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Climate action, environment, resource efficiency and raw materials

BINGO

Bringing INnovation to onGOing water management – a better future under climate change

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None

Dissemination and uptake
This report can be used for decision support at the research site and is relevant for other cities and regions that struggle with developing adaptation strategies or implementing adaptation measures.

Short Summary of results (<250 words)
This report presents the final analysis of the policy and governance situation at the research sites, using the three layer framework. It provides an overview of the adaptation measures selected for each research sites as well as an assessment of the governance requirements for implementation of these measures and the extent to which these are met at the research sites. Based on this assessment, recommendations for improvement are proposed for each of the sites. Finally, a comparison of measures, challenges and recommendations between the sites is made to identify common issues and solutions across Europe. This deliverable is part of the result of the work in WP5 (T5.1, T5.2 and T5.3)

Evidence of accomplishment
report

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1. Introduction

1.1. Introduction

This Deliverable is part of the European Union's Horizon 2020 BINGO (Bringing INnovation to onGOing water management-a better future under climate change) project. Project BINGO studies the regional hydrological impacts of climate changes across Europe and together with end users and stakeholders develops adaptation measures to address these impacts. The research was conducted at six research sites in six European countries: Portugal, Spain, Cyprus, Germany, the Netherlands and Norway. These research sites represent a huge variety of different geological, hydrological, land-use and governance contexts. The BINGO project will therefore generate insight into common climate change adaptation challenges in Europe, as well as into the context-specific adaptation challenges that face different European regions.

Within the BINGO project, Work Package (WP) 5 aims to develop risk treatment and adaptation solutions for each research site. The work is divided into three tasks. Tasks 5.1 focuses on identifying adaptation measures through desk research and stakeholder collaboration in so called Communities of Practice (CoPs). The second (out of six) CoP meeting was instrumental to that task. D5.2 gives an overview of the results of this workshop across the six sites. In task 5.2 a socio economic analysis of the selected adaptation measures was performed, not only focusing on direct risk reduction but also on the broader socio-economic impact of the measures. The main results are briefly summarized in the case study chapters. A more detailed report can be found in D5.3. Task 5.3 examines the policy and governance context for adaptation to climate change at the six BINGO research sites. It identifies governance strengths and weaknesses, based on which recommendations will be provided for improvement at the research sites, and beyond.

This report is the final outcome of Task 5.3. It builds on D5.4 (First report on the assessment of the current situation and recommendations for improvement at the research sites using the three layer framework) in which a general assessment was made of the policy and governance situation at the research sites. In this assessment strengths and weaknesses in policy and governance were identified, using the three layer framework as a model, and recommendations for improvement were made. In this report, D5.5 (Complete report on the assessment of the current situation and recommendations for improvement at the research sites using the three layer framework), the same framework is applied to the specific adaptation measures selected in Task 5.1. This gives an overview of governance requirements with regard to the implementation of specific adaptation measures. This analysis is then added to the results of D5.4.

The report is structured as follows. Chapter 1 outlines the theoretical framework used for the analysis and explains the approach used. Chapters 2-7 describe the findings of the governance analysis per research site. Chapter 8 makes a comparative analysis as a main conclusion.

1.2. The Three Layer Model as the theoretical framework used

For the analysis of governance needs per adaptation measure, we use the Three Layer Framework for Water Governance (see Figure 1). This framework, designed by Havekes et al. (2013), was developed against the background of increased experiences with water-related stresses around the world. According to the World Economic Forum's Global Risks Assessment, water problems are one of the biggest future threats facing humanity (World Economic Forum, 2015). In the United Nations Office for Disaster Risk Reduction (UNISDR) floods and droughts rank in the top 3 most experienced climate-related disasters between 1980 and 2011[1]. The UNISDR's Global Assessment Report of 2015 emphasizes that dealing with these hydrological impacts of climate changes requires more than a governmental and top-down technical approach. Just as important

[1] https://www.flickr.com/photos/isdr/7460711188/in/album-72157628015380393/

as technical solutions are good governance practices that provide the necessary legal, financial and administrative capacities to implement adaptation measures and ensure a sufficient amount of stakeholder participation and public accountability to safeguard the legitimacy of adaptation efforts. The Three Layer Framework for Water Governance was developed as a tool for assessing water governance practices against these general values.

The framework builds on the work done by the Organization for Economic Co-operation and Development (OECD 2011) on governance gaps in water governance, and

Figure 1: The Three Layer Framework

elaborates on these gaps with the building blocks for good water governance identified by the Dutch Water Governance Centre (WGC 2011). The framework distinguishes between three layers of governance. First, the "content" layer looks into the substance of adaptation policies. Through this layer, adaptation policies are characterized by their degree (are relevant climate-related risks addressed in the policy framework, or do certain risks remain untreated?) and nature (e.g., do adaptation policies rely on technical, legal and/or financial policy instruments?). In addition, the content layer assesses the available expertise and skills needed to develop relevant adaptation policies in a governance context. In this report, this is further specified in terms of information about the regional impacts of climate change and knowledge about possible coping strategies to deal with these regional risks.

Second, the “institutional” layer deals with the organizational aspects that support the effective implementation of designed adaptation policies. In the Three Layer Framework, good institutional capacities entail clear and legally anchored divisions of responsibility, strong legal and administrative capacities (which for example includes workforce (fte), management and supervisory qualities, implementing capacities, monitoring capacities)and a robust financing structure.

The third “relational” layer of the framework refers to the requirements placed on the wider governance context of adaptation to climate change. The Three Layer Framework makes a distinction between culture and ethics, communication and cooperation, and participation in this regard. This is further translated into the extent to which developed adaptation policies establish links between different sectors, the extent to which adaptation governance is clear and open to the public, and the extent to which stakeholder participation is realized in regional governance contexts.

This framework is applied in all Task 5.3 governance analyses to facilitate mutual comparisons. In D5.4 is was used as a framework for a questionnaire and structured interviews with local stakeholders and experts to assess the policy and governance situation at the six research sites. For this report the framework was used to develop a template to assess the selected adaptation measures for their governance requirements. This template can be found in Annex 1.

1.3. Approach

In multiple stakeholder meetings at each research site, a selection of adaptation measures for each research site was made. These measure were then analyzed on their risk reduction and socio-economic impact (D5.3) and on their governance requirements (this report). This analysis was done by filling out a governance analysis template for each specific measure. The governance analysis template (see Annex 1) was developed as a set of questions based on the Three Layer Framework. These templates were send out to the research partners, asking them to fill in the templates in collaboration with local end users and stakeholders.

The templates form the basis of the analysis in this report. A summary of the templates can be found in tables in the different case study chapters. These tables do not present all the information from the templates, but only the information relevant for an assessment of the site specific governance needs. The complete templates will be added to the Portfolio of Adaptation Measures (D5.1).

Based on the templates key governance challenges have been identified and recommendations were formulated by the WP5-team. These recommendations have been shared with the research sites as part of Milestone 23.

