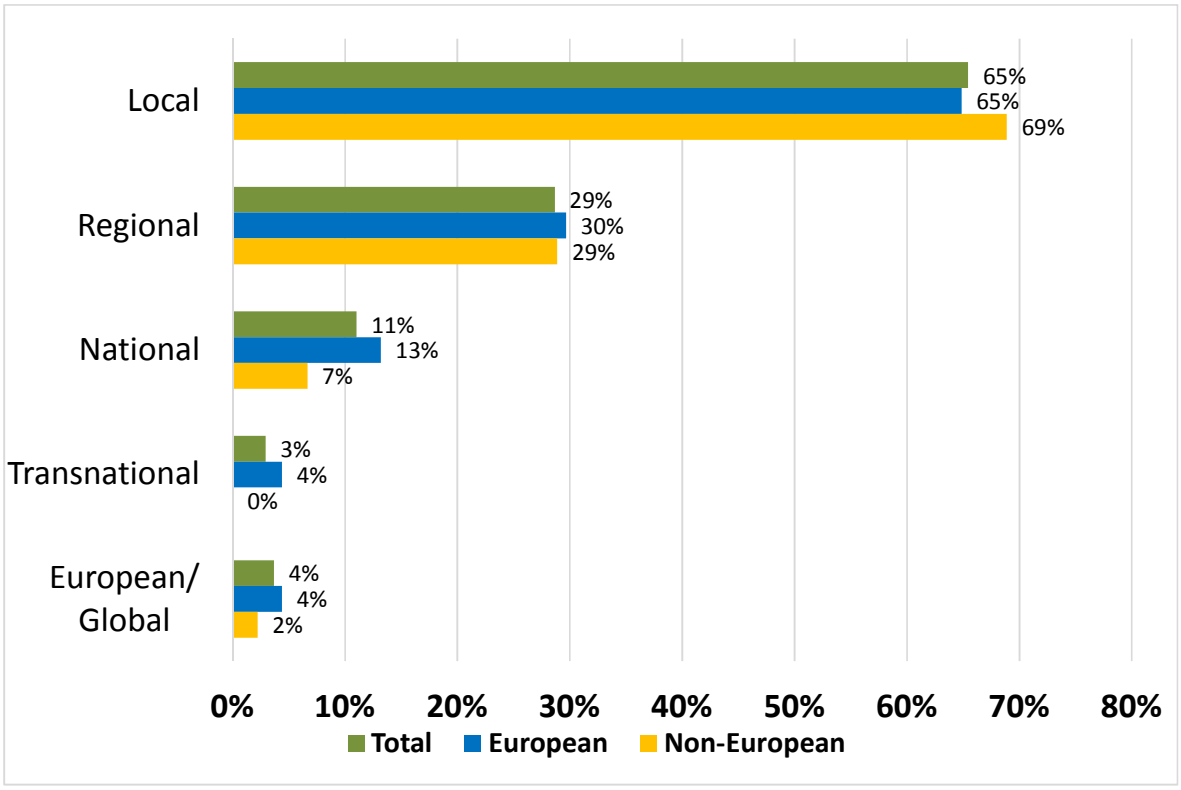
Figure 3: Stakeholder groups in reviewed case studies



4.1.3 Scale of reviewed case studies

The scale of the reviewed case studies differs between European to local case studies (see Figure 4). The focus of the review is clearly visible with 65% at local level and 29% at regional level. The national, transnational and European/global scales combined only represent 18% of the case studies. For non-European case studies the focus on local scale (69%) is even more significant, similar to European case studies with 65% on the local scale.

Figure 4: Scale of reviewed case studies

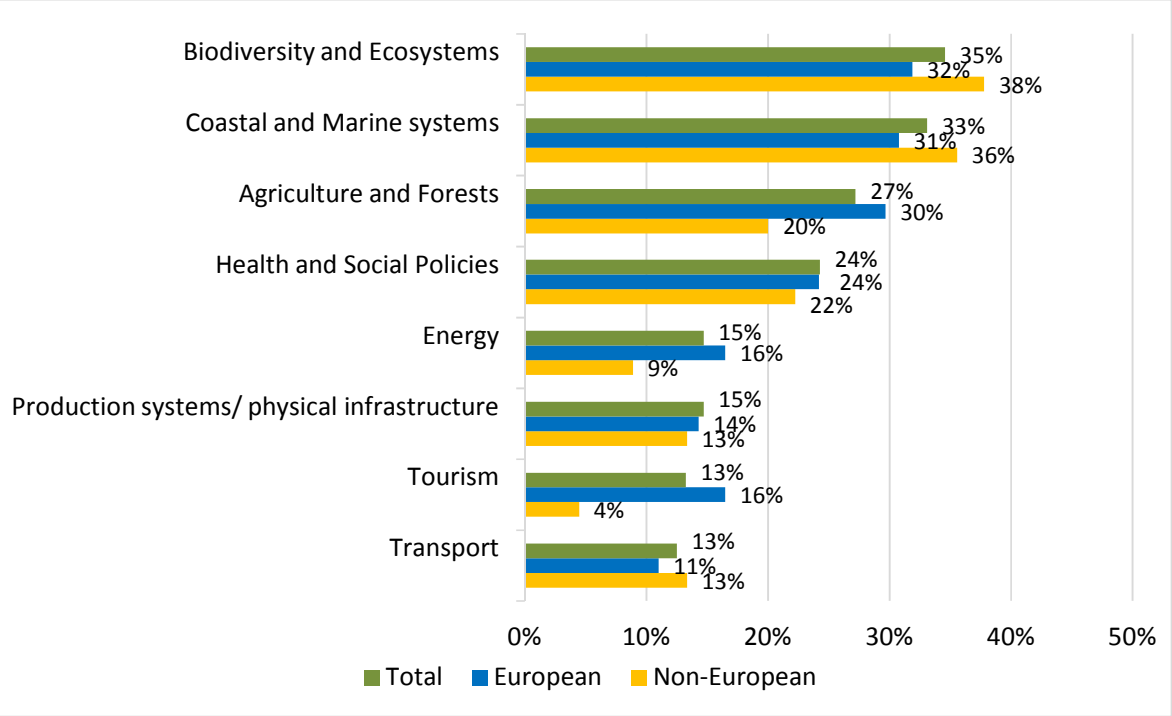


4.1.4 Sectors in reviewed case studies

For the screening of the sectors focused in the reviewed case studies, the major sector directly analysed in each case study is screened (see Figure 5). For the 136 case studies, most case studies focus on biodiversity and ecosystems (35%). This is followed by coastal and marine systems (33%), agriculture and forests (27%), and health and social policies (24%) as the main sectors addressed in the case studies. A lower number of case studies represent production and physical infrastructure, energy, and tourism and transport, with each of these sectors representing less than 15% of the case studies.

Divided between European and non-European case studies, it can be seen that both European and non-European case studies deal mainly with biodiversity and ecosystems, coastal marine systems, agriculture and forests, and health and social policies. In comparison, non-European case studies focus slightly more on agriculture and forestry, while European case studies focus slightly more on energy and tourism.

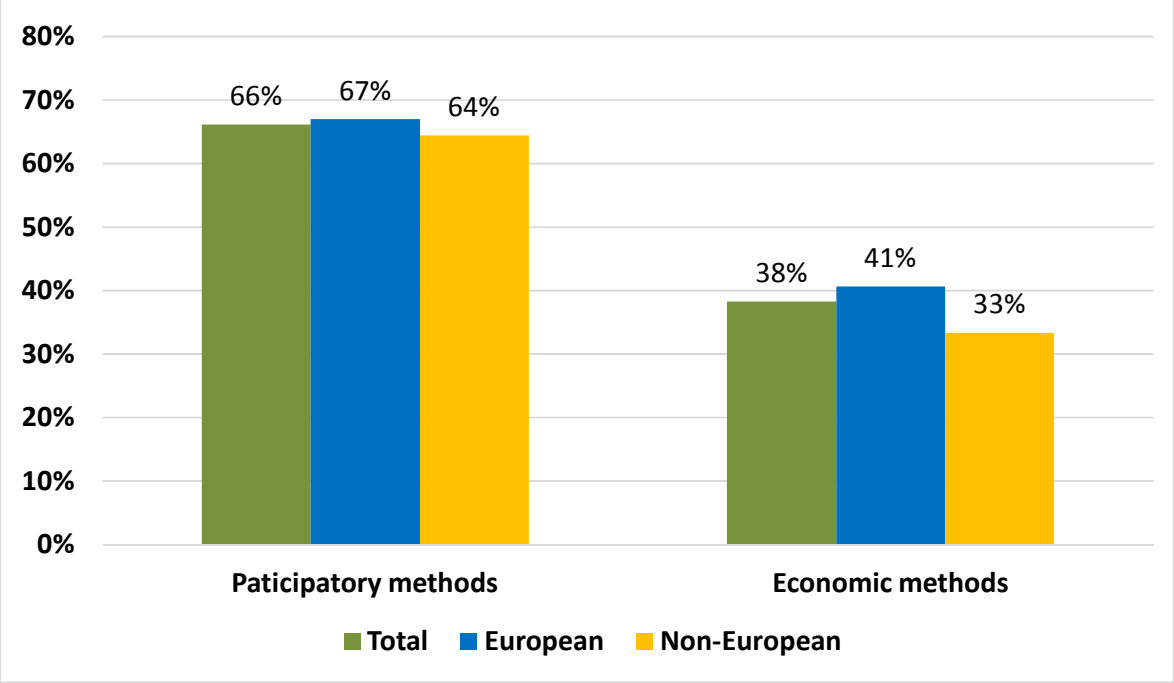
Figure 5: Sectors in reviewed case studies



4.1.5 Decision support tools in reviewed case studies

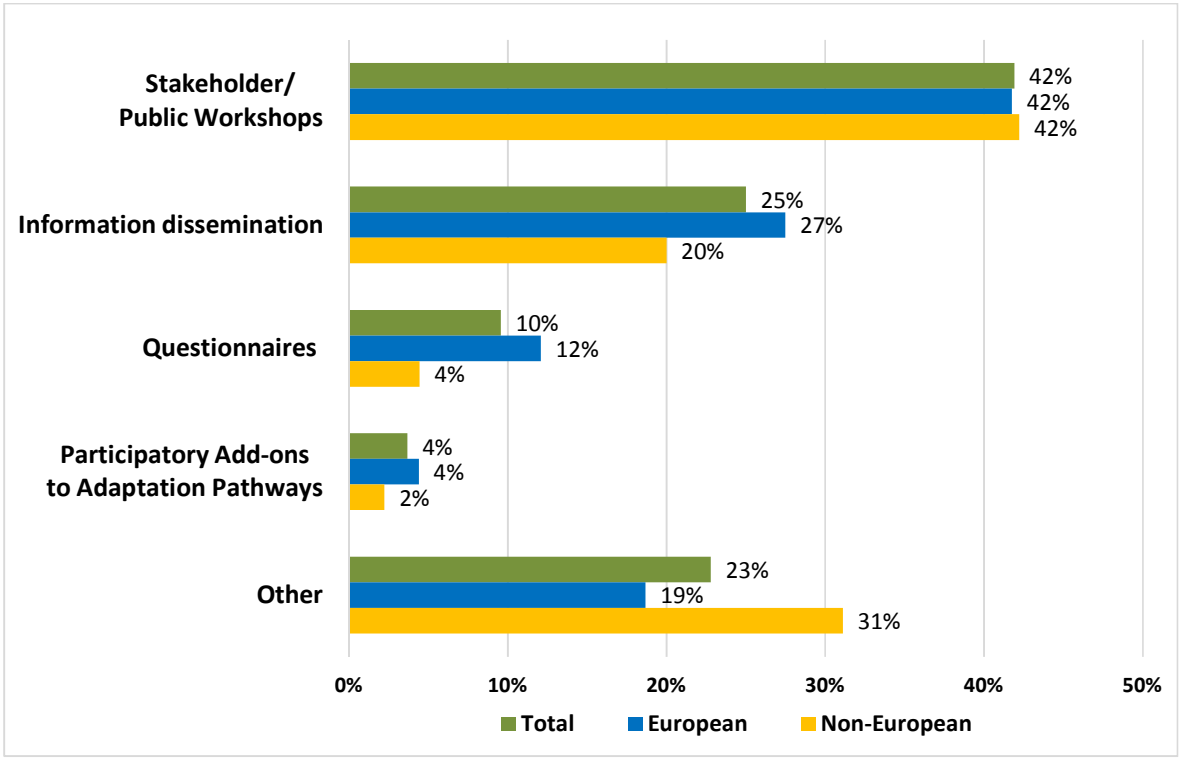
One of the major foci in this report is the use of decision support tools in the gathered case studies (see Figure 6). Through the general assessment, participatory methods were identified in 66% of the case studies and economic methods were identified in 38%. For non-European case studies, participation methods were identified in 64% of the case studies and economic methods in 33%, while European case studies had 67% and 41%, respectively.

Figure 6: Decision support tools in reviewed case studies



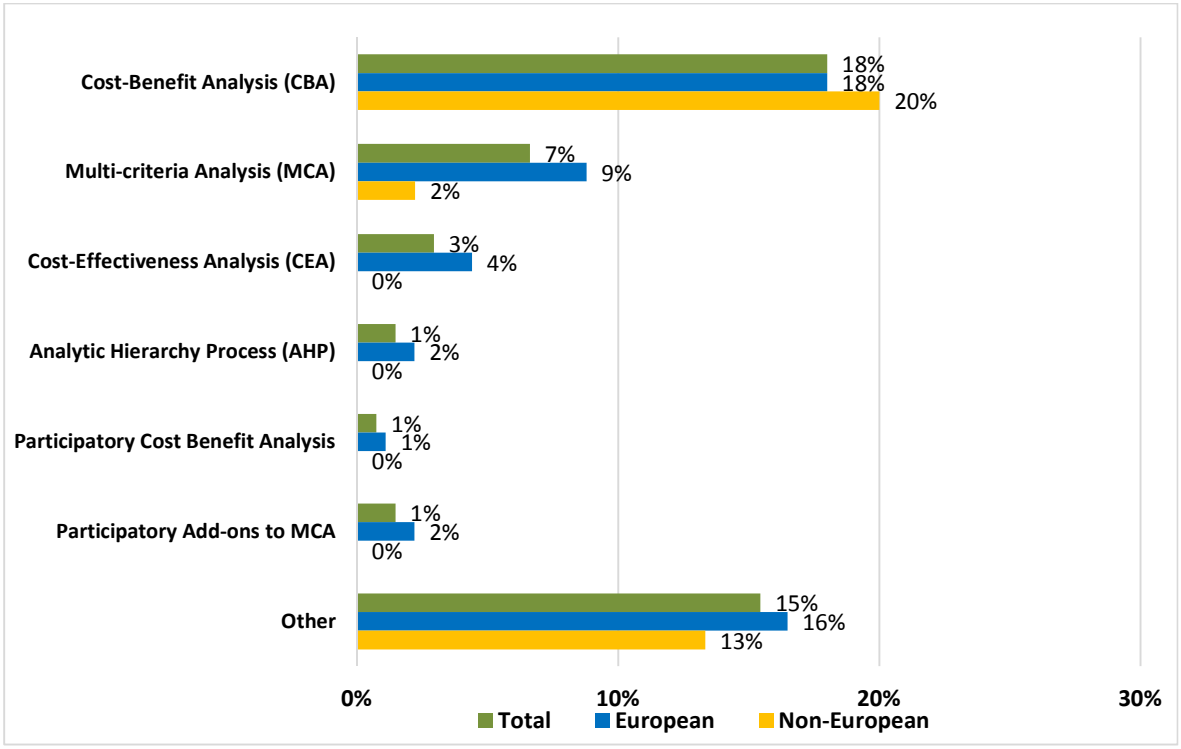
A further detailed assessment of the participatory methods identified stakeholder and public workshops in 42% of the case studies (Figure 7). Furthermore, dissemination of information material via web pages, factsheets, leaflets, brochures, etc. was identified in 25% of the reviewed case studies. Questionnaires and participatory add-ons to the adaptation pathway method were identified in less than 10% of the case studies and these were especially not seen in non-European case studies. In the answer category “others”, different methods are covered, e.g. personal and telephone interviews, surveys, a plebiscite, and training courses. Also, case studies which indicate an integration of stakeholder views but do not further explain are included in the answer category “others”.

Figure 7: Participatory decision support tools in reviewed case studies



By far, the economic method identified most in case studies was cost-benefit analysis (18%) (see Figure 8). The other methods are used only in a very low number of case studies. In the answer category “others”, different economic methods were indicated, e.g. socio-economic scenarios, impact assessment, a water pricing model, risk analysis, and cost assessments.

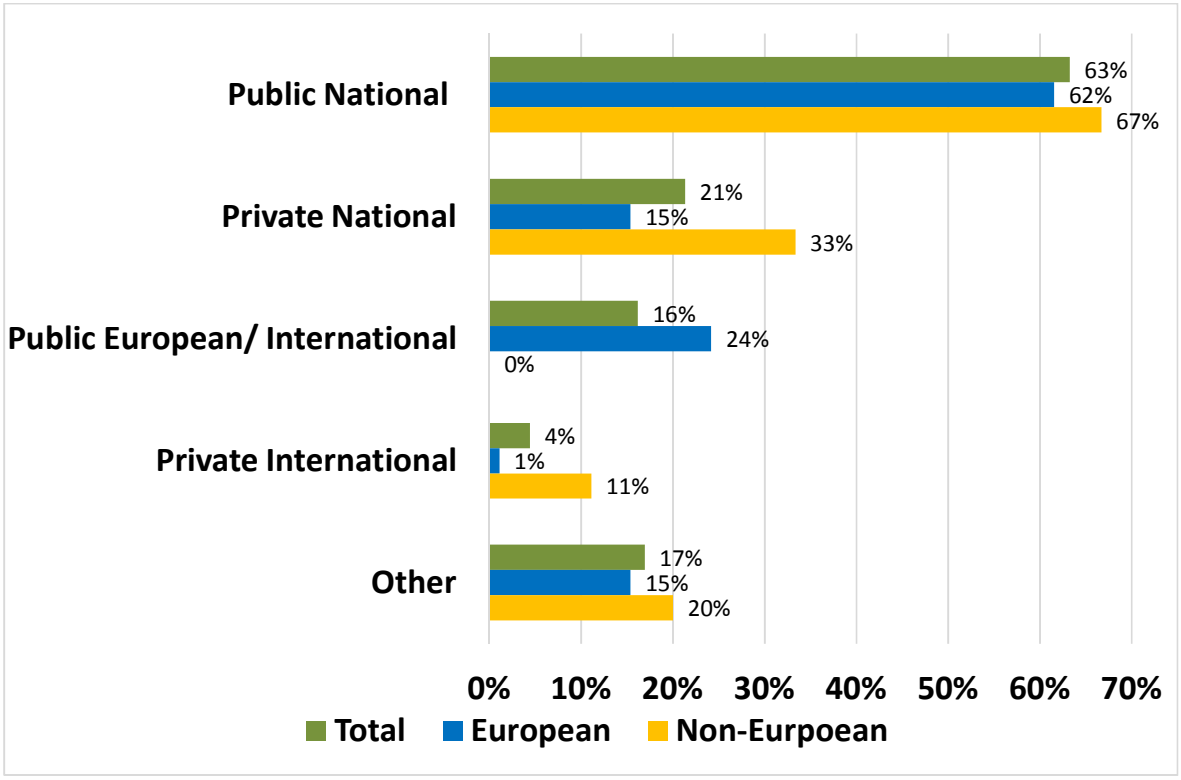
Figure 8: Economic decision support tools in reviewed case studies



4.1.6 Funding sources in reviewed case studies

The funding sources (see Figure 9) identified in all case studies are dominated by public funding (63%). National public funding sources were identified in 62% of case studies in Europe and 67% in non-European case studies. Furthermore, other funding sources are used by non-European case studies, e.g. regional and local public funding, but also donations, financing via issued bonds or water and waste water user rates. In European case studies other funding sources are mainly regional and city budgets. Funding, in this exercise, refers to a broad category of actions, covering the funding of research and development (e.g. workshops), adaption measures and maintenance costs.

Figure 9: Funding sources in reviewed case studies



The 136 identified case studies offer a broad mix of examples of measures implemented to adapt to climate change both in European and non-European countries. Soft measures are the type of measure most often implemented, with 47% in Europe and 56% in non-European countries. Public administration bodies on different levels are the main stakeholders included in the reviewed case studies – with 80% representing this group in Europe and 76% in non-European case studies. In terms of scale, the focus is 65% on the local level and 29% on the regional level. In regard to the sector, most case studies focus on biodiversity and ecosystems (35%) and coastal marine systems (33%). The general assessment also identified participatory methods in 66% of the case studies and economic evaluation methods in 38%. Public funding is also the main source for financing both European and non-European case studies.

4.2 In-depth assessment

The in-depth case studies presented here are divided into sections covering grey, green and soft measures. As adaptation measures and actions (green, grey, soft) are often combined (EEA, 2013), they are described separately as far as possible for the analysis.

4.2.1 Grey adaptation case studies

On the following page two case studies for grey measures are described in-depth: (1) Climate Adaptation in Logistics implemented by a German company focuses on grey measures while (2) the Melbourne Adaptation Strategy and Action Plan describes a mix of measures at used to combat climate change.

The case studies highlighted below provide two examples of how grey climate change adaptation measures can be based on results from participatory workshops and integration with business interests, as in the German logistics case, and how a mix of measures can help secure and prepare a city against future climate change impacts.

Climate adaptation in logistics	
Location: Germany plus other European countries in which the company is active (Italy, Poland)	*Cost: 3,000,000.00 EUR* *Decision Support Tool: Participatory*
The logistics company paneuropa-Rösch is active throughout Europe and faces the challenge of climate change, e.g. transport disruption due to detours, damaged transported goods due to extreme rainfall, affected performance of drivers due to heat. This case study provides an interesting example of how a private business in the logistic sector developed and implemented adaptation measures. Several studies show that the logistic sector will be one of the most impacted economic sectors. The logistic company paneuropa-Rösch developed the adaptation measures in a participatory setting within a series of workshops with different stakeholders and a supporting research team. Climate adaptation measures were developed and implemented by paneurope-Rösch and other partners since 2009. The climate adaptation measures were developed together with different stakeholders and partners in a participatory process. The participatory process was supported by the German-funded research project KLIMZUG nordwest 2050. The objective of the developed and implemented measures was to reduce disruptions and bottlenecks due to climate impacts. In the logistic sector, it is very important to transport and deliver goods on time. Punctuality can be assured with certain flexibility between rail and road transport. Paneuropa-Rösch decided to increase their share of transported goods by railway, due to better predictability of transport time and higher transport safety. For the last kilometre to and from the clients, the trailers will be loaded from the railway to the street. Furthermore, a short-notice shift to road transport would be possible in case of any disruption due to extreme events. To protect the transported goods from heat and water, paneuropa-Rösch is using transport boxes which avoid the infiltration of water during extreme rainfalls. The boxes are also better protected against heat. Paneuropa-Rösch also developed together with partners, e.g. the producer of the trailers, a cooling trailer which can be transported by rail and road. The cooling trailer can cool down and freeze the transported goods and can be lifted between road trucks and railway wagons.	

Figure 10: Cooling trailer of paneuropa-Rösch

Source: Hintemann, R. (2014)

This is an innovative approach because cooling trailers for railways did not exist and were especially developed in conjunction with software, developed to assure that the entire logistics chain remains cold. To date, paneuropa-Rösch is the only provider of this combined road-rail cooling transports. Paneuropa-Rösch is also expecting other goods, e.g. olive oil, will need to be transported in cooled containers in the near future.

Additionally, the driver's cab was coloured in light colours to reduce the temperature during hot summer days. Air conditioning in the driver's cab was strengthened due to driver complaints of high temperatures which influence their concentration during driving.

Transports to Southern Europe for which an Alp crossing is necessary, alternative routes were prepared which can be used in case of a disruption due to avalanches, flooding or other extreme events. To date, these measures have been introduced in all company locations in Germany, Italy and Poland.

Barriers to these adaptation measures were the need to develop an IT-platform and rail-suitable equipment, such as trailers, etc. Furthermore, knowledge and experience with climate-adapted solutions was not available in the company, which required staff trainings on new work processes and structures and information updates to clients via marketing measures. Through the combination of rail and road transport, fixed costs increased due to the fixed booking of rail transportation. To reduce costs, paneuropa-Rösch expanded their offered services to include more rail transported goods so that block train connections are used and increased the number of possible destinations they deliver to.

The participatory process for the development of the adaptation measures was implemented over 1.5 years. Paneuropa-Rösch, together with research partners of the project KLIMZUG nordwest 2050 and other partners, developed the concept in a series of workshops. The first workshop was carried out in 2009, where participants discussed how the company could be impacted by climate change. Further workshops focused on how to develop an adaptation strategy for paneuropa-Rösch and the step-by-step implementation strategy. The measures were evaluated according to criteria such as CO_2-reduction and cold chain-disruptions and client acceptability was screened.

The climate adaptation of paneuropa-Rösch is one of the rare examples of climate adaptation of companies, including a participatory process with research partners and clients. The strategy was developed by integrating expert knowledge and discussions between different stakeholders. Furthermore, a mix of different measures was implemented: the innovative product development of a cooling trailer for railways and the shift from road to more rail transport. The business risk associated with this transition (due to increasing costs) had to be complimented with further adjustments to the business activities.

The participatory process was at least partially funded by the German project: KLIMZUG nordwest 2050, financed by the German Federal Ministry of Education and Research. The implementation of the

developed adaptation measures were financed by the company paneuropa-Rösch.