2. Wupper River Basin, Germany

2.1. Outline of the case study

The Wupper River Basin is located in the state of North-Rhine Westphalia, Germany, with an area of 813kilometres and a population of approximately 950,000 inhabitants. The Wupper is an upland river with a length of about 115 kilometers, rising in Marienheide-Börlinghausen (Oberbergischer Kreis district) and flowing into the Rhine River at the city of Leverkusen. The Wupper River and its many tributaries form a river network of ca. 2,300 kilometres. The Große Dhünn Reservoir – the second largest drinking water reservoir in Germany – is located within the Dhünn River catchment area, one of the main tributaries of the Wupper River.

The Wupper Association is responsible for water quantity management and quality of all water bodies within the Wupper River Basin. As a public body, the Wupper Association performs its tasks in the public interest and for the benefit of its association members: town councils, local and district authorities, municipal water suppliers, and effluent disposal businesses, trade, and industrial organizations in the catchment area of the Wupper River. Their contributions cover the costs of wastewater treatment with sewage sludge disposal, flood protection, managing water flow during dry periods (raising low water levels), water supply provision, and maintenance and ecological development of rivers and streams. Close cooperation allows also for the identification of water management strategies. The Wupper Association operates twelve reservoirs, eleven wastewater treatment plants, numerous storm water tanks, and flood control reservoirs.

2.2. Summary of first assessment of policy and governance situation at the research site

This paragraph provides a summary of the first assessment of the policy and governance situation at the Wuppertal research site, focusing on the strenghts, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

The confidence among the stakeholders to work together on climate change issues stands out as a strong suit for Wuppertal. This is in part because the personal relations and communications are well developed. Moreover, Water policy in the Wuppertal is well integrated with other policy fields. Land-use planning is mentioned as a successful example, as well as the integration with the water economic master plan of Solingen.

A wide range of tools is available to tackle current climate risks, such as floods. The professionals who deal with these issues have the right knowledge, skills and training to do so. In addition, the publication of official flood maps is thought to have actually reduced the stress on affected areas. In addition, transparency is considered as a strength. There are regular conferences that are organized on water management and stakeholders feel up to date about new problems and developments in this field.

Weaknesses

The Wuppertal lacks a comprehensive, coordinated strategy to deal with future climate change. There seems to be a lack of climate adaptation concepts and a general discussion/strategy on climate change adaptation. This can be caused by a lack of knowledge about future climate change. Scenarios of climate change effects on the Wupper Basin and more reliable predictions of extreme weather events are missing. This also makes it hard to work on climate adaptation. Besides, the duration (2-5 years) and bureaucratic nature of the planning process is mentioned as a weakness.

Governance needs (what can be improved)

The Wuppertal would benefit from a systematic inclusion of climate change adaptation in all layers of governance. For the content layer this means developing a general, coordinated strategy on climate change adaptation. This requires more specific knowledge about the future state of the climate in the Wupper Basin and the effects that it has on the different stakeholders (institutional layer). This knowledge then has to be implemented in mandatory guidelines (for instance for urban planning) and clear strategic goals, including responsibilities, action plans and time lines. Also, the Wuppertal would benefit from the introduction of a financing scheme (through fees) specifically to finance climate adaptation.

Considering the relational layer, the coordination of climate change adaptation among different stakeholders and different levels of government could be improved. This could be done by expanding the integrated planning approach for climate change adaptation, create better networks and comprehensively institutionalize the collaboration on climate change adaptation. One suggestion is to appoint a climate change officer to coordinate climate change related activities among the stakeholders.

2.3. Proposed Adaptation Measures

2.3.1. Description of measures

For the Wuppertal, a distinction can be made between measures focusing on alleviating the impacts of floods and flash foods (too much water) and measures focusing on alleviating the impacts of droughts (too little water). In the following paragraphs the selected measures for the Wuppertal will be discussed based on this distinction.

Measures focusing on alleviating floods

Technical protection measures for property

Through this measure property can be protected until a specific desired or possible level is being met. It aims at effective point specific risk reduction and targets local and individual property. The effectiveness depends upon static (soil) conditions of buildings on the property. The measure requires very little interferences with the surrounding environment. Also, once capacity and knowledge has been built for property owners, they will capable of adapting and reacting more independently. Yet, gathering the individual funding for the measure has been proven to be a challenge. The measure is designed to alleviate the risks related to flash floods and normal floods and focusses on the safety of people and property. It is technological, educational and informational in nature.

Alignment protection

The measure increases the hydraulic capacity of a stream. It shifts hazards in the probability of occurrence of an extreme flood event due to delayed overflow; reduces local risks; and decreases operational costs due to erosion, sedimentation, vegetation etc. It is a single, small measure, which achieves efficient and high local risk reduction. The measure can be implemented to counter the risks of flash floods and it scoped at enhancing the safety of people and property. The measure is technical in nature.

Retention basin

Through this measure a reduction of high discharge peaks can be realized, as well as a reduction of downstream flood risks in urban areas and a shift of hazard in the probability of occurrence of an extreme flood event due to delayed overflow. However, it demands enough space to construct and requests special topographic conditions (dam height). Advantages of the measure are that public services can independently implement these measures and a synergy between urban drainage and flood protection can be realized. The measure is technological in nature and aims to enhance the safety of people and property.

Measures focusing on alleviating droughts

Substitution with alternative water sources or water saving

This measures can be implemented to enhance the availability of water supplies and consists of three variants: the abstraction of groundwater, the abstraction of bank filtrates and the reduction of water demand at the consumer level. The main risks addressed are the decrease of both water quantity and quality due to droughts. Via this measure the continuity of service can be enabled and the water resources can be managed sustainable. The measure is technical in nature, whilst also including educational, informational and behavioral aspects.

Transition between reservoir catchments

By transitioning water from another catchment, the measure can help to increase the availability of water at the site. Moreover, the measure allows excess water of one reservoir to be allocated at another. The measure is technical in nature and aims to enhance to continuity of services, as well as to allow for the sustainable management of resources. The main risks addressed are the decrease of both water quantity and quality due to droughts.

Reduction of low water elevation

The measure allows for water savings in the reservoir during extreme dry periods; it regulates the minimum downstream river discharge from the reservoir; and it demands changes of planning permission to adapt to increasingly dynamic climate conditions. As such, the measure contributes to handling risks related to a decrease of both water quantity and quality due to droughts. Moreover, it is aimed at improving the continuity of services and the sustainable management of the resource. Besides, the measure is easy to execute and is relatively low-cost. This measure can be characterized as technical, however also requiring laws and regulations, as well as government policy and programs.

2.4. Foreseen consequences of the proposed adaptation measures

The risk reduction and socio-economic analysis for the Wupper River Basin was not yet finished when this report was written. D5.3 contains the full analysis in detail.

2.5. Governance requirements of the proposed adaptation measures

Table 1 and

Table 2 show the governance requirements for the proposed adaptation measures, following the expert analysis of the three-layer-framework. The colors indicate whether a certain condition is met (green), partially met (light red) and not yet met (dark red).