Links:

http://www.umweltbundesamt.de/publikationen/handbuch-zur-guten-praxis-der-anpassung-an-den

http://www.paneuropa.com/ambiente/klimaverantwortung.html?L=2cmr-cim%2F

http://www.paneuropa.com/umwelt/gruene-logistik.html

http://www.paneuropa.com/unternehmen/presse.html

Melbourne Adaptation Strategy and Action Plan	
Location: Australia, Melbourne	*Cost: 28,877,829.96 EUR (at least)* *Decision Support Tool: Participatory*

This case study focuses on the Australian city Melbourne's Adaptation Strategy and corresponding Action Plan, implementing all types of adaptation measures: green, grey and soft. It is included in this section, because many of the measures are grey and this report does not have a section for mixed measures. The city's initiative to implement multiple aspects of their Adaptation Strategy represents a strong and successful start to combating the effects of climate change on a local scale in an integrative and collaborative manner.

Melbourne is located in south-eastern Australia, part of the larger region of Victoria. As Victoria's capital city, it is the administrative, industrial, recreational and cultural hub of the state. The metropolitan area sits north of Port Phillip Bay, covering around 7,694 km^2 and hosting around 4.1 million inhabitants (as of 2010) and over a million international visitors per year. The city centre itself is around 37.6 km^2 with a residential population around 96,500 (as of 2010). Melbourne's local government manages the transport, commercial and retail hub of the Greater Melbourne metropolitan area, including the Port of Melbourne, the Central Business District, leisure and art complexes, sporting, parks and gardens, as well as universities, research facilities and hospitals (Fünfgeld et al., 2013).

In 2008, a risk assessment on climate change impacts concluded that by 2030 Melbourne should expect to be increasingly affected by warmer temperatures and heat waves, intense storm events and flash flooding, sea level rise and lower rainfall and drought. To minimise the effects of these impending impacts, the City of Melbourne released its Adaptation Strategy in 2009 and the following Climate Change Action Plan in 2010, establishing its long-term response to the key risks identified above (Fünfgeld et al., 2013; NCAARF, 2013). Previous and ongoing efforts to implement adaptation measures target the sectors of agriculture and forests, energy and health and social policies.

The City of Melbourne identified two key actions that offer multiple benefits for the city:

1. *Harvesting storm water across the municipality* – this helps with reducing drinking water usage, watering parks and street trees, preventing floods, building water system resilience and protecting biodiversity.
2. *Increasing the city's passive cooling efficiency* – the city centre can be up to 7°C hotter than less urbanised places, so reducing heat levels will help counter rising temperatures.

The city's efforts were multi-pronged, reflecting the various adaptation measures to be implemented. Key stakeholder groups were primarily engaged via the Inner Melbourne Climate Adaptation Network, an invite-only network which includes climate managers, water utilities, energy providers, CSIRO, Victorian Centre for Climate Change Adaptation (VCCCAR) and its affiliated universities (i.e. the University of Melbourne, Monash, RMIT and Swinburne), Bureau of Meteorology and Victorian Government departments of Transport, Sustainability and Environment, Health, Human Services and

Emergency Service organisations (NCAARF, 2013).

Since 2010, the City of Melbourne implemented a mix of adaptation measures to address the identified threats associated with climate change: the Heatwave Response Plan, Urban Forest Strategy, Green Roofs, Total Watermark- City as a Catchment and the 1200 Buildings programme. Soft policy measures were combined with green and grey measures aimed at retrofitting buildings to reduce energy and water consumption, plant trees, install storm water harvesting tanks and conduct major changes to irrigation systems, as well as public and community outreach activities. Concrete grey, green and soft actions of the local government include:

- Enacting projects including urban green space expansion, development of green roofs and walls, forest expansion, integrated water management and storm water harvesting, streetscape adaptation and introducing permeable pavements.
- Retrofitting 13 Council buildings, expecting to save 133,174.46 EUR in energy costs, 11,791 kilo litres of water and 1,560 tonnes of greenhouse gas emissions
- Installing storm water harvesting tanks in Fitzroy Gardens, Darling Street East Melbourne, the Docklands development, Birrarung Marr and Alexandra and Queen Victoria Gardens- decreasing the city's reliance on mains water by 363 million litres
- Implementing drought proofing in open spaces, including converting turf to warm season grasses and conducting major changes to irrigation systems
- Planting over 12,000 new trees and adding 10,000 km^2 of green space
- Implementing water restrictions and government campaigns.
- As part of the Heatwave Response Plan, a communication strategy is activated during heat waves issuing information to service providers and agencies that interface with members of the community.
- Running a four-year citizen engagement program to develop public awareness about the impacts of drought on the urban forest.
- Developing guidelines for species diversification to minimise vulnerability to pests and disease.
- Running a Green Roofs Forum quarterly since 2010 to facilitate knowledge transfer to community and industry and developing the Growing Green Guidelines – Australia's first guide for constructing green roofs.

The success of the 1200 Buildings programme was recognised in September of 2013, when the City of Melbourne won the prestigious international City Climate Leadership's Energy Efficient Built Environment award, presented by C40 and Siemens in London. In New York in September of the following year, 2014, the City of Melbourne won the City Climate Leadership award again for Adaptation and Resilience.

This case study clearly illustrates the support and effort of the City of Melbourne to implement various adaptation measures to address the identified key climate risks to the city. Aspects to be improved upon include more information regarding how the decision to implement and invest in the specific adaptation measures and what economic methods, if any, were used in this process.

Adaptation partners included climate managers, water utilities, energy providers, CSIRO, Victorian Centre for Climate Change Adaptation (VCCCAR) and its affiliated universities (i.e. the University of Melbourne, Monash, RMIT and Swinburne), Bureau of Meteorology and Victorian Government departments of Transport, Sustainability and Environment, Health, Human Services and Emergency Service organisations.

Funding was provided by the Department of Climate Change and Energy Efficiency (DCCEE) under its Local Adaptation Pathways (LAPP) Program and the City of Melbourne Council. The City of Melbourne invested 21,027,546.09 EUR in climate change policy and initiatives in 2010–11, and 7,850,283.87 EUR

in 2011-12.

Links:

http://www.vcccar.org.au/sites/default/files/publications/Framing_adaptation_case_study_report_Melbourne.pdf

http://www.nccarf.edu.au/localgov/sites/nccarf.edu.au.localgov/files/casestudies/pdf/Case%20Study_City%20of%20Melbourne%20Climate%20Change%20Adaptation%20Strategy%20and%20Action%20Plan.pdf

https://www.melbourne.vic.gov.au/Sustainability/CouncilActions/Pages/AdaptingClimateChange.aspx

http://www.melbourne.vic.gov.au/1200buildings/Pages/Home.aspx

https://www.melbourne.vic.gov.au/Sustainability/CouncilActions/Pages/CityCatchment.aspx

http://cityclimateleadershipawards.com/2014-project-melbourne-urban-landscapes/

4.2.2 Green adaptation case studies

On the following pages, three case studies focusing on green measures are described in-depth: (1) Sky Island Restoration Project in Arizona, USA, (2) Urban Storm Water Management in Malmö, Sweden, and (3) Saltmarsh as a Coastal Defence in Essex, UK. In addition one case study focuses the use of a grey-green measure: (4) Dike in Dune combined with parking garage in Katwijk, Netherlands.

The case studies highlighted below provide four examples of how green climate change adaptation measures based on results from participatory workshops in the Sky Island example; how multiple potential benefits can be created when implementing green adaptation measures; and how green measures can create nationally important habitat, such as in the UK; and finally how grey and green measures combined can be used to defend against rising water.

Sky Island Restoration Project	
Location: *United States, Arizona*	*Cost*: *198,985.87 EUR (at least)* *Decision Support Tool*: *Participatory*
The Sky Island restoration project is a strong example of the implementation of green climate change adaptation measures using participatory methods. Through multiple workshops and the establishment of the Arizona Climate Change Network, stakeholders from various backgrounds and representing differing interests cooperated to identify, discuss and act upon the most pressing climate change threats in the Sky Island region. Characterised by their steep elevations and surrounded by lowland desert and grasslands, the Sky Islands are isolated, forest-topped, mountain ranges that span between the Sierra Madre in Mexico and the Rocky Mountains and overlap the boundary between the Sonoran and Chihuahua deserts, located in south-eastern Arizona, southwest New Mexico and northern Mexico. The Sky Island region is amidst one of the fastest warming regions in the United States (Karl et al., 2009), with parts of the United State's Southwest warming over 1.1°C compared to average 20th century temperatures (Misztal et al., 2013). Associated climate change impacts are seen through reductions in winter precipitation, soil moisture, seasonal shifts in species' life cycles, widespread vegetation mortality and increases in the frequency of wildfires (Robles and Enquist, 2010). These impacts are in conjunction with land use and land cover changes, habitat fragmentation and a decadal-scale drought.	

As the political situation in this region spans two countries and two States, land tenure and regional authority varies. In the United States area of the Sky Island region, land management can be attributed to roughly 34% federal agencies, 30% state agencies, 27% private land owners and the last 8% to Native nations, local jurisdictions and conservation interests (Misztal et al., 2013). One of the main challenges this area faces is how to implement adaptation measures at the local level while taking into account various land management boundaries.

To help address some of these challenges, Sky Island Alliance (SIA) initiated the project *Adapting to a Changing Climate in the Sky Island Region* in 2009 which conducted a three-part regionally focused climate change adaptation workshop series. The objectives of these workshops were to (1) develop and implement on-the-ground and policy-level adaptation strategies that address key ecosystem management vulnerabilities, and (2) integrate climate change information into participants' planning and work (Misztal et al., 2013). In addition, a regional knowledge-action network of professionals was established to cooperate and improve natural resource management under changing conditions.

Prior to the first workshop, a survey was sent to selected natural resource managers to assess the most pressing regional climate change threats and vulnerabilities as well as their associated barriers to and needs for reducing vulnerabilities. Results of the survey identified the treats of water scarcity and drought, human pressures on ecosystems, invasive and non-native species, and fire; and the identified management needs included stable funding, a framework for dealing with uncertainty, translation of science, and effective communication among colleagues, partners and stakeholders (Misztal et al., 2013).

The two-day workshops incorporated both a science delivery and information exchange sessions. The science delivery component highlighted threats and greatest current needs identified in survey responses, while breakout groups discussed the need for better communication and coordination between jurisdictions within agencies and among different agencies and organisations in the region. Participants in these workshops included personnel from federal, state, and local agencies; non-governmental organisations; universities; and Native nations and private landowners. Held in Tucson, Arizona, the workshop dates were 20-21 September 2010, 13-14 April 2011 and 21-22 May 2013 (Misztal et al., 2013).

Workshop 1: The first half-day of the workshop was dedicated to presenting region-specific information on projected climate changes, fire, water, wildlife range shifts, adaptation efforts, pre-workshop survey results and background about the Desert LCC. Afterwards, participants were pre-assigned into three facilitated breakout groups to address the following vulnerabilities and needs: water scarcity, species and habitat conservation, and research and monitoring.

Workshop 2: The first half-day of the workshop was dedicated to presenting information on (a) likely climate changes in the region, (b) how those changes may affect hydrology, fire, invasive species, and connectivity and corridors, (c) vulnerabilities of species in the region, (d) a framework for dealing with uncertainty, and (e) case studies of managers incorporating climate change considerations into current work. Informal scenario planning was used to consider the range of possible futures by using the models that best capture climate processes in the region of interest, noting areas of agreement while also considering extreme but plausible projections to give a sense of the potential range and direction of change. For the remainder of the workshop, participants developed preliminary adaptation plans in ecosystem-specific breakout groups.

The second day was structured to facilitate participants' discussion of interactions across ecosystems, landscapes, and stressors to ensure that each breakout group thought about ways in which different ecosystems and strategies influence one another (Misztal et al., 2013).

Workshop 3: The focus of the last workshop was on further developing practical adaptation strategies for natural resource management implementation in the Sky Island region, advancing ongoing collaborative projects, examining what was learned, introducing new tools and research, and topic specific discussions on natural resources (Misztal et al., 2013).

Results from these participatory workshops and efforts on behalf of the Arizona Climate Change Network helped initiate and secure funding for the *Spring and Seep Inventory, Assessment, and Management Planning Project* to gather data on biological, hydrological, geomorphological and management status of springs and seeps in the Sky Island region. The gathered information was then applied to guide the management of sensitive and invasive aquatic species, prioritise restoration and conservation funds and manage wildlife that rely on surface water (Misztal et al., 2013). The project was implemented by the SIA as well as regional resource managers from Pima County, the U.S. Forest Service, the Spring Stewardship Institute and volunteers.

Green measures were utilised to help restore nine springs to a more natural state, including hydrology, vegetation and animal communities, geomorphology and ecosystem function. Measures addressed the climate impacts of rural droughts, water scarcity and soil erosion and sought to increase habitat resilience in the face of a changing climate. Restoration efforts focused on:

1. The construction of three new ponds, designed as a watering place for bats, a habitat and breeding area for Chiricahua leopard frogs and to provide food and cover for pollinators and wildlife;
2. The removal of invasive plant species and replaced with native ones to increase wildlife resources and to decrease plant water use;
3. The installation of rock structures to control soil erosion and slow water; and
4. The instillation of fencing around two springs to keep cows out, maintain plant diversity and improve water quality; as well as the instillation of wildlife entry and exit ramps at developed springs to support meta-populations of endangered Chiricahua leopard frogs.

Through a top-down and bottom-up approach, the Sky Island Restoration Project managed to use the results from the participatory workshops to implement green climate change adaptation measures aimed at increasing resilience in Arizona's spring habitats. The timeline and overview of implementation activities can be seen in the table below (Misztal et al., 2013).

Spring and Seep Inventory, Assessment and Management Planning	
Threats	↑ temperatures, ↑ aridity, ↑ scarcity of water that supports wildlife and biological diversity
Vulnerabilities	Lack of data on condition of springs/seeps, alteration of springs/seeps for human uses, likely inability of managers to maintain water where it currently exists
Adaptation Strategy	Conduct field-based assessment of spring/seep condition, species present, water quality and quantity, solar exposure and human alteration; indentify appropriate restoration and protection activities
Project Partners	Lead- Sky Island Alliance, Spring Stewardship Institute, Pima County, Pima Association of Governments, Arizona Game and Fish Department, The National Park Service, The Nature Conservancy, U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, Ft. Huachuca, Coronado National Forest, U.S. Geological Survey, Arizona Water Resources Research Centre, Desert LCC
Implementation Activities	
Nov 2011—May 2012	Determine areas of high management priority for conducting assessments with project partners

Apr 2012	Train volunteers and agency personnel in spring/seep assessment protocols
May 2012—Aug 2013	Utilise volunteers to assess 50 springs in high-priority areas
Apr 2012—Ongoing	Work with agency personnel and complementary projects to assess springs/seeps being visited for other projects
Nov 2011—Aug 2013	Develop a regional spring/seep online database accessibly to all jurisdictions
Aug 2012—Ongoing	Direct restoration and protection money and efforts to newly prioritised springs, and incorporate new spring data in project planning (e.g. prescribed fire)
Jan 2013	Implement restoration of natural flow and vegetative structure on 12 priority sites

Economic considerations used in the decision-making process for Sky Island restoration activities did not follow the methodologies identified within the BASE matrix. Rather, financial limitations and cost-saving actions were deemed most important to the project. Volunteers played a major role in meeting these financial objectives by undertaking restoration work such as hand-digging ponds, pouring concrete from ramps and planting native plant species while removing invasive ones. At the individual project level, informal cost-benefit analyses assessed the use of volunteers versus hiring skilled contractors for specific actions. For example, contractors were hired to install fences to keep out grazing cows rather than relying on volunteer labour, when considering the functionality of the fence and start up investments.

The Sky Islands case study is a good example of well-executed implementation of green climate change adaptation measures based on results from participatory workshops. These workshops ensured adequate representation of various stakeholders and their associated interests in the Sky Island region, the presentation of relevant information via science delivery and information exchange sessions, as well as practical results which could then be utilised and acted upon. These efforts capitalised the joint interests of public and private bodies, citizens and representatives from various government levels to see on-the-ground results and the establishment of networks to continue information exchange and cooperation. Additionally, outputs and further details of the workshops and implementation activities are well documented and freely available online, thus providing a means of sharing lessons learnt and dissemination of project outcomes (see links below).

Aspects of this case study that could have been improved upon include more information regarding economic methods included in the project activities and how individual springs were selected for restoration. The workshops and participatory methods in this case study are well-developed and have been useful in the implementation of green adaptation activities; however, the rationale behind the selection of green adaptation options and their respective financial implications were not described.

Project partners: the Springs Stewardship Institute, Coronado National Forest, Pima County, Arizona Game and Fish Department (AZGF), Bureau of Land Management (BLM) Safford Field Office, Bat Conservation International, Southwest Research Station, USGS, U.S. Fish and Wildlife Service (USFWS), University of Arizona Water Resources Research Center, The Nature Conservancy, Desert Botanic Garden, Desert Landscape Conservation Cooperative, University of Arizona, National Park Service Sonoran Desert Monitoring Network, Saguaro National Park, Pima Association of Governments, and private landowners

Project funding was provided by the Kresge Foundation, the Nina Mason Pulliam Charitable Trust, the Wildlife Conservation Society Climate Change Adaptation Fund and the Desert Landscape Conservation Cooperative.

Links:

http://www.cakex.org/case-studies/springs-sky-island-region-inventory-protection-and-restoration

http://skyislandalliance.org/adaptationworkshops.htm

http://www.skyislandalliance.org/misc/SIRC2014/Springs%20Restoration.pdf

http://www.fs.fed.us/rm/pubs/rmrs_p067/rmrs_p067_060_067.pdf

Urban Storm Water Management in Malmö, Sweden	
Location: Augustenborg, Malmö, Sweden	*Cost: Approximately 21,594,307.74 EUR* *Decision Support Tool: Participatory*

The urban storm water management project in Augustenborg Malmö (1998-2002) is an example of implemented green adaptation measures using participatory methods. It demonstrates how multiple potential benefits can be created when implementing green adaptation measures. The costs of the physical improvements in the project have been assessed but the associated benefits have not been monetised.

The main driver for the project was the regeneration of the neighbourhood to make it more attractive for residents with a focus on innovative environmental improvements (reduction in flooding, improved waste management, CO_2 emissions reduction and biodiversity improvement); a direction and focus that was primarily driven by policy changes at city level aimed at moving Malmö from a post-industrial city towards an environmentally sustainable city (Kazmierczak and Carter, 2010; Lager and Lundquist, 2004). From the start, the project was not explicitly aimed at 'climate adaptation' (probably because this was not a conventional term in the 1990s). However, it is a good example of implementation of climate adaptation measures.

The 32 ha Augustenborg neighbourhood in Sweden's third largest city of Malmö consists of 1800 apartments (1600 of them rented from Malmö Municipal Housing Company) in low-rise buildings containing approximately 3000 residents (Kazmierczak and Carter, 2010). During the 1980s and 1990s, the area was characterised by high unemployment rates, unoccupied flats and economic and social problems. Furthermore, the area was frequently flooded due to an insufficient, overflowing drainage system. Underground garages and basements and roads and footpaths were frequently flooded, and untreated sewage often ended up in nearby watercourses (Climate-ADAPT, 2015; Kazmierczak and Carter, 2010). Subsequently, there were health problems due to untreated sewage water (Worldhabitatawards, 2015).

Future climate projections demonstrated that the number of heavy downpours in autumn and winter would increase to 8 days with more than 10 mm precipitation in the period up to 2080 (Kazmierczak and Carter, 2010). Consequently, it was proposed that storm water from Augustenborg should be disconnected from the existing combined sewer system and drained through an open system. The main aim was to handle 70% of the storm water from roofs and sealed areas with capacity to handle an intense storm event every 15 years as the baseline (Kazmierczak and Carter, 2010).

Key stakeholders driving this process were the City of Malmö and the housing office (Kazmierczak and Carter, 2010). The Ekostaden approach aimed at transforming the neighbourhood into an ecologically, socially and economically sustainable city. In the process, the local citizens and a range of other stakeholders (both public and private) were involved in developing the recreational areas. In particular, there was a focus on involving local residents via community workshops, regular meetings and informal gatherings (Kazmierczak and Carter, 2010). Approximately one fifth of the tenants in the area have participated in dialogue meetings about the project and some were very active in contributing to the

development of the project (Kazmierczak and Carter, 2010). Augustenborg school pupils were involved too, for instance in making one of the rainwater ponds transferable to an ice rink, development of a school garden, musical playground and sustainable building projects (Rolfsdotter-Jansson, undated). According to Kazmierczak and Carter (2010), the project encountered little opposition despite resident fears that courtyards would be turned into unusable areas of open water.

The end results were implemented through the creation of sustainable urban drainage systems (so-called 'sustainable urban development (SUD)); more specifically, the creation of 6 km of water channels and 10 retention ponds. Rainwater from roofs, roads and car parks is now channelled through trenches, ditches, ponds and wetlands, and only the surplus water after this transportation is led directly to a conventional sewer system. These new landscape features were integrated into the townscape within 30 courtyard areas, which provide recreational green spaces for the citizens and can be flooded during heavy rain falls. Furthermore, green roofs have been installed on all infrastructure built after 1998, and retrofitted on some existing buildings. In total, there are 30 green roofs in the neighbourhood; additionally, from 1999-2001, Scandinavia's largest green roof was established on an old industrial roof. Implementation is co-managed between the housing company and the City of Malmö (Kazmierczak and Carter, 2010; Climate-ADAPT, 2015).

A number of barriers and challenges had to be overcome during this process. One challenge was to find areas suitable for the SUD's because they had to fit into the existing infrastructure, ensure access for emergency vehicles. SUD's also had to be underlain with geotextile to avoid water damages to nearby buildings, which limited the systems functioning to only water retention and not infiltration. Another challenge was to address health and safety issues to avoid problems for children and elderly when they passed the SUD's. These health concerns also extended to the noise and dust problems during the implementation phase, as well as problems regarding algae growth in the ponds. Lastly, aesthetics and retention of recreation spaces were very important for local residents which had to be incorporated into the functioning of the system (Kazmierczak and Carter 2010; Climate-ADAPT, 2015).

Despite these challenges, there have not been any flooding events in the area since the open storm water system was implemented. Malmö experienced a 50 year precipitation event in 2007, which cut most of Malmö from the rest of Sweden, but Augustenborg was not affected. In fact, the system performs better than expected, since 90% of the storm water is estimated to end up in the open system. Besides decreasing flooding risk, this has improved the functioning of the combined sewer system in the surrounding area (Kazmierczak and Carter 2010; Climate-ADAPT, 2015). Other benefits of the city's initiative include (Kazmierczak and Carter, 2010; Climate-ADAPT, 2015; Ecodistricts, undated):

- More green spaces between building blocks with the possibility to grow food, support leisure activities, and play areas for children, etc.
- Green roofs have a cooling effect on the buildings during heatwaves, etc.
- Decline in graffiti and vandalism
- Biodiversity has increased by 50%
- Environmental impact of the area (carbon emissions and waste generation) decreased by 20%
- Increased interest in renewable energy and sustainable transport among residents after they heard about similar plans in other areas
- In the period 1998-2002, tenancy turnover decreased by 50 %; unemployment rates fell from 30% to 6% (which is Malmös average); participation in elections increased from 54% to 79%
- Three new local companies have started as a direct result of the project: Watreco AB, the Green Roof Institute and a car pool company
- Adaptation experiences from Augustenborg are now being replicated in other Malmö projects

- 15000 visitors have been in Augustenborg from all over the world to learn about their experiences

Further analysis is needed to determine how much of these effects are caused by the Augustenborg project would, but there are clear indications of comprehensive benefits. Regardless, the nation's image of the Augustenborg area has significantly improved and recognition of the success of this initiative was seen in 2010 when Augustenborg as an 'Eco-neighbourhood' won the World Habitat Award (Climate-ADAPT, 2015; Worldhabitatawards, 2015).

There were several elements within the case study which helped to facilitate its success (Climate-ADAPT, 2015): (1) the initiative and enthusiasm of central actors in the Service Department in Malmö Municipality and the housing company MKB and the decentralisation of power from city level to district level; (2) joint management of the programme; (3) involvement of the residents resulted in little opposition, generated local sense of ownership and empowerment and raised awareness; (4) extensive funding from local authorities and the housing company was important to provide a stable financial base.

Aspects of this case study that could have been improved upon have already been highlighted during the project's duration. These mainly focus on stakeholder participation and the difficulties associated with participatory processes. For instance, some claim that involvement of local residents was low (due to apathy, language barriers, lack of time to commit to this type of project, etc.). There were concerns that 'louder' residents made their voices heard, while viewpoints from more quiet individuals were often overlooked. Finally, there were some implementation problems when the local housing company changed executive directors (Ecodistricts, undated). According to Ecodistricts (undated), the new director re-organised the company by replacing the project officer with a new one, who did not have the same knowledge and in-depth understanding of the project as the former project officer.

According to the project coordinator, in practice, public participation did not become as extensive as initially hoped, although many initiatives were taken to involve the residents (Lager and Lundquist, 2004). These initiatives included a built model of the area which the residents could relate to and explain their wishes, meetings were merged with barbecues, information was provided in different languages and the project coordinator invested time to increase visibility in the area. Despite these actions, there was difficulty in maintaining continuous local participation (Lager and Lundquist, 2004).

Another aspect that could have been improved upon in this case study is lack of information regarding how economic methods were used in the implementation phase. In general, the case study demonstrates that there are many different types of benefits that can be connected to developing green adaptation measures at the scale of the Augustenborg measures. And it demonstrates some important barriers too. It also demonstrates some challenges in getting the residents deeply involved in the processes.

Project funding: total cost of physical improvements has been estimated to be 21,594,307.74 EUR (Climate-ADAPT, 2015). However, these costs also cover extensive renovation work on the apartments to improve energy efficiency and were not solely used for climate adaptation purposes. Of the 21,594,307.74 EUR, approximately 10,797,153.87 EUR was invested by the housing company; 2,591,316.93 EUR by the Swedish Government; 431,886.15 EUR of the Swedish Department of Environment; 647,829.23EUR of EU's LIFE programme (for the botanical roof garden) and some funding from the EU URBAN programme (Kazmierczak and Carter, 2010).