Table 1: Governance requirements for the 'too-much-water' measures

Requirements	Alignment protection	Technical protection measures for property	Retention basin
Knowledge requirements	Hydraulic knowledge, hydrological knowledge, design floods, capacity of stream-flow, potential flooded areas and typical engineering skills are needed.	Hydraulic and hydrological knowledge, design floods, capacity of stream-flow, potential flooded areas and typical engineering skills are needed. Additional geo-technical, building systems and structural knowledge is required.	Hydraulic knowledge, hydrological knowledge, design floods, capacity of stream-flow, potential flooded areas and typical engineering skills are needed.
Organizational requirements: Responsibility structure	Spatial planners, water authorities, engineers, environmental agency, affected inhabitants and the land-owners are involved. Currently first actors are involved. Besides, legal and environmental requirements need to be coordinated. To date, these need to be set up.	Main actors are the property owners. Additionally water authorities and engineers will be involved. Currently, general information has been shared with property owners. But not every property owner is convinced to be responsible to take own actions. Legal requirements have to be met. Support and funding needs to be coordinated between public services and property owners. This still has to be set up.	Involved actors are spatial planners, water authorities, engineers, and environmental agencies and inhabitants affected by the retention basin. Before the construction also the land-owner is involved. Furthermore, legal and environmental requirements need to be coordinated. Today the land is already acquired and funding is already discussed with the higher authority.
Organizational requirements: Administrative resources	Approval procedures need to be clear. The technical expertise is necessary. The necessary actors have been involved.	Approval procedures need to be clear. Also, technical expertise is necessary. Main resources are necessary to advise and support the people.	Approval procedures need to be clear. The technical expertise is necessary.
Legal requirements	Legal requirements are being met.	The measure requires the setting of legal standards, also for insurance reasons.	Legal requirements are being met.
Financial requirements	The costs of planning, land purchasing, construction and operationalizing need to be covered. This is done through the collection of fees, funding and taxes.	Planning, construction and operational cost. These costs can be covered by funding, however this is not yet available and has to be clarified. It mainly depends on private equity and the property owner.	Planning, land purchasing, construction and operational cost are the main expenses. These are funded by fees, funding and taxes.
Relational Requirements: Culture and ethics	Public opinion will be positive, because action of water authorities is expected and welcomed. A support of the public and the municipality is therefore likely.	Currently, the public opinion still considers the public services as the only one responsible for flood protection. This has to be modified.	Public opinion will be positive, because action of water authorities is expected and welcomed. A support of the public and the municipality is therefore likely.
Relational requirements: Public accountability,	Awareness raising of remaining risk (due to overflow by extreme events) is needed, as well as communication of need for individual action for personal	Awareness on peoples own responsibility to take actions, and the required maintenance and revision along the lifetime of the measure should be raised. In addition, capacity	Awareness raising of remaining risk (due to overflow by extreme events) is needed, as well as communication of need for individual action for personal property protection.

communication, and participation	property protection. Also general information on planning and construction progress should be provided.	building for property owners should take place (communication of "help for self-help").	Also general information on planning and construction progress should be provided.

Table 2: Governance requirements for the 'too-little-water' measures

Requirements	Reduction of low water elevation	Substitution with alternative water sources or water savings	Transition between reservoir catchments
Knowledge requirements	Knowledge of downstream environmental and water demand conditions (Dilution of urban inflows, water usage, eco-morphological requirements) is required. At the research site there is growing knowledge and practical experiences	Hydraulic knowledge, hydrological knowledge, design floods, capacity of stream-flow, potential flooded areas and typical engineering skills are needed.	Knowledge of water demand, Hydraulic knowledge, hydrological knowledge, geo-technical knowledge and typical engineering skills are needed.
Organizational requirements: Responsibility structure	Water authorities, engineers, environmental agency, and ecologists are the main actors. Legal and environmental requirements need to be coordinated. These are partially sufficiently involved and coordinated (ongoing process)	Water authorities, engineers, environmental agency, consumers in the supplied area and contractual partners are the main stakeholders. Legal and environmental requirements need to be coordinated. Public campaigns for water saving are necessary.	Water authorities, engineers, and the environmental agency should be involved. Additionally the property owner affected by the route. Currently the latter are not yet involved. Also, legal and environmental requirements need to be coordinated. This is not yet done.
Organizational requirements: Administrative resources	Advising from water supervisor authority, monitoring resources, environmental-technical (natural science) resources. Furthermore a moderation process between relevant stakeholders is required.	Approval procedures/water rights need to be clear. The technical expertise is necessary. Communication channels for public information must exist.	Moderation of finding phase and proving of alternatives between the different stakeholders. Proving of the technical concept (environmental impact, technical feasibility). Technical expertise to plan and construct the route. Resources are basically available but planning has not been finished.
Legal requirements	Legal requirements are being met.	Water withdrawal rights, land use rights	Legal standards need to be set. This is not yet done as the implementation is still in the planning phase.
Financial requirements	Planning costs and opportunity costs (less electric power generation) can be covered from fees, funding and taxes.	Regarding water saving there will potentially be financial losses of water utilities. The costs of water abstraction fees planning, construction and operational costs, need to be covered. This will be done through income out of fees, funding, taxes.	Planning, land purchasing / land use rights, construction and operational cost are to be made. This will be done through income out of fees, funding, taxes. If this is available is not yet evaluated as the project this still in the planning phase.
Relational Requirements: Culture and ethics	Opinion from the ecological point of view might be negative. Necessary to carry out extensive explanation and clarification efforts.	Complaints about water might be possible, if e.g. mixed water is harder. Complaints can also come from the public due to necessary investment	Ecologists could criticize the measure. Land owners might be opposed to the route.

		on new water disposal devices.	
Relational requirements: Public accountability, communication, and participation	The public needs to be informed about the process.	The public needs to be informed about the process of water substitution. Also, public campaigns on water saving necessities and behavioral recommendations are required.	There are informational needs for ecologists and land owners for low impact of route to the environment. Also, general information on planning and construction progress for wider public is required.

Content layer

Looking at the analysis of the different measures related to the alleviation of both flood and drought impacts provided by the Wuppertal experts, knowledge requirements are generally being met in both cases. In general, the flood related measure require hydraulic and hydrological knowledge, knowledge of the design of floods, knowledge on the capacity of the stream-flow, knowledge on which areas are potential flooded areas and finally, typical engineering skills. While some of the drought related measures require a broader range of knowledge (e.g. *reduction of low water elevation* and *transition between reservoir catchment* require knowledge on (downstream) demand conditions).

From the previous analysis (D5.4) it became evident that there is a lack of scenarios on future climate change developments at the Wuppertal. The work in BINGO has contributed to this kind of knowledge to the extent that this is no pressing issue in relation to the implementation of the measures. However, since the life time of most measures goes beyond the time horizon of BINGO, the requirement for longer term projections remains in place.

Institutional layer

Regarding the institutional layer, measures selected for alleviation of floods and droughts differentiate substantially for the Wuppertal. For the flood related measures these requirements are generally sufficiently in place, or at least partly in place. The flood measures, *alignment protection* and *technical protection measures for property* still partly lack a clear responsibility structure. For both measures the responsibilities of different actors need to be coordinated more effectively. In the case of *technical protection measures for property*, this also includes convincing property owners that they have a responsibility to take. This lack of responsibility structure corresponds with the challenges discussed in D5.4, where municipal coordination of competences and responsibilities were found to be insufficient. Based on the analysis, it is noted that this might be caused by a lack of guidance at the ministerial level on the division of responsibilities for flood protection. As potential way to solve this, the appointment of a climate change officer is suggested, who would coordinate responsibilities (D5.4).