Links:

http://climate-adapt.eea.europa.eu/viewmeasure?ace_measure_id=3311

www.ecodistricts.org

http://www.worldhabitatawards.org/winners-and-finalists/project-details.cfm?lang=00&theProjectID=8A312D2B-15C5-F4C0-990FBF6CBC573B8F

Salt marsh as a coastal defence	
Location: Abbott's Hall Farm, UK	*Cost: Land costs: 3,790,005.61 EUR; managed realignment costs: 905,390.23 EUR* *Decision Support Tool: Participatory*

This case study demonstrates the benefits of replacing a grey adaptation measure with a green adaptation measure. The case is about the development of a salt marsh (green measure) in an area opened up to tidal inundation by breaking up a 3 km hard sea defence (grey measure) to realign the shoreline. The measure has created a nationally important habitat in the UK and provided a sustainable flood defence. The measure is expected to provide a softer and more flexible defence better able to respond to future sea rises than grey structures (Ourcoast, undated). The case study further demonstrates the challenge of creating social and economic benefits too, and it demonstrates the importance of involving stakeholders in this type of project (Essex Wildlife Trust, 2005).

It was vital to the project to identify all stakeholders correctly and to communicate with them as early as possible (Essex Wildlife Trust, 2005). Stakeholders involved include the local sailing community, oystermen, and general public. Participatory methods were applied in an effort to include stakeholder concerns in the development of the salt marsh. The methods included both one-on-one meetings as well as a series of guided walks:

1) A large part of the consultations took part as personal meetings with a single stakeholder each time. This approach was time consuming, but had the advantage that people's concerns could directly be addressed, misunderstandings corrected and information given to the specific individual/group/stakeholder.
2) A series of guided walks were held in the area to explain what were being planned and how it would look. The idea here was to be totally honest about what the project would mean to strengthen the engagement from stakeholders and avoid later disappointments.

In the Essex Wildlife Trust (2005) Fact Sheet attention is drawn to the idea that media tends to seize on bad news. This can be poisonous for a new project being planned involving land owners, because it can make the locals have negative towards the project and can have a negative effect on the local political decision-makers. Ideally, project owners should therefore focus on generating positive publicity to raise public awareness. Furthermore, it is a good idea to develop a communication strategy to avoid disagreements between stakeholders with different viewpoints.

Regarding economic methods, there was no cost-benefit analysis as such, but two central financial aspects within the case study were identified:

1) Raising the funds. Significant investment is required to acquire land and plan, design and implement the realignment. Depending on funding, authorities might have to aim for an area which is not the optimal from an environmental/adaptation viewpoint if the funding is not sufficient. In this project, a partnership was built with several groups interested in having a stake in the project. The advantage of this is that a partnership on financing pools resources: finances, knowledge, expertise and it furthermore spread the risk of failure. Conversely, there are different objectives (maybe conflicting) to be met by each partner, and each wants to gain something from their participation in the project. This can make decision-making very complicated if there are no obvious win-win-solutions (Essex Wildlife Trust, 2005).
2) Deriving an income from the project. This is much more difficult. Main benefits are reduced flood risks borne by the tax payers, but the financial position of the landowner getting his land flooded is more uncertain. When Essex Wildlife Trust (2005) wrote the fact sheet there had been a cut in the government grants which were reduced from 20 to 10 years. Alternative long-term sources of income have been implemented, such as sheep grazing as well as well as growing alternative

crops. Other suggestions being considered include recreational sport fishing and the development of a marina, which could create jobs and boost the local economy. Bottom-line was that subsidies is a good economic base for the landowner but not sufficient alone – more benefits are needed.

Initially, there was no planning of interpretation/information boards etc. at the project location when the case study was implemented. When project managers realised that this was important to explain the ongoing development of the project to casual observers during implementation, it was very difficult to find funding for this type of information tools.

Monitoring of how the measure performs is important for the evaluation process. Sufficient monitoring was not at place from the outset. For instance, the project was confronted with accusations that the project had created mud problems further downstream, but it turned out that these mud problems had nothing to do with the Abbot's Hall Farm project (Essex Wildlife Trust, 2005).

Links:

http://ec.europa.eu/ourcoast/index.cfm?menuID=8&articleID=5

http://www.essexwt.org.uk/reserves/abbotts-hall-farm

http://data.wildlifetrusts.org/sites/live.data.wt.precedenthost.co.uk/files/FS9%20Lessons%20Learned%20from%20Realignment.pdf

Dike in dune combined with parking garage	
Location: The Netherlands, Katwijk	*Cost: 71,000,000 EUR; whereof 13,000,000 EUR for parking garage* *Decision Support Tool: Participatory and Economic*

The village of Katwijk is located at the Dutch North Sea coast. Its main water defence system is formed by a beach-dune system. The water defence system not only protects the village of Katwijk but also the hinterland, which is low-lying flatland and highly urbanized. Due to erosion, the whole Dutch North Sea coast is susceptible to erosion. This erosion led to several improvement projects and a constantly on-going nourishment programme. The speed of erosion will be altered by sea level change, which affects the safety standards maintained for the dunes along the coast, hence subsequent defences are necessary (Delta Commission, 2008). Based on risk assessments under the old standards, the shore along the centre of Katwijk was deemed as a weak spot in the coastal defence system. The water defence system should be able to withstand a 1:10,000 year chance of breaching in the old safety standards. The Katwijk flood defence was therefore included in the High Water Protection Programme (HWPP; DP, 2015). New standards came into effect in 2014. These new safety standards are based on a new flood risk reduction philosophy, not only calculated based on the probability of a flood, but also integrating the consequences for individuals and capital behind the flood defences (Schultz van Haegen and Wieriks, 2015; Zandvoort and Van der Vlist, 2014). In the new safety standards the chance of flooding for this stretch of coast became a 1:30.000 year chance (DP, 2015, Appendix 1), which was included in the refurbishment of the water defence system.

At Katwijk the old flood defence ran through the village, leaving approximately 3000 citizens outside the primary defence zone. To fully protect the village, and upgrade the defence to the new standards, a novel approach was sought, which was already experimented with in the nearby town of Noordwijk: building a hard dike within the sandy dune system. This allows for preservation of the sandy, natural environment, while it simultaneously provides the high safety standard needed to protect the hinterland against the sea. This includes projected sea level rise in the coming decades by dimensioning robust enough under different climate change scenarios. These scenarios are integrated into the method of calculation of the

new safety standards (DP 2015).

In the Dutch Delta Programme, the overarching policy programme for establishing strategies for Dutch water management up to 2100, a new approach was taken for creating strategies. This Adaptive Delta Management approach (Van Rhee, 2012; Van der Brugge et al., 2012; Vlieg and Zandvoort, 2013) emphasised amongst others mainstreaming different stakes, including climate change adaptation, in projects (Uittenbroek et al., 2012). This philosophy was also sought after in the Katwijk case, where the municipality wanted additional parking space in the vicinity of the beach. In coupling the necessity to upgrade the flood defence, include climate change adaptation by anticipating future sea level rise and storm surges, and local economic stakes, the project resulted in the combined construction of the dike and the parking garage within the dune system.

Under obligation of EU regulations (Directive 85/337/EEC) and Dutch infrastructure regulation (Law on Spatial Planning, 2009 (Wro)) an environmental impact assessment and a cost-benefit analysis were executed. In the municipality, information and Q&A sessions were organised to inform and discuss the project (in the context of the whole master plan for the village) with inhabitants (21 May 2013; 8 January 2014). Although there was some opposition regarding the parking garage (the responsible Elderman initially exaggerated the amount of parking lots, which went from a 1000 to 663) the procedures went without much trouble (Municipality Katwijk aan Zee, 2014). The construction of the parking garage was seen by inhabitants as an opportunity to close some parts (including the boulevard at the sea side) for cars, and to remove parking space out of the centre. The benefits of the project are both based on the exploitation returns of the parking garage (in 30 years a profit of approximately 2,800,000 EUR) and an increase in tourism due to the improved access (approximately + 0.25%) and an increase in spatial quality (Schasfoort and Bijl-Weisz, 2014). Both investment and maintenance costs will be higher than traditional dike reinforcement.

The project was funded by the Ministry of Infrastructure and the Environment (Min I&E) for the costs related to the flood defence system, and partially for the research and organisation costs. The Province and the water board also funded a part of these costs, the first also contributed around 2,000,000 EUR for the enhancement of the spatial quality. The municipality was responsible for the costs of the parking garage. The division of the total costs was around 60% for the flood defence system (dike, dune and beach nourishment) and 40% for the parking garage.

General and specific research was executed by the respective governmental actors (Min I&E, water board, province and the municipality) and by consultancy from firms (i.e. Arcadis, Deltares, Droogh Trommelen en Partners, OKRA landscape Architects, Royal HaskoningDHV) and Wageningen UR.

Governments (Min I&E, water board, province and the municipality), citizens (amongst others organised in a group support for a car-free boulevard a Neighbourhood Council (Wijkraad Katwijk aan Zee), and also able to react as individuals), local retail owners (organised in two retailer cooperations (Winkeliersvereniging Zuidzijde and Princehaven).

Two Q&A sessions with room for formal objections, questions, discussions and recommendations for changes of the plan were organised. These are formally obliged under Dutch law. Also, there were several periods for objections and questions in writing, extending several weeks and open for everyone.

In the cost-benefit analysis a societal analysis was included. Therefore two stakeholder workshops were organised by Arcadis and Wageningen UR, the first was aimed at the local project group, the second was open for all stakeholders including citizens. The results were used to balance monetary with non-monetary values in the choice for a preferred alternative.

Links

http://www.kustwerkkatwijk.nl/

http://www.ruimtevoorklimaat.nl/cases/16-Kustversterking-Katwijk

4.2.3 Soft adaptation case studies

On the following pages, three case studies in which soft measures are used are described in-depth: (1) CIRAC- Floods and Flood Risk Maps in Climate Change Scenarios in Portugal, (2) Hydroecoclimate in Serral, Spain, and (3) CARE Brazil's experience in local development - Reducing vulnerabilities and improving capacities for adaptation in the coast of Bahia through soft measures (PROSULBA program).

The case studies highlighted below provide three examples of how soft climate change adaptation measures can be based on results from participatory workshops to help address flood risk and vulnerability in Portugal; to raise awareness and enhance water efficiency; and how participation of local communities can increase adaptation to climate change in rural Brazil with the added benefits of fighting poverty and inducing social, political and economic changes.

CIRAC - Floods and Flood Risk Maps in Climate Change Scenarios	
Location: Portugal (Lisboa, Porto, Algés, Vila Nova de Gaia e Coimbra)	*Cost: 310,465.00 EUR* *Decision Support Tool: Participatory*

The design of policies and procedures for disaster risk management as well as land management play an important role in adaptation, by for example limiting the development in flood prone areas, and by encouraging flood and drought risk-sensitive land use and management practices (Climate-Adapt, 2015). CIRAC - The Flood Risk and Vulnerability Mapping in Climate Change Scenarios project conducted in Portugal was a partnership between The Portuguese Association of Insurers (APS) and the Faculty of Sciences University of Lisbon that have developed a flood vulnerability assessment tool and a flood risk visualization tool that will assist stakeholders in making strategic decisions. This case study is an example of implementation of a soft or non-structural climate change adaptation measure. During the planning and validation activities several participatory approaches were promoted, such as the establishment of a monitoring commission with representatives of several insurance companies and a scientific panel. This commission was consulted in several meetings to better evaluate the work and was also thought to increase the cooperation between actors to work together in reducing vulnerability and adapt to the impacts. Also maps and further details of the project are well documented and freely available online providing insurance businesses companies, academics and various government levels with this important assessment tool (see links below).

Floods are one of several natural hazards to which contemporary society is exposed to, being one of the main phenomena responsible for human, economic and environmental loss in the global context (Schmidt-Thomé et al., 2007) These concerns have been increasingly taken into consideration by the insurance sector, which has been making more and more significant investments in assessing and controlling the risk of flooding (e.g. 2006).

The European Union, the Directive 2007/60/EC of 23 October 2007, transposed into Portuguese law by Decree-Law 115/2010, of 22 October 2010, establishes a framework for the assessment and management of flood risks that Member States should follow, providing relevance to the need for the "... creation of flood hazard maps and flood risk charts indicative of potential adverse consequences associated with different flood scenarios ...".

In Portugal, there was no information in a structured and detailed manner while floods are responsible for huge losses, and significant changes are still expected in precipitation regimes, the frequency and intensity of weather phenomenon and extreme climate events, such as intense rainfall over short periods (Santos and Miranda 2006, Dias, 2013).

It is in this context that emerged the project "Flood Risk and Vulnerability Mapping in Climate Change Scenarios" (CIRAC). Project funding was provided by The Portuguese Association of Insurers (APS), a non-profit employers' association, founded in 1982, that congregates insurance and reinsurance

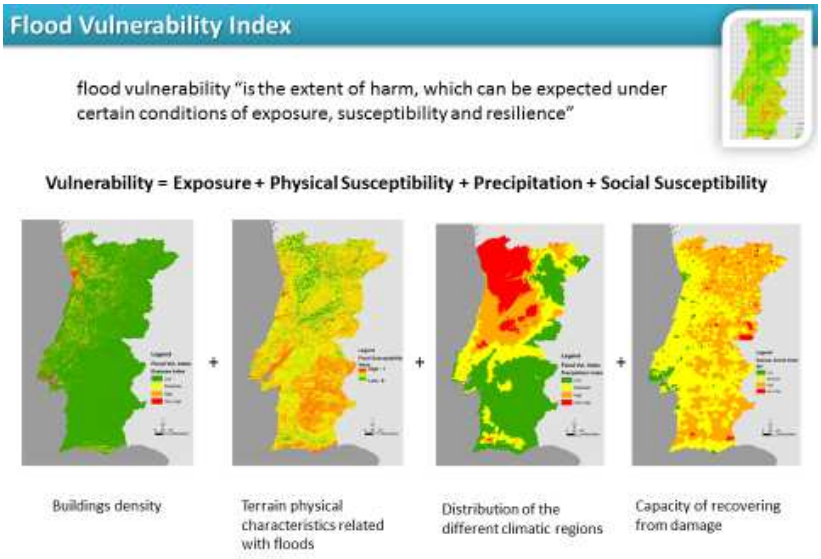
companies operating in the Portuguese market, irrespective of their legal nature or country of origin (the members of APS presently account for 99% of the insurance market in terms of business turnover and human resources employed by the sector), in partnership with the research group Climate Change Impacts Adaptation and Modelling (CCIAM) of the Faculty of Sciences University of Lisbon. The CCIAM research group has established itself as a reference European research and training centre on climate change integrated analysis, adaptation policy and modelling. The group brings together scientists from several scientific fields who conduct trans-disciplinary research on both national and international level.

The CIRAC project aimed to evaluate flood risk and vulnerability in Continental Portugal for present and future conditions (using climate change scenarios). Ultimately, the provision of indexes that enable to assess different types of vulnerability and risk and the definition of flood risk and vulnerability maps will assist stakeholders in making strategic decisions and help decision makers define more effective adaptation strategies in climate change scenarios.

To assess flood risk and vulnerability two main approaches were developed. The first was a high-resolution qualitative perspective to assess flood vulnerability at the national scale where several physical and social components characterize the exposed elements that in this case were buildings such as houses, schools or factories. Simultaneously the project developed a risk assessment approach producing a very high resolution risk analysis to characterize the potential impacts and damage for Lisbon, Algés, Coimbra and Porto/Gaia where a multidisciplinary team was gathered to: (i) characterise climate extremes and future projections, (ii) characterise sea level rise, (iii) develop hydrodynamical models for the case studies, (iv) and develop risk maps. These tasks had the collaboration of the Geology department of the Faculty of Sciences of the University of Lisbon and the Portuguese company Action Modulers. In short, during this project two tools were developed: a Flood Vulnerability assessment tool and a Flood Risk Visualization tool (see links below).

A Flood Vulnerability map server was developed were several components can be assessed in a combined index enabling the extraction of the contribution of each vulnerability component. These gathers the physical susceptibility (characterises the exposed infrastructure in terms of propensity to floods due to natural terrain configuration); the social susceptibility (characterises the population's ability to cope with floods and recover from damage); the exposure (characterises the exposed infrastructures in terms of propensity to be affected by floods); and precipitation characteristics. A modular concept of flood vulnerability was developed that enables adding and removing different components providing flexible information that aims to reflect different user needs. The maps are open access in the Internet in the APS homepage.

Figure 11: Flood vulnerability in Portugal



Source: Garret et al, 2014

These models were combined to a flood risk analysis to identify and quantify the expected damages resulting from the flood phenomenon. These were calculated using: a) flood maps containing the water height for different return periods, obtained by hydrological modelling; b) damage maps at the building scale calculated from damage curves, which relate the water height with the average potential damage. This assessment was performed for the present-day climate and for two global climate change scenarios (A2 and B2 IPCC SRES scenarios) (Nakicenovich and Swart, 2000). To engage a multi-institutional interaction, a collaboration with the VA-4D11 project, developed for the European Space Agency, was established to implement a collaborative platform that helps different stakeholders like the Portuguese Environmental Agency, Civil Protection, insurance companies and local governments to take coordinated actions and planning activities before, during and after a flood event. This collaborative platform was presented in February 2013 in a workshop where all the stakeholders were present. The main goal was to capture different perspectives on how to use this platform and what were the main functionalities that should be developed to address their different needs and at the same time promote the interaction between people that share responsibilities in flood risk management at different levels/scales.

Results from this workshop showed that several groups of stakeholders, like the local government and the Portuguese Environmental Agency, identified the need to couple the tool with a simulation model in order to experiment different types of solutions for their planning activities. In the other hand, institutions that work in emergency or prevention situations, addressed the need to add real time visualisation capabilities to be integrated in an early warning system. These two requests are being handled and several improvements are being made by the research team to improve the tool in order to answer the identified needs. This risk assessment visualization tool can also be found online (see links below).

Thinking in collective action in building local adaptative capacity (Adger et al., 2013) and the promotion of traditional strategies for coping with external pressures (Folke et al., 2005; Nelson et al., 2007) a collaboration was established with a national radio channel (Rádio Renascença/RR). A journalistic report was made during a flood event, "Um Próximo Dilúvio" (*An Upcoming Deluge*), and CIRAC researchers were invited to explain the increase in the number and magnitude of extreme precipitation events due to climate change. Also they shared some bottom-up adaptation measures that they identified during the research this combined with interviews to the local population used to have strategies to deal with flood events. Despite being a radio channel the RR internet homepage provides video report and infography based in the project results. Being the first systematic study of flood risk integrating climate change in

Portugal, there are several actions that can still be done to improve the base scientific data to ensure that the hydrological modelling and the flood maps are the most accurate and detailed as possible, and there is a future need to include different climate change scenarios, in order to obtain the uncertainty associated with these models, which is not possible using only one model. Despite these limitations and uncertainties, the methodology used to quantify the risk is robust and conclusive, allowing the definition of strategies for integrated flood risk reduction (adaptation).

Links:

http://www.apseguradores.pt/CiracMaps/HomePage.aspx

http://www.ca3-uninova.org/project_va4d

http://rr.sapo.pt/um-proximo-diluvio/

http://siam.fc.ul.pt/cirac/floodvis/

http://rr.sapo.pt/um-proximo-diluvio/

Zaragoza: combining awareness raising and financial measures to enhance water efficiency	
Location: Spain, Zaragoza	*Cost: 2,500,000.00 EUR* *Decision Support Tool: Participatory*

The Zaragoza Water Saving City programme is a case study that provides an interesting example of the implementation of climate adaptation soft measures to reduce and prevent water scarcity. This programme is already recognised as being a good example of a "Behavioural change initiative" (2030 WRG, 2013).

This case was mainly developed and implemented because of other policy objectives, but with significant consideration of climate change adaptation aspects (Climate ADAPT, 2015). Rather than increasing supply to meet demand, an alternative way of addressing water scarcity is to manage consumption. Reducing leaks from distribution pipelines, dissuading wasteful use and promoting water-saving fittings and appliances are all ways in which cities can sustain growth and reduce their vulnerability to climate change without negatively impacting on environmental resources and social needs. The programme was initiated in 1996 and included awareness raising campaigns, the implementation of examples of good practice and voluntary public commitments by citizens and businesses. The water tariffs were revised to provide disincentives and incentives that ensure a full cost recovery whilst maintaining affordability for low income households. After 15 years, the city achieved a reduction of water consumption by almost 30%, mainly due to changes in water use behaviour and is now known throughout the world as a leader in the field of water conservation (ICLE, 2011).

Zaragoza is the fifth largest city in Spain and the capital of the Autonomous Community of Aragón, with a population of around 700,000 inhabitants. This is a semi-arid region with an average annual precipitation of only 314 mm, most of which falls during the cold winters. Consequently, water shortage is a serious issue for the municipality. This was made obvious in the early 1990s when a prolonged drought resulted in water restrictions that caused public anger and political fallout at a national scale. In the future the number of consecutive dry days is projected to increase significantly in southern and central Europe, in particular in summer, thus possibly exacerbating the problem of water scarcity.

The city of Zaragoza decided to take action addressing the water management to satisfy the needs of the developing economy and the future demands of a growing population (the population of Zaragoza is projected to reach one million shortly after 2020). To do so, the city moved away from continued exploitation of limited resources to curbing water demand. Following water shortages in the 1990s, the

municipality of Zaragoza managed demand by developing a “water saving culture” in the city.

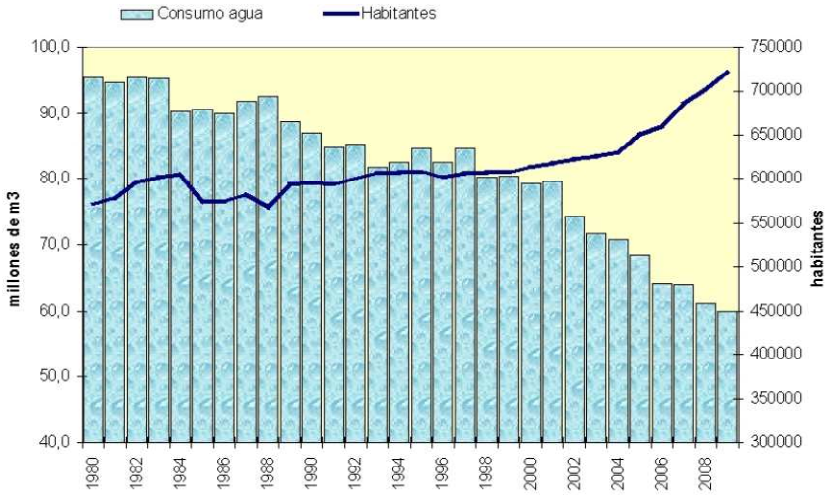
The Municipal Strategic Plan 1996-2010 set out an ambition objective to reduce total city water consumption from 84.7 mm^3 in 1995 to 65 mm^3 by 2010. A municipal Water Commission was established by the City Council in 1996 to oversee the implementation of a range of ambitious long-term water saving initiatives. The Zaragoza Water Saving City programme was initiated in 1996 by the NGO Fundación Ecologica y Desarollo (FED) with the municipality support.

The programme was implemented through a widespread awareness-raising campaign to reduce water consumption within homes, public buildings and commercial activity through behavioural change and water saving technology. A ‘50 Good Practices’ guide was developed. This evaluated the use of water technology and behaviours in gardens, parks, buildings and industry. It provided businesses with a reference model for identifying water efficient technologies and practices in parks, gardens, public buildings and industry to demonstrate performance and encourage uptake on a wider scale throughout the city. The initiative was then extended to schools to ensure that children were actively engaged with the concept of cutting water wastage; 168 educational establishments, 428 teachers and 70,000 students directly participated in the campaign's educational programme (2030 WRG, 2013).

Another initiative to reduce water consumption in the city included a review of the water tariffs structure to make it more equitable and demand-responsive, with the aim of achieving full cost recovery through revenues, including the direct costs of service provision as well as indirect costs within the water cycle more generally. This was done through: equitable charging, ensuring that the cost of water is related to the benefits it delivers to the user; affordable access to basic water services for all, including the availability of subsidies for vulnerable households (pensioners, unemployed, large families); an incentive for the consumer to use water efficiently, in the form of water bill discounts rewarding households that were able to reduce their annual water consumption by 10% or more; penalising excessive consumption with higher prices.

The results of this comprehensive campaign reduced the water consumption from 180 litres per capita per day (lpcd) in 1980, through 136 lpcd in 2000, to just under 100 lpcd in 2010. In terms of the overall water savings, the city exceeded its own target: in 2009 total water consumption was 59.9 Mm^3. Thus, 15 years after the start of the campaign, the city achieved a reduction of water consumption by almost 30%, despite a 12% population increase in the same time. In response to these achievements, new goals have been set that aim to reduce per capita consumption of potable water in the city to 90 litres per person per day and overall consumption to 58 Mm^3 per year by 2015. The bulk of the achievements were due to changes in water use behaviour, largely brought about through the awareness-raising and promotional activities. As early as the first phase of the Water Saving City programme, the percentage of citizens aware of potential water saving measures had risen from 40% to 72%. The review of tariffs was less influential in reducing the water consumption but nonetheless had a large economic impact on water services.

Figure 12: Water savings and population growth in Zaragoza from 1980 to 2009



Source: ICLEI, 2011

The success of this approach appears to have largely depended on the implementation of the following actions:

- Working directly with stakeholder representatives - the goal of reducing water use by all types of consumers required the cooperation of a wide range of stakeholders. The stakeholders participating in the initiative included the City of Zaragoza, the Zaragoza Water Commission, which itself is made up of representatives of different municipal departments, citizen groups, organised civil society and other stakeholders, non-governmental organisations (Ecology and Development Foundation, the Foundation for a New Water Culture (FNCA) and the San Valero Foundation), businesses and local residents. Working closely with stakeholder representatives allowed the identification of realistic and acceptable water conservation measures and took advantage of existing channels of communication to reach out to members of the different target groups. Providing citizens with the information, means and incentives to actively commit themselves to saving water raised awareness about the benefits of contributing to the overall conservation goals of the city.
- The establishment of a central coordination unit - rather than being a collection of fragmented, individual initiatives, the setting up of the Zaragoza Water Commission provided effective coordination of consultation, implementation and evaluation of the different activities, with the aim of achieving a common goal.
- Encouraging public participation - domestic water consumption was identified as a key area where significant water savings could be made and this drove the involvement of the local residents in the work of the Water Commission.
- Targeting specific sectors - instead of promoting generic water saving messages, awareness-raising activities targeted specific user groups with information that was directly relevant for their business or lifestyle. The production of dissemination guides for different consumer types also resulted in explicit benefits and incentives of reduced water use to be clearly outlined and promoted.
- Leading by example - high-use groups and the general public were likely to ignore awareness-raising campaigns if they felt that the authorities responsible for water were not equally committed to improving their own performance. By providing an efficient and reliable water and wastewater service, businesses and residents were more inclined to contribute themselves.