Considering the implementation of a *retention basin*, a responsibility structure is already in place. The necessary actors are involved and the measure has been discussed with the higher authorities. Moreover, for the *retention basin* and *alignment protection* measures, also all the necessary administrative resources are available as well as the legal and financial requirements. For *technical protection measures for property,* however administrative and financial resources are still lacking. The latter is mainly due to the necessary involvement of the private property owners.

Considering the measures related to the alleviation of droughts, the institutional requirements are not entirely met. For none of the discussed measures the required actors are involved currently. For the t*ransition between reservoir catchments* measure, none of the institutional requirements are currently in place, as this measure is still in the first stages of the planning phase. *Reduction of low water elevation*, on the contrary, meets most requirements of this layer. A possible explanation for this would be that the measure has a strong technical nature (see D5.4). In comparison, the *substitution with alternative water sources or water savings* measure faces more institutional barriers as it involves also actors outside the water management sector and includes behavioral and educational aspects. The challenges related to this are noted by the experts as they state that communication channels with the public need to be set up and water rights need to be arranged, while this is currently not yet done.

Interestingly, difficulties related to the institutional layer for the Wuppertal are generally discussed in relation to flood management (see D5.4), while drought management seems to face more pressing issues based on this analysis of the measures. Nonetheless, D5.4 considers some more general points which are related to the institutional aspects of the drought case. Respondents, interviewed for the analysis of D5.4, for instance advised to establish a climate fund for the funding of these measures. In the analysis of measures a fund is commonly mentioned as a means to finance implementation. The establishment of a climate change adaptation fund could therefore be also beneficial for both flood and drought related measures.

Also, support in program management and an overview of relevant programs is mentioned to be useful to help non-water managers obtain funding (D5.4). Relating this back to the selected measures, this could particularly of interest for the measures requiring non-governmental actors to be involved, such as *technical protection measures for property.*

Relational layer

Considering the measures related to flood protection, relational requirement are only not being met for the *technical protection measures for property.* This could be explained by the shifting of responsibilities to private actors which is required for this measure. Culturally, the general public perceives flood control to be a responsibility of the government and are therefore unwilling to invest and collaborate. Regarding the accountability for this measure the responsible authorities need to communicate the public responsibility to implement this properly. Also the required maintenance needs to be discussed. This can be done by promoting capacity building amongst property owners, but is currently not yet done. The other flood measures are expected to meet the relational requirements. *Alignment protection* and the creation of a *retention basin* will be executed by the water authorities, and therefore these measures are expected to result in less resistance. Nonetheless, for the implementation of both, the communication of existing risks and necessary corresponding individual measures are still required. For these measures to be successful, the public accountability regarding measures protecting individual properties need to be discussed.

Regarding the drought related measures all measures are expected to potentially yield negative responses, or complaints from different parts of the public. The implementation of a *reduction of low water elevation* and *transition between reservoir catchments*, are expected to receive criticsim from an ecological standpoint, and explanation and clarification efforts might be needed. Considering *substitution with alternative water sources or water savings*, particularly changes in water characteristics (e.g. hardness of water), are expected to require explanation. In general all measures call for carefully informing the public. The *substitution with alternative water sources or water savings* measure, in addition, demands behavioral changes to be enacted to make water savings.

2.6. Key governance challenges and recommendations for improvement

2.6.1. *Key governance challenges*

The key governance challenges pointed out for the Wuppertal vary between the two cases. For the implementation of some of the flood related measures (*alignment protection* and a *retention basin)* the availability of land is a challenge. In general the *retention basin* is expected to be very costly and takes a lot of time to implement, although most other requirements are currently being met.

For the implementation of *alignment protection* there are also difficulties expected after implementation itself, as the operational efforts are expected to increase. From the evaluation of requirements for *technical protection measures for property* it can be concluded that involving the private actors is a potential obstacle for implementation. Especially convincing them to take responsibility seems to be a challenge, due to the high costs of the measure to individual property owners.

The drought related measures face very different key challenges. For the *reduction of low water elevation* these are mostly technical and legal in nature. First, it is difficult to monitor the flow of streams going from the reservoir and thus assessing their current flow and therefore the required reduction. Second, it is challenging to define an effective framework for low water regulation. A key question is which conditions have to be met to reduce the water flow. This is both a technical and a political question.

Substitution with alternative water sources or water savings requires people to change their behavior in water consumption. This is challenging, since water is a relatively cheap resource that is always readily available. Also, individuals usually do not have much insight in their daily water consumption which makes it difficult to identify opportunities to save water. Finally, reducing water consumption often means investments in new houshold apliances that use less water.

When water sources change, people may notice quality changes in the water such as smell, color and hardness. Particularly the last aspect may lead to complaints. Substituting to alternative water sources also requires new transportation routes from the abstraction point to the treatment plants. This requires substantial infrastructural investments as well as land use rights.

Transition between reservoir catchment faces a broad range of challenges. It requires access to and the right to cross private properties for construction and maintenance of the transport route. Transporting water between different catchment can have environmental impacts that are yet unknown and difficult to assess. The topgraphic conditions of the transport route makes this a potentially expensive solution, and it takes a very long time to implement the measure.

2.6.2. *Recommendations for improvement of the policy and governance situation and overcoming implementation barriers*

In the first analysis of the policy and governance situtation at the Wuppertal, three recommendations were made:

1. **Improve the coordination of climate change adaptation** among different stakeholders and different levels of government. One suggestion is to appoint a climate change officer to coordinate climate change related activities among the stakeholders
2. **Develop a coordinated strategy on climate change adaptation**; based on specific knowledge about the future state of the climate in the Wupper Basin and the effects that it has on the different stakeholders; and implemented in mandatory guidelines (for instance for urban planning) and clear strategic goals, including responsibilities, action plans and time lines.
3. **Introduce a financing scheme** (through fees) specifically to finance climate change adaptation.

The anaylsis of the adaptation measures confirms the need for better coordination of climate change adaptation policies and activities. This is particularly challenging when the involvement of private citizens (such as property owners) is concerned. In the Wuppertal case, flood protection is considered a government responsibility and private actors are usually not willing to contribute (financially) or participate in the flood protection of their own properties. Private citizens could be better involved in adaption measure through a number of ways. First, the awareness of the impact of climate change can be raised by providing information about future climate change impacts (such as is developed in BINGO) as well as the activities that the different governments agencies undertake to manage these impacts. Second, the capacity of property owners to manage their own adaptation efforts can be increased, by providing information on what kind of improvements can be made on their properties or assist them in doing the improvements.

Awareness raising is also important in convincing people to start saving water. Public information campaigns could be undertaken to achieve this. As mentioned above, the campaigns can address the impacts of climate change, for instance referring to recent drought events to create a sense of urgency. Information should also be provided on the actual water consumption, the impact of that level of water consumption and the opportunities to save water. Here, a link can be made to energy, since much of the water use in households is associated with energy use (primarily heating). The link with energy can provide stronger incentives for saving since energy is more expensive than water.

Instead of voluntary water saving, it can also be considered to put restrictions on water use in dry periods. For instance, water use for car washing and irrigation of gardens can be restricted by rules and regulations. This does require extensive monitoring capacities.

As was mentioned before installing a climate change officer could improve coordination in adaptation activities and policies. This officer could be in charge of coordinating different agencies and offices in implementing the different measures. The need for more coordination is clear from the evaluation of requirements, showing the relational structures are not yet in place in the Wuppertal, especially related to the responsibilities of actors outside water management (property owners, ecologists, etc). Besides installing an officer, also making effective use of the CoP can stimulate communication and mutual learning.

The necessity of a financing scheme is evident from the analysis of the measures. Most measures are quite costly and require investments that do not fit within the current budgets. Additional taxes should be considered, or targeted fees (for instance on high water consumption in dry periods) or funding from subisidies.

Table 3 provides a summary of the recommendations.

Summary of recommendations	
1.	**Improve the coordination of climate change adaptation** among different stakeholders and different levels of government.
2.	**Appoint a climate change officer** to coordinate climate change related activities among the stakeholders.
3.	**Develop a coordinated strategy on climate change adaptation**; based on specific knowledge about the future state of the climate in the Wupper Basin and the effects that it has on the different stakeholders; and implemented in mandatory guidelines (for instance for urban planning) and clear strategic goals, including responsibilities, action plans and time lines.
4.	**Raise awareness among the general public** of climate change impact and activities to manage this impact.
5.	**Raise awareness among the general public** on the issue of water saving and link this to energy saving.
6.	**Consider putting restrictions on water use** in periods with increased drought risk.
7.	**Increase the capacity of property owners** to manage their own adaptation efforts.
8.	**Introduce a financing scheme** (through fees, taxes or funding) specifically to finance climate change adaptation.

Table 3: Summary of recommendations for Wupper River Basin

3. Veluwe, The Netherlands

3.1. Outline of the case study

The Veluwe is a forest-rich ridge of hills (1250 km^2) in the province of Gelderland in the Netherlands. The Veluwe features many different landscapes, including woodland, heath, some small lakes and Europe's largest sand drifts. Water abstractions provide ca. 2 million people with drinking water and further services industries, agriculture and nature. The water system is vulnerable to droughts, which previously have led to a ban on overhead irrigation, a deterioration of water quality and insufficient good quality water for humans, nature and agriculture. Increasing droughts will have an effect on vegetation and soil composition, which will in turn influence groundwater recharge. These effects are not accounted for in current models.

The Province of Gelderland is responsible for the groundwater resources in the subsoil of the Veluwe and is an important land owner. Water utility Vitens abstracts groundwater for drinking water production. The surface waters are mostly managed by the Water Authority Vallei & Veluwe. Furthermore, land on the Veluwe is owned by the National Forestry Commission (Staatsbosbeheer) and by numerous private land owners.

3.2. Summary of first assessment of policy and governance situation at the research site

This paragraph provides a summary of the first assessment of the policy and governance situation at the Veluwe research site, focusing on the strenghts, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

The Netherlands has a strong tradition in water policy, with the water boards being the oldest democratic institutions in the Netherlands. Consequently, water policy is well institutionalized, with a clear division of responsibilities among the governmental organizations. The level of knowledge about water systems in general is high, and the Netherlands is leading in water research. Water policy is transparent, with sufficient information available to stakeholders and the public.

The national Deltaprogramma provides guidance for regional and local stakeholders to work on climate and water related issues. It provides kick starter funding to local and regional stakeholders to set up initiatives that benefit water safety, water quality and the availability of fresh water. Climate change scenarios are provided by the KNMI, these provide a reference for all climate change related policies in the Netherlands.

Weaknesses

There are three main concerns with regard to climate change adaptation at the Veluwe. Firstly, there is insufficient knowledge about the impact of climate change at the Veluwe and how it will affect stakeholders. Therefore, it is difficult to convince stakeholders of the urgency of climate change adaptation. This makes coordinated efforts difficult, because stakeholders don’t see the need disregard their own interest in favor of climate change adaptation.

Secondly, water policy is, in practice, not very well integrated within the water system itself and with other policy fields. Respondents indicate that a vision on the whole water system is lacking. The lacking integration of water policy with spatial planning is also reason for concern. This separation is strongest at the national level. There used to be a coordinated spatial planning in the Netherlands, but that is now more or less abandoned and left to lower levels of government. Instead of a long term vision for the whole of the country, a more locally oriented problem solving approach is now dominant.

Thirdly, climate change adaptation is overall not at the forefront of the debate. The National Adaptation Strategy that was recently passed by the Dutch parliament is not as powerful as the Delta program, as it lacks legislative and regulatory instruments. The Delta program, albeit a strong program, has a primary focus on water related issues, with ‘spatial adaptation’ and playing just a minor role. Despite the encouragement in the EU Climate Adaptation strategy to develop a holistic vision to adaptation, such a vision is lacking in the Netherlands, which was also noted in an audit by the General Audit Chamber of The Netherlands.

Potential improvements

Climate change research in the Netherlands is very much focused on water. This should be expanded to other sectors as well (Health Care, ICT, Transport) to obtain a broader risk assessment. At the national level, this is challenging, since government departments are highly specialized and often have opposing views and interests. At the regional and local level, this should be easier, because the effects of climate change become more tangible.

Research such as the BINGO-project could lead to more knowledge and awareness of the impact of climate change at the Veluwe. These impacts can then be addressed as a shared challenge for the stakeholders and allow for more cooperation and coordination. This should be done based on a shared vision of the Veluwe in which different policy areas are integrated. Adaptation should not be incidental, but integrated into the regular operations in the area.

3.3. Proposed Adaptation Measures

3.3.1. *Description of measures*

Agricultural water restrictions

Agricultural water restrictions can be implemented by discouraging or prohibiting the use of sprinkler installations. The measure “no sprinkler irrigation” is relevant for an area just outside of the main study area. The ecological streams are dependent on the groundwater system of the Veluwe for their base-flow and sprinkler irrigation can possibly lower groundwater levels. This enhances the infiltration from streams, allowing Veluwe water in the stream to be lost through infiltration. Prohibiting sprinkling can thus be used to sustainably manage the groundwater resources and counter the risks of decreased water quantity due to drought. The measure can be considered an institutional measure, as it mainly consists of setting laws and regulations.

In the area East-Veluwe were the ecological streams are situated sprinkler irrigation can be banned. About 60- 80 farmers will be involved in this measure. Investment in farming development in the region will be necessary to implement this measure, because change in crops and soil management is necessary to be able to farm without using sprinklers. By implementing this measure both farmers and nature are set for the future. Participation is voluntary so commitment is high and no monitoring necessary.

Artificial retention

Artificial retention is a technological measure which can be implemented to allow for sustainable management of the resource. It helps alleviate pressures on the available water quantity due to droughts. From the river Nederrijn and from the lake north of the Veluwe surface water will be pumped. With this water infiltration of 30 million m3/year will be used to compensate groundwater extractions for drinking water. This is a major project. Preparation time will be long for studies, procedures and decision making , 2 Intake structures, 40 km pipeline, 40-50 hectares of infiltration ponds and 3 new groundwater pumping station. Through implementing this measure, increase in potable water use can be compensated without putting extra strain on regional ecological systems.