- Gaining political commitment - key stakeholder consultation and public participation to reduce water consumption in Zaragoza was specifically mentioned in the municipal strategic plan, with the implementation of many activities taking place through Local Agenda 21 commissions. A supportive city council allowed policy commitments to be made, increased the availability of funding and provided the means to generate public pride in the city's achievement through events such as Expo '08.

Participation of the city in the following projects was also relevant:

"SWITCH - Sustainable Water Management Improves Tomorrow's Cities' Health", undertaking innovation in the area of integrated urban water management in 12 cities across the globe to further reinforce the commitment of the city to manage its water resources sustainably.

Optimizagua - a Reference Model for the Efficient Management of Water (LIFE 2003 ENV/E/000164) shortlisted as best environment project by the EC.

Aquanet (ES/07/LLP-LdV/TOI/149053), which resulted in a guidebook for an efficient water management (Source: ICLEI, 2011)

The approximate cost of the public awareness campaigns between 2002-2010 was around 2,500,000 EUR. The project used a partnership approach, with funding coming through multiple sources. The European LIFE programme provided 46% of the funding. The rest was provided by the Zaragoza City Council (17%), the Aragon Regional Government (17%), Ibercaja (12%), the Four Companies (6%) and the Fundacion Ecologia y Desarollo (2%) (2030 WRG, 2013).

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Other initiatives such as the control of leakage from the water supply distribution network also played a part. By 2008 recorded pipe bursts within the system were less than half those reported in 1997 and losses from the system as a whole were reduced by over 40%, meaning that almost 20 million m^3 of water were saved each year (ICLEI, 2011). The considerable savings in commercial and domestic water consumption were achieved primarily through a change in water use behaviour among businesses and citizens as well as, to a lesser extent, the uptake of water efficient technology (Climate ADAPT, 2015). The results allow to conclude that combining changes in water use behaviour (soft adaptation measure) with some water efficiency technology and reduced leakage can generate sufficient savings to make new and costly water supply infrastructure unnecessary (grey adaptation).

The case of Zaragoza demonstrates in particular how the successful mobilisation of a city's citizens has the scope to achieve considerable water savings. Through the active promotion of a 'water saving culture' in the city, Zaragoza was able to convince its residents of the value of water, the consequences of using it wastefully and, perhaps most importantly, that reducing consumption delivers social and economic benefits – both for individuals and for the collective – without impacting upon quality of life. It also made the City of Zaragoza more resilient to future droughts and water scarcity associated with climate change.

Links:

http://www.zaragoza.es/ciudad/medioambiente/switch/

CARE Brazil's experience in local development - Reducing vulnerabilities and improving capacities for adaptation in the coast of Bahia through soft measures (PROSULBA program)	
Location: Brazil, Bahia, Costa do Cacau (Cocoa Coast) - Bahia's south coast, Ilhéus (Brazil's Atlantic Forest)	*Cost: 628,187.24 EUR* *Decision Support Tool: Participatory and Economic*

CARE Brazil provides an example of how participation of local communities is used to increase adaptation to climate change in rural Brazil alongside fighting poverty and inducing social, political and economic changes. Along Bahia's south coast there are vulnerable groups such as a large number of families of agricultural workers and migrants from urban outskirts. These vulnerable groups are dependent on local ecosystems for agrarian as well as gathering activities. The negative impacts of climate change threaten the local livelihoods and food security of these groups. They were given access to land resulting from the agrarian reform policy carried out during the 1990s. However, the policy failed to provide any additional support to residents such as food and water security, education and educational inclusion, income diversity, market access, compliance with environmental laws, access to justice, or roads recovery. Such issues were left for the local residents or advising organizations to sort out.

Since 2002, CARE Brazil has been working with local communities along the Costa do Cacau (Cocoa Coast) region, Bahia's south coast. Participatory workshops with local residents were used to engage with communities, raise awareness, provide educational opportunities, and to improve water resource management. The goal is to improve the value chain of cocoa and its sustainable production. The programme was developed along with several social, public and private organizations and a number of participatory initiatives were implemented.

Between 2007 and 2009 a test pilot project for forest restoration was created. It aimed to create a collective learning process in regard to environmental compliance, which could be replicated in other areas. Families from affected areas were invited to workshops, informative meetings, and eventually to debate and select areas for restoration or isolation.

In 2008 CARE Brazil carried out four workshops (four days each and including field trips) over the course of 12 months. Working with a local university, the workshops aimed to provide environmental education, focusing on water management, and provided qualification for teachers. It was the aim that trained educators would act as multipliers, transmitting their knowledge to other groups.

In another effort CARE Brazil with a local NGO to raise awareness and inform community leaders and others about climate change and opportunities, particularly carbon markets, in the region to address it. The process consisted of a training over twelve months, using two four-day modules each, for 35 organisations. The workshops also provided capacity building and a platform to address doubts and questions.

The 'Cocoa Dialogue' was a series of workshops established to discuss environmental services as well as to execute a pilot project on the payment for water services.

CARE Brazil is also engaged in the Atlantic Forest Restoration Pact, which seeks to raise awareness and inform public administrators about the implications of the new laws and its correct application in rural communities. A series of four one-day seminars were given in different municipalities so that new laws could be discussed.

Economic methods were limitedly used and a market study on the potential supply of settlement products and improving the cocoa value chain conducted.

CARE Brazil is a case study that demonstrates how support and active engagement in regional processes of social mobilization can contribute to local development in an effort to adapt to climate change as well as combat poverty. This is done through workshops, debates, dialogues, and educational events.

Funding was provided by Kraft Foods do Brasil SA, Peierls Foundation, Joseph Ellis Foundation, Weyerheuser Company and the case study was promoted by CARE Brasil.

Key Stakeholders in the project include Instituto Ecologica, Cocoa Dialogue Executive Secretariat, NUMA – Atlantic Forest Center, Povo de Itabuna Bank (microcredit fund), Banco Popular (community bank), AATR – Rural Workers Lawyers Association, "Unicamp (Campinas State University), Geosciences Institute, local teachers/schools, Unesc – Santa Cruz State University, Municipal Education Secretariats, Banco do Brasil (community bank), and Environmental Service Working Group.

Links:

http://www.careclimatechange.org/

http://www.careclimatechange.org/files/reports/CARE_Brasil-Bahia_Reducing_Vulnerabilities_Enhancing_Capacities.pdf

4.3 Database assessment

The process to gather and select case studies began with an initial search of databases on climate change adaptation, as described in the methodology section above (see section 3). BASE partners searched the selected databases for potential case studies relating to their respective countries and applied the first level of criterion to determine input into the matrix. This section is dedicated to partner's experience in searching these databases, extracting case studies and assessing the level and quality of information found within. The databases include InfoBase, Global Adaptation Network, Climate-ADAPT, Climate Adaptation Knowledge Exchange (CAKE), weADAPT, United Nations Framework Convention on Climate Change (UNFCCC) and MEDIATION. Furthermore, researchers conducted broader web based searches to identify additional potential case studies.

InfoBase is a searchable European database of climate adaptation projects, maintained by the CIRCLE-2 project. InfoBase includes country-specific definitions of 'adaptation' in addition to research projects finalised after 2005, at local, national and transnational scales. Overall, the database had very little to offer with respect to implemented climate change adaptation case studies. Many of the national/joint projects listed made reference to 'climate change' and 'implementation'; however, few offered examples of implemented adaptation measures. Rather, the focus was more on research and assessment studies. The implementation often quoted would be with respect to modelling platforms, assessments, quantification of risks or vulnerabilities, etc. Moreover, entries in InfoBase were often difficult to understand if the entry was a scientific or academic study or an implemented case study, as there was often a lack of specifying information in the platform. Oftentimes it was necessary to search the entry on the web to find more information, as no links for web sites from the study or case study were provided for some entries. Also, when using the advanced search options with the name of the country and "Adaptation measures" the results were often very difficult to understand for each entry, based on the information for each project if the proposed adaptation measures were implemented.

Global Adaptation Network aims to help build climate resilience in vulnerable communities, ecosystems and economies through mobilising adaptation knowledge. This website links to other regional networks that focus on climate change: APAN for Asia-Pacific, REGATTA for Latin America, WARN-CC for West Asia and AAKNet for Africa. In general, the website and the following regional networks were difficult to navigate and locate material related to implementation of climate change adaptation measures. There were no sections dedicated to case studies or climate change adaptation in practice, but rather introductory text relating to climate change and the need for adaptation.

Climate-ADAPT (Climate Adaptation Platform) is an initiative of the European Commission to help users access and share information on climate change adaptation, including:

- Expected climate change in Europe
- Current and future vulnerability of regions and sectors
- National and transnational adaptation strategies
- Adaptation case studies and potential adaptation options
- Tools that support adaptation planning

As the focus of this platform is on European adaptation, it was useful for the European countries listed previously. Specifically, the most useful section was 'Case Studies,' which could be filtered by country. Though some of the case studies lacked information regarding status of implementation, many of them did specifically state or imply this within the text. As the site depends upon the respective input per case study, it provides varying levels of information per case study example. This also means that the interpretation of the information categories is up to the individual who submitted the case study example. Consequently, the category for 'Costs and Benefits' can lack monetary information regarding the costs of the project and possible savings and 'Stakeholder Participation' can lack specific mention of which/how stakeholders were incorporated into the study. Climate-ADAPT was particularly useful in identifying case studies in Spain. However, some partners found that the search function in Climate-ADAPT is not optimal. For example, if one writes 'Denmark' as a search term the data base returns (June 2015) only one Danish case study, but if one uses the pre-selected countries and chooses 'Denmark' the data base returns two case studies .

Climate Adaptation Knowledge Exchange (CAKE) aims to build a shared knowledge base for managing natural and built systems in the face of rapid climate change. It was established by EcoAdapt[8] and Island Press in 2010 and is managed by EcoAdapt. With respect to North America, this database provided a significant number of climate adaptation case studies. The most useful feature was an interactive map which makes it easy to find the case studies pertaining to specific countries. However, not all of the case studies refer to implemented examples. Like Climate-ADAPT, CAKE has varying levels and interpretation of information for each case study example, as case studies are input into the database via individual submission. A noted benefit is the section for 'project implementation' within each case study; however, this does not necessarily refer to implementation of adaptation measures. Rather, this section is specific to the project and can represent implementation of research projects and assessment studies dealing with climate adaptation. Conversely, a noted drawback is the lack of financial and methodology information per case study.

weADAPT is supported by the Stockholm Environment Institute and represents an open space on climate adaptation issues and potential synergies with climate mitigation. weADAPT was useful for identifying case studies in Scandinavia. It allows practitioners, policy-makers and researchers to access information and to share experiences and lessons learnt. Like CAKE, weADAPT has an interactive map which indicates a significant amount of entries relating to Africa, India, Southeast Asia, Latin- and South-America, in addition to a limited number of entries relating to Europe and North America. However, some of these entries were not related to implemented climate change adaptation measures but rather represented 'themes' of climate change adaptation (e.g., Using Climate Information, Vulnerability, Transforming Governance, etc.). Overall, there are 15 'themes' that are central to climate change adaptation and the synergies with mitigation, none of which specifically relate to implementation.

United Nations Framework Convention on Climate Change (UNFCCC) provided some adaptation examples within the *Private Sector Initiative Database* as well as the *Database on Local Coping Strategies*. The *Private Sector Initiative Database* is an online database which features good practices and profitable climate change adaptation activities undertaken by private companies. The *Local Coping Strategies* database provides information on long-standing coping strategies and mechanisms, as well as knowledge and experience from communities. The private sector database allows the user to search using a search bar, facilitating a relatively easy search for country-specific information. The local coping database allows

[8] EcoAdapt is an American NGO focusing on capacity building for climate adaptation.

the user to search via region: North America and Europe, Latin America, Africa and Asia and Pacific while the number of case studies per country varies considerably. As was the case with other databases, some of the examples fail to provide more information regarding specific costs of strategies, economic or participatory methods used, stakeholders involved, years of implementation, etc.

MEDIATION was not useful with respect to providing information for implemented case studies focusing on climate change adaptation. Rather, the case studies included in the project MEDIATION were, on closer inspection, ongoing research case studies facilitated by the project and not ones that have already been completed.