Land use change

Land use change can be considered an ecosystem based measure allowing for sustainable management of the resource, whilst protecting the environment. It can be implemented to deal with risks related to a decreasing water quantity due to droughts. In the Veluwe, changing pine tree forests (evapotranspiration 500-600 mm/y) in heather/grassland (evapotranspiration 200-300mm/y) or broadleaf forests (evapotranspiration 400-500 mm/y) will reduce evapotranspiration and increases groundwater recharge. This will counter act the possible reduction of groundwater recharge and the increase in ground water demand for drinking water. The measure provides a natural approach to increase groundwater infiltration. It potentially increases biodiversity, and creates a more robust ecosystem and improved soil conditions.

Two possibilities are considered: reducing the pine forest by 2,000 hectares, and replanting the area with broadleaf forest ("Sustainability Eventually") or clearing the area of all pine forest (10,000 hectares), planting some broadleaf forest (2,000 hectares), and leaving the rest as heather/grasslands (6,000 hectares) and open sand (2,000 hectares).

3.4. Foreseen consequences of the proposed adaptation measures

This paragraph provides a summary of the multi-criteria analysis performed as part of Task 5.2. A more extensive description can be found in D5.3.

3.4.1. Effectiveness as regards risk reduction

To assess the risk reduction, the Veluwe case study focusses on the effects of the measures on the amount of groundwater recharge at the Veluwe. For the first measure, agricultural water restrictions, the effects are minimal. There is some effect on local groundwater levels (0.2 - 0.3 million m^3/year of groundwater would be saved) but this effect is negligible at the regional scale.

The artificial infiltration is much more effective. According to the modeling, an additional groundwater recharge of around 30 million m^3/year is expected. The effect is the highest right below the infiltration sites, but spreads around to most of the Veluwe.

The ‘Economy First’ scenario of the land use change measure has a similar but somewhat smaller effect than the artificial infiltration (15-20 million m^3/year), but is more spread out over the Veluwe area and at different locations. Due to its smaller scale, the ‘Sustainability Eventually’ scenario is less effective (1-2 million m^3/year).

3.4.2. *Socio-economic impacts*

The ‘Sustainability Eventually’ scenario is by far the most cost effective measure (although its effect may be too small to matter) while it provides around 22m^3 of additional groundwater recharge per euro invested (over a 10 year time period). The ‘Economy First’ scenario and the Artificial infiltration measure only provide around 1,1m^3 of additional groundwater recharge per Euro invested. Finally, the Agricultural Water restrictions are the least cost effective, while only providing around 0,4m^3 of groundwater recharge per Euro invested.

The measures have more or less the same score in the Multi Criteria Analysis (see D5.3). The Agricultural water restriction is considered a very flexible instrument, with overall positive effects on aquatic nature. It does, not surprisingly, have negative effect on agriculture, but scores average on most other categories. Artificial infiltration has a strong positive effect on drinking water production and ecosystem services. However, it is not very flexible and requires a substantial amount of energy. Finally, the land use changes measure (both scenarios) have a large (and positive) effect on aquatic nature, but also on tourism since it provides a more interesting landscape.

3.5. Governance requirements of the proposed adaptation measures

Table 4 and Table 5 show the governance requirements for the proposed adaptation measures, following the expert analysis of the three-layer-framework. The colors indicate whether a certain condition is met (green), partially met (light red) and not yet met (dark red).

Site: Veluwe, Netherlands		
Requirements	**Agricultural water restrictions**	**Artificial retention**
Knowledge requirements	Knowledge is required on climate change effects, agriculture, crop use (technical); supporting farmer change crop types and water use (administrative); and behavioral preferences of farmers and participation schemes. Knowledge is present at research institutes (WUR) and RVO. Administrative knowledge is with the province.	Development of the pipeline and intake requires technical knowledge. In addition, hydrological knowledge on where to place the intakes is needed. Administrative knowledge is required to determine how are you going to weigh the different EU directives.
Organizational requirements: Responsibility structure	Involved actors are Water boards, the Province of Gelderland, farmers, municipalities and farmer organizations. Farmers are not yet involved in the CoP. Coordination between actors will be fostered through a 'gebiedsproces'. That requires a programmatic approach with some support staff.	Important actors are the province, land owners, nature managers, Vitens (PWS), Rijkswaterstaat, and municipalities. Some are involved in the CoP. municipalities and Rijkswaterstaat not. Existing structures are used for coordination.
Organizational requirements: Administrative resources	A project organization must be set up with all roles that are part of that. Project manager, project secretary, project team etc.	Project organization is organized by Vitens. This is similar to dune infiltration projects, for which the administrative capacities are widely available. However, it is not yet done at the site.
Legal requirements	If the measure is implemented though voluntary participation, no legal means are required. If not, a provincial decree may be necessary. Right to pay lower water board taxes, can be a tradeoff for participation.	Recht van overpad (for pipeline), permission for land use. Acquisition of land (possible). Dutch Water Act.
Financial requirements	Investment in changing farming practices and farm development. Water board and province and to a lesser extent the farmers (who will benefit in the long run). Farmers can be offered lower water authority taxes.	Investment costs depend mainly on the m3 of water transported and the distance. Operation and maintenance costs are mainly the energy costs. Vitens and Province, who will generate resources through taxes and water pricing.
Relational Requirements: Culture and ethics	Cultural heritage can be an issue. Maybe obstruction to change from farmers.	No ethical or cultural issues appear.
Relational requirements: Public accountability, communication, and participation	All measures with land exchange have to be accountable and transparent. Public accountability is high.	Regarding public accountability and transparency, the provincial parliament will monitor this and need to be politically involved.

Table 4: Governance requirements for Agricultural water restrictions and Artificial retention

Site: Veluwe, Netherlands	
Requirements	**Land use change**
Knowledge requirements	Technical (existing knowledge on forest management and effect on ecosystems); administrative (EU directive, Natura 2000 planning and licensing etc.); and behavior and interest (public opinion, preferences of people). Knowledge is mostly present, but still a tough puzzle.
Organizational requirements: Responsibility structure	Involved actors are land owners (incl. National Forest Management), (Vitens), Bekenstichting (the CoP), the province, tourism industry and municipalities. Some of them are in the BINGO CoP or other platforms, e.g. Veluwe-op-1. The province needs to direct this process and connect it to existing platforms involved in (forest) management of the Veluwe. Although the capacity is there, to date this is not yet in place.
Organizational requirements: Administrative resources	Platforms such as Veluwe-op-1 are in place. The Province has the necessary authorities to enact these changes. Execution of the measure will be primarily by the land owners. Administrative and legal is present at the province.
Legal requirements	The Veluwe area is part of Natura 2000, which is focused on conserving land use. Land use will be codified in regional Natura 2000 management plan. If voluntary cooperation does not work, the Province could enact a decree to enforce land use change.
Financial requirements	The replacement of pine forest by broadleaf will probably yield more income, than the costs of planting new trees (positive balance of €550-3510/ hectare). However, there will be no management revenues, as there will no longer be timber harvesting. The province covers the costs, generated through national taxations.
Relational Requirements: Culture and ethics	Cultural heritage issues might occur. Cutting 1 million trees may lead to ethical issues. Unless a different strategy is used, such as natural forest management, where you cut gradually and do not replace trees.
Relational requirements: Public accountability, communication, and participation	The public accountability for the measure is very high. A public and national level political discussion is needed. This requires a new vision on forest management, which given the Dutch political context will be a national, public debate. Land use change is now gradual, not policy driven and needs to change to policy driven.

Table 5: Governance requirements for Land use change

3.5.1. Summary of requirements and foreseen implementation barriers

Content

For *agricultural water restrictions* various types of knowledge are required, including technical knowledge on climate change effects, agriculture and crop use. In addition, administrative knowledge is needed on how to support farmers in their crop and water use. Finally, behavioral knowledge on preference of farmers and participation schemes is required. This knowledge is available at the Veluwe, however it is distributed over different actors. Knowledge institutes, the national government (RVO) and the province have most of the knowledge required for this measure.

The implementation of *land use changes* also requires a combination of technical, administrative and behavioral knowledge. Technical knowledge on forest management and the effects of the measure on ecosystems is required, as well as administrative knowledge on EU directives and Natura2000 planning and licensing. Behavioral knowledge is required on the public and political opinion regarding deforestation and the transformation of natural areas, as well as peoples preferences for different types of nature. Also in this case the required knowledge is mostly present, however, combining and putting the existing knowledge to effective use is still a though puzzle for this measure.

Finally, for the *artificial retention* measure the required knowledge is currently in place. For this measure mainly technical and administrative knowledge is required. Technical knowledge is required for the development of the pipeline and intake, and to determine where to place the intakes. Administrative knowledge is needed on how to weigh the different EU directives that are relevant for this measure.

In general, it can be concluded that sufficient knowledge is present at the Veluwe. Yet, different bodies behold different types of knowledge (knowledge institutes, provinces, national government, etc.). This is in line with the findings from the first analysis (D5.4) where it was shown that, although there is a high level of knowledge on water systems, the knowledge on other related fields and climate adaptation is sometimes lacking. This particularly plays a role in the land use change measure, where a broad range of actors will be involved in implementation and have some of the required knowledge. Another main finding of D5.4 for the content layer is that the biggest knowledge gap for the Veluwe relates to knowledge on groundwater systems. Knowledge on this topic is found to be lacking and requires translation into policy and planning. As all selected measures are linked to groundwater as well, expanding knowledge on these systems is very relevant for the implementation. This has for a large part been done in BINGO but needs continuation and expansion through other projects.

Institutional

Considering the institutional layer, not all requirements are currently being met for the different measures. Especially considering *agricultural water restrictions*, these requirements form an obstacle for implementation. For this measure, both the responsibility structure and the administrative resources are not yet in place. The actors that need to be involved are identified, but not yet all involved. The farmers, who will be the actors eventually enacting the measure by stop using sprinkler installations, are currently not yet part of the Community of Practice. A so-called gebiedsproces (locally embedded stakeholder process) needs to be initiated. However, no project organization, manager or team is appointed yet, who would organize such a process. *Agricultural water restrictions* can be implemented as a voluntary measure, requiring no legal means. Yet, to stimulate participation by farmers a tradeoff could be offered, e.g. by lowering the water board taxes of participants. The latter links to the financial requirements to implement the measure. These are also not met for *agricultural water restrictions*. These requirements should mainly be covered by the water boards and provinces, and to a lesser extent by the farmers (who will benefit in the long run).

For the implementation of *artificial retention*, the institutional layer also includes various barriers for implementations. Whilst for this measure the responsibility structure is sufficiently in place, with all necessary actors being involved in the Cop, the other requirements are not being met. Considering the administrative resources, these are only partly met. The responsible actor for the project organization, Vitens, has not implemented a comparable project in the Veluwe before. However, as the measure is similar to techniques used in the Dutch the dune areas, administrative capacities will be accessible form other water utilities in the Netherladns. The financial and legal requirements are not in place at the moment to implement *artificial retention*. To set the legal basis for the project, the right of passage for the pipeline must be established, as well as the land use permissions. Potentially, some land needs to be acquired. Financially, the costs mainly depend upon the length of the pipeline transporting the water, as well as on the capacity. Costs would be covered by the province and Vitens (drinking water company), however, this is not yet arranged.

Finally, for the implementation of *land use changes*, the required responsibility structure is only partly in place. Actors are involved in several platforms, yet the province needs to direct the process and link the relevant actors and platforms. As a result of the existence of the communication platforms and the nature of the measure requiring landowners to execute the changes themselves, all administrative requirements are met for this measure. Considering the legal requirements, however, there are more barriers identified. The measure would be implemented in a Natura 2000 area, which prescribes the conservation of existing land uses. Therefore land use change needs to be codified into the regional Natura 2000 management plans. Moreover, if voluntary cooperation does not work, the Province could enact a decree to enforce land use change.

Finally, the financial requirements are not yet in place to implement the measure. In theory the replacement of pine forest by broadleaf will probably yield more income, than the costs of planting new trees (positive balance of €550-3510/ hectare). However, there will no longer be forest management revenues, as there will no longer be timber harvesting. The province will need to cover the costs of implementation.

Reflecting on the institutional layer, it can be stated that *agricultural water restrictions* and *land use changes* face difficulties as they depend strongly on the cooperation of actors outside water management. Difficulties of these kind are also identified in D5.4, as it was found that new coalitions for climate change adaptation are currently in the making, however, as soon as they go beyond the water sector, coordination of different actors is a challenge. For *artificial retention* this is no issue. However, also this measure does not meet all requirements. In general the legal and financial requirements are most difficult to obtain for all measures.

Relational

For none of the measures all the relational requirements are met yet. Only for the technological measure *artificial retention*, no ethical or cultural issues are expected. For *agricultural water restrictions* cultural heritage might be an issue and might cause obstruction to change from the farmers. For implementing *land use change* the most ethical concerns are expected, as it will involve cutting close to one million trees. This could be avoided if a different strategy would be applied, like natural forest management in which trees are cut gradually and not replaced.

Considering the public accountability, none of the measures meets the requirements. However, the challenges faced for implementing *land use changes* seem most severe, as the measure is expected to require a national political discussion on how forest management should be performed in the future. Forests management need to become policy driven, rather than incremental, which will require a substantial change in management practices. For both *agricultural water restrictions* and *artificial retention* no such large scale changes are required.

3.6. Key challenges and recommendations for improvement

3.6.1. Key challenges

For each of the measures discussed for the Veluwe, the main governance challenges are identified. Regarding *agricultural water restrictions*, the main governance challenges are twofold. Changing farmers' behavior to no longer using sprinklers and altering their crop types is expected to be a challenge, as well as mobilizing the political will from both municipalities and water boards.

Regarding *artificial retention*, the implementation costs might become too high for the drinking water company (Vitens) to cover at the current water price. Moreover, a discussion about the technological nature of the measure, as opposed to more ecological measures, might hamper implementation.