As the databases described above were in English, provided various levels of information and catered to specific needs or audiences, partners widened their respective search to include regional or country-specific databases (e.g. klimatilpasning.dk, klimaanpassung.at), scientific publication databases (e.g. Web of Science), grey literature and general web-fishing.

Overall, the databases highlighted above enabled the research team to identify case studies for in-depth assessment while each database can be improved in regard to usability, information available, and ease of understanding.

5 Conclusions

This report highlights the use of grey, green, and soft measures to adapt to climate change in Europe and globally. Moreover, it seeks to identify and describe how participatory and economic methods were used in specific examples in the design and implementation of adaptation measures. A review of available online databases was used to identify case studies for assessment in this report. The databases provided various levels of information and catered to specific needs or audiences. Overall, the databases reviewed enabled the research team to identify case studies for in-depth assessment. At the same time, the databases can be improved in regard to usability, information available, and ease of understanding. In many instances, the databases had significant information gaps or lacked clear information.

Despite the significant number of databases focusing on climate change, it was nevertheless difficult to identify case study examples that met the criteria developed for this report. This could be due to terminology and the lack of identifying or highlighting an implemented action as one addressing a climate threat, or the lack of some existing adaptation databases which fail to provide implementation information. The research focus on already implemented measures, or at least case studies that have already started their implementation, reduced the number of case studies tremendously. It became very clear that many examples in the databases included case studies from research projects that developed and/or evaluated adaptation measures as a research exercise without any interlinkages to real implementation.

To compound the problem, examples of implemented adaptation measures often lacked information regarding the decision-making process, especially in the case of economic methods and tools, as well as the cost of the adaptation measure itself, key criteria for case study selection used in the assessment. As such, though the general case study assessment found economic methods mentioned in 33%, very little adequate information regarding the economic method and its application was found. Consequently, even fewer economic methods were identified in the in-depth assessment, resulting in the majority of case studies for in-depth assessment representing participatory methods, due to access to and more information regarding these processes. One reason for this lack of information could be a lack of knowledge of these databases at the implementation level. Especially, implementers of measures on local and regional level might be not aware of these databases, their uses and how to add to them. Almost all case studies in the database are supported by research institutions; these could have a reason in the current phase of adaptation activities, but also in the interest of research projects and institutions to make their experiences publicly available to a national or international audience.

The analysed in-depth case studies show that participatory methods are seen as very fruitful and necessary methods. The workshops in the logistic case studies were seen as essential to build up such new ideas such as a cooling trailer for railways. In the Sky Islands case study the participatory process was the basis for a funded project which gathered data on relevant aspects. Also in the Augustenborg case study the integration of the area's residents was essential and it was seen that during the project's implementation little opposition occur, ownership and empowerment was generated. The participation process was reported as one of the success factors of the project. In the coastal defence-case study in the UK, personal one-on-one interviews and guided walks were included to discuss the project's objectives, effects and stakeholders' concerns. Also in the Zaragoza case study it was stated that the success of the programme was relying e.g. on the direct work with the stakeholder representatives, the public engagement of local residents and the implementation of concrete examples. The case studies show the high potential of participatory processes in implementing adaptation measures. The projects see the participation of stakeholders and residents as a clear added value and success factor for the projects. But problems are reported in engaging the local participants. A useful instrument to deal with this barrier e.g. establishing a structured communication strategy was mentioned.

Within the assessment, 136 case studies displaying a broad mix of examples of measures implemented to adapt to climate change both in Europe and elsewhere were identified. The 136 identified case studies offer a broad mix of examples of measures implemented to adapt to climate change in both European and non-European countries. The results indicated that soft measures are the type of measure most often implemented with 49% in European and 56% in non-European countries. As mentioned previously, soft

measures are often characterised as cheaper to implement than grey and green measures, though this is not always the case. Given this, the results of this review can be expected given lack of funding for climate change adaptation remains a large barrier within the EU (EC, 2013b).

Public administration bodies on different levels are the stakeholders which are mainly involved in the reviewed case studies – representing 80% in European case studies and 76% in non-European case studies. As public funding is also the main source for financing both European and non-European case studies, these results can been seen as being connected. Overall, it makes sense that the organisation which funds the adaptation measure is also active in its implementation. The funding results also reflect the slight difference between European and non-European countries, with non-European case studies having a larger share of other sources of funding, and thus having a lower percentage of case studies involving public administrative bodies.

In terms of scale, the focus is 65% on the local level and 29% on the regional level. Despite the source of funding and involvement of public administrations, the majority of the case studies represent local bottom-up adaptation actions. In this regard, many of the ‘public bodies’ are considered local administrators and local governments, not part of the national or federal levels. Nevertheless, because multiple levels of governance are involved climate adaptation measures (i.e. funding, research, and implementation) both bottom-up and top-down examples were included in this review.

In regard to the sector, most case studies focus on biodiversity and ecosystems (35%) and coastal marine systems (33%). Concerning effectiveness of the in-depth case studies, it can be said that some examples show a clear benefit, e.g. the Augustenborg case study. In this case study the implementation of the measure led to a reduced risk for flash floods. The area can now cope with 90 % of storm water in an open system and only 10 % has to be delivered to the sewer system which exceeds the original plans to handle 70 % of the storm water from an every 15 years-event in the open system. Furthermore, a lot co-benefits occurred by this project, e.g. cooling effect during summer, more green space and biodiversity increase. The coastal defence case study in UK shows beside coastal protection effects on environment, biodiversity and also social co-benefits (the area can be used as a recreation area). The soft measures: Floods and flood risk maps In Portugal reach their objective of increasing the knowledge base and the ability to select and implement suitable adaptation measures. The Zaragoza-project shows a clear reduction of water use. In the 1990s, awareness raising campaigns, implementation of good practice examples and voluntary public commitments were implemented and the water tariffs were also revised. 15 years later the water consumptions in the city is almost 30 % lower.

Adaptation options can be grouped under three broad categories, as we can find in the European Commission Adaptation White Paper (EC, 2009) and the EU Strategy on Adaptation to Climate Change (EC, 2013a): 'grey' options that rely on technology and civil engineering projects; 'green' options that make use of nature; and 'soft' options that aim at altering human behaviour and styles of governance. Often, implementing a combination of these measures is an effective way to ensure resilience. A trend in the literature is the increased replacement of traditional grey measures with green (ecosystem-based adaptation) and soft measures (e.g. management) (Andrade Pérez et al., 2010; Jones et al., 2012; Voskamp and Van de Ven, 2015).

The general description of advantages and disadvantages of green, grey and soft measures shows that a mix of measures seems to be for many circumstances suitable, e.g. the combination of grey infrastructure measures and green infrastructure for flood protection or the mix of investment in hard flood protection measures and early warning systems. Also investments in improving the water infrastructure can be combined with soft measures as awareness campaigns for reducing water demand.

The multiple case studies reviewed demonstrate the use of grey, green, and soft measures to support climate change adaptation. However, in many instances measures are used in combination or mixed to address climate change and, thus, the separation into the three categories is only useful for assessment and discussion. In this review grey measures are seen to be used by private actors to take action and adapt to climate change and ensure future business activities as seen in the ‘Climate adaptation in logistics’ case study. Following discussions in the literature, they are also used in combination with green measures

as seen in the 'Dike in dune combined with parking garage' case study to provide flood defence to a village in the Netherlands. In this instance, the combination of grey and green actions helps to protect and preserve the natural environment in the area while also providing additional security benefits. Green measures in the assessed case studies are used to help restore and protect natural environments and increase local resilience to climate change as in the Sky Island Restoration Project and create multiple benefits (i.e. green spaces, increased biodiversity, etc.) in the case study focusing on urban storm water management in Malmö, Sweden. An example of direct shift from grey to green adaptation measures can be seen in the UK, where a hard sea defence (grey measure) was removed and a salt marsh was created to adapt to rises in sea level. Soft or non-structural measures are used in CIRAC case study in which a tool in the form of open access maps to evaluate flood risk and vulnerability was created to provide businesses, academics and governments increased access to information about climate change. In Zaragoza, Spain soft measures are used to mobilise a city's citizens to achieve water savings by promoting a culture of water saving while in the CARE Brazil example, soft measures are used to build capacity to adapt to climate change (improved water management) while also working for social, political and economic goals. Finally, the Melbourne Adaptation Strategy and Action Plan Strategy demonstrate how a municipality can create a city-wide plan using a mix of measures to adapt to climate change and increase resilience.

In addition to the types of measures selected in the case studies, the assessment was also used to look at the methods, participatory and economic, used in the design and implementation of measures. In the case study focusing on 'Climate adaptation in logistics' participatory processes are seen to be a useful and innovative way to include knowledge from research partners and clients in the design of adaptation actions and ensure future business activities. Looking at the Melbourne Adaptation Strategy and Action Plan Strategy, the city engaged with key stakeholder groups and established a network group to work on the adaptation strategy. In the Sky Island restoration project, multiple workshops and the establishment of the Arizona Climate Change Network brought together stakeholders from various backgrounds and representing different interests to discuss threats and options for the region. Similarly, the city of Malmö, Sweden engaged with local citizens and a range of stakeholders via community workshops, regular meetings and informal gatherings to develop recreational areas. In Abbotts Hall Farm, UK early communication with stakeholders was established, and methods such as one-on-one meetings were used to raise awareness and increase public support. Finally, as obligated under national law, the dune in dike case study in the Dutch village of Katwijk an official Q&A session was used so that formal objections, questions and recommendations could be taken into account. Economic methods for the design and implementation were identified in two of the nine case studies assessed. In the case study focusing on the Dutch village of Katwijik, a cost-benefit analysis was used to balance monetary with non-monetary values for preferred alternatives. The limited use of economic methods in the form of market study on the potential supply of settlement products and improving the cocoa value chain was identified in the CARE Brazil case study. The identification of higher use of participatory methods in the nine case studies assessed in depth, is in line with the findings from the general assessment of 136 case studies, where a higher percentage (66% vs 38%) of participatory vs economic methods were identified.

Another trend identified in the nine selected case studies is the focus on adaptation to the climate change threats of water scarcity and increased frequency and intensity of extreme storm events. Other themes identified in case studies focused on addressing the climate threats associated with coastal flooding or erosion as well as higher temperatures and heat waves. However, as the climate threat focus of the case study was not a criterion used for selection this could potentially be circumstance.

In regard to funding (e.g. research, implementation of measures, maintenance costs), a variety of sources are identified in the case studies reviewed in-depth. These funding sources range from research (i.e. government), to national ministries, local municipalities, and private companies. In one case study a single funding sources is seen, while in seven case studies mixed sources are identified, and one remains unknown. Mixed funding sources can also be mixed in that they come from different government sources (e.g. national and local sources), government and public sources, and combined public sources. Mixed funding sources enable the funders to spread and therefore minimize the individual risk of the investment. It also helps to ensure that opinions and decisions are not linked to one funding source. Stakeholders

selected also represent a significant mix of groups covering those in the case study area and coming from research, government, local municipalities and designated authorities (e.g. housing), private companies as well as local citizens.

It is a mix of several factors such as the threats that must be addressed (i.e. grey measures are most often associated with defending against water), as well as the culmination of local elements (e.g. policies, budget, stakeholder interests) and the methods used to select, design and ultimately implement measures to adapt to climate change. Yet, a clearer link between the specific measure selected and the reasoning for its selection should be provided in the literature and case study documentation, so that researchers can assess this. Moreover, in many instances there is limited information on the case study - in the databases but also in original sources, such as project websites, published brochures or other documents, etc. – Especially the lack of information on how methods are used, for what purposes, and in what phases of development, makes it difficult to assess this in conjunction with the case study. More information, such as the reasoning and justification for the selection of stakeholders or specific data used in economic assessments is also minimal.

Several publications are planned based on the research and review presented here. Potential publications will focus on the review and assessment of public databases, the general assessment of adaptation measures used in Europe and internationally and the use of participatory and economic methods in the selection of adaptation measures.

In conclusion, the main messages and lessons learned coming from this assessment are:

- Despite the significant number of databases focusing on climate change and climate adaptation, in many instances the databases vary in the amount of information provided and are often lacking information, such as on the decision-making process or assessment tools used which makes it difficult to share and analyse success factors and further experiences during the selection and implementation phase of adaptation measures.
- Through the case study assessments it is shown that participatory methods are often very fruitful and can be critical to the success of projects, providing added value for the implementation. These can be an innovative way to include knowledge from local stakeholders, research partners and clients in the design of adaptation actions and ensure future business activities.
- Very little information in regard to economic methods and their application is available.
- Corresponding to the literature, a mix of measures seems to be for many circumstances implemented and advantageous e.g. the combination of grey infrastructure measures and green infrastructure for flood protection.
- In most instances adaptation projects rely on a mix of funding sources (e.g. government, private companies, etc.). This helps funders to spread and therefore minimize the individual risk of the investment and also helps to ensure that opinions and decisions are not linked to one funding source. But it also increases the effort for the applicant or the institution which connects the different funders.
- To disseminate lessons learnt of the selection and implementation of adaptation measures, documentation of adaptation projects and the methods used to select, design and ultimately implement adaptation measures should provide a clearer description of the reasons why a specific measure was selected by a local/regional community.

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