Finally, for the implementation of *land use changes* the justification of these changes in relation to the Natura2000 goals is expected to be the biggest challenge. Different options for implementation might be discussed such as implementing this over the whole Veluwe area through management or only targeting small areas of 100 ha.

Relating these challenges to the findings of D5.4, it can be concluded that implementation of these measures at the Veluwe still faces several barriers. D5.4 identified low urgency to act (both from stakeholders and on a policy level); insufficient knowledge about the impact of climate change on the Veluwe; and a weak integration of water policy in the water systems and in other policy fields. These issues are also recognized for the different measures. Changing farmer behavior and mobilizing political will are mentioned to be challenges for the implementation of *agricultural water restrictions.* Both of these challenges can be related to a low sense of urgency. Also, the weak integration of policy, corresponds with the challenge of integrating the goals of Natura2000 with climate change adaptation measures (*land use changes*).

3.6.2. Recommendations for improvement of the policy and governance situation and overcoming implementation barriers

To support decision making on adaptation measures at the Veluwe, a shared vision on the future of the Veluwe should be developed. This vision should make a link between the different functions of the Veluwe and how they can be mutually supportive. Future land use change should be based on such a vision, as well as opportunities for additional groundwater abstraction and potential artificial infiltration.

This vision should also include the impact of climate change and potential responses to that. As such, this vision could increase the awareness of climate change among different stakeholders at the Veluwe, which is necessary to secure support for large scale adaptation measures. From the hydrological analysis in BINGO it was found that small scale measures do not have much impact in the groundwater at the Veluwe. To impact the groundwater level, large scale measures should be taken, such as substantial land use change or artifical infiltration.

The impact of climate change should be studied in conjunction with the impact of economic growth, land use change and increased water use. This has been partly done in BINGO, but requires more attention for the coming years. Table 6 provides a summary of recommendations for the Veluwe.

Summary of recommendations	
1.	**Develop a shared vision on the future of the Veluwe** which integrates different policy fields.
2.	**Land use at the Veluwe needs to be reconsidered, based on current and future needs**. This may require political decision making at the national level.
3.	**Increase awareness of the impact of climate change** and increased water use among different stakeholders at the Veluwe.
4.	**Focus on large scale measures** to increase the Veluwe ground water supply.
5.	Climate change impacts seem to fall within historical range. **Develop scenarios for future economic growth** and increase water demand due to political decisions.

Table 6: Summary of recommendations for the Veluwe

4. Tagus, Portugal

4.1. Outline of the case study

The Portuguese research site addresses climate change adaptation of two key sectors of the lower Tagus basin, public water supply and agriculture, being the hazard under consideration the water resources deficit, associated with long periods of reduced precipitation and high water demand.

In the agriculture case study of Sorraia Valley Public Irrigation Perimeter (Sorraia PIP) water reduction losses in the irrigation transport and distribution system is the major concern, due to infrastructures aging and degradation (internal vulnerability).

In the remaining Portuguese's case studies, agriculture in Lezíria Grande de Vila Franca de Xira Public Irrigation Perimeter (LGVFX PIP) and EPAL, the main public water supply utility, the water resources management (WRM) improvement is the major key concern (external risk factor), when water bodies are shared for multiple purposes.

Deliverable D5.4 put in evidence the existence of some water resources governance issues that do not facilitate adaptation of water dependent socio-economic activities, mainly those sharing water bodies. In this report the issues directly related with the adaptation measures proposed are addressed.

4.2. Summary of first assessment of policy and governance situation at the research site

This section provides a summary of the first assessment of the policy and governance situation at the Portuguese research site, focusing on the strengths, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

The majority of significant water user's entities in lower Tagus are well informed and aware of climate change concerns. A set of adaptation measures is already being implemented by the main sectors of activity. In fact, they already deal with the climate variability typical of southern European countries. They see climate changes as an increase of the existing climate variability, either in frequency or intensity. With no real knowledge of future climate change impacts this is quite a pragmatic approach.

In the agriculture sector significant improvements were noticed along the last two decades in the implementation of efficient irrigation techniques, technologies and practices aiming water use efficiency, rational fertilization and plagues control, and agriculture sustainability. European Common Agriculture Policy contributed largely to this improvement. In the public water supply sector, EPAL (partner in BINGO, supplies the right margin of the Tagus river, as well as the municipalities located downstream, in metropolitan area of Lisbon. Overall it supplies one third of the Portuguese population, therefore its effectiveness is quite relevant for the overall water resources balance. EPAL has already adopted a risk management approach in the company to face climate change, eliminated or reduced present internal vulnerabilities and is already implementing a set of measures to face climate changes and its impacts in water resources.

Adaptation requires synergies. The commitment of certain entities has a positive impact on others, mimicking a contagious effect. In fact, it is mainly the exchange of experiences regarding win-win measures that triggers the generalization of process. The seed is already planted in lower Tagus basin, being a significant strength.

Weaknesses

Adaptation in the lower Tagus region is following a bottom-up approach, mainly by the most significant and skilled sectoral water users. The same level of awareness does not exist in all users of Tagus or Zêzere sub-basin water resources. Several entities located upstream and downstream of the lower Tagus region, sharing the same water resources, do not yet comply with the existing legal framework in what concerns pollutants discharge, nor reach the same levels of water use efficiency. The degree of rationalization of water resources uses by each entity affects the other entities sharing the same water resources.

At the same time, water resources management follows a top-down approach, with no real stakeholder's engagement and no integrated management policies or practices. As a consequence, water dependent socio-economic activities, sharing water resources, can only accomplish adaptation up to a certain extent. Water resources management is seen as an additional risk factor, increasing exposure vulnerabilities to water resources deficit hazard. The uncertainty and lack of equity principles in WRM introduces additional costs in the adaptation process of adapting entities.

A weaknesses is the uncertainty about the extent of the impacts on the water resources, and therefore in their sectorial activities, and how fast the process will evolve. A National Climate Change Adaptation Strategy (ENAAC) was approved by the national government in 2010 but with reduced real impact, as it lacks legislative and regulatory instruments. The sectors of activity did not acknowledge this top-down strategy, considering it detached from reality. That is the case of the agriculture sectoral plan that is presently being reviewed, with larger stakeholder's involvement. First version of ENAAC also lacked a holistic vision to adaptation, not favouring inter sectorial adaptation. Presently, there is a tendency of considering climate change adaptation in all plans, but the majority do not have legal binding follow up.

Another weakness, often referred by the stakeholders, is the reduced storage regulation capacity in the Portuguese part of the Tagus basin apart the Zêzere sub-basin.

Governance needs (what can be improved)

It is necessary to evolve from a top-down water resources management approach to a water resources governance model, as foreseen by the WFD and to develop an integrated and holistic vision. It is also needed to implement a missing operational water allocation policy, based on equitable principles attending to the each sectoral economic value of water; assuring transparency. It is necessary to develop tools to support decision making, communication and transparency.

Once the present WRM weaknesses are overcome, climate change can really be addressed. As an example, a debate on whether water allocation strategies and water resources tariffs should reflect water use efficiency, is an important issue, to help promoting adaptation. Incorporate a risk assessment approach to support this type of difficult decisions is also needed

4.3. Proposed Adaptation Measures

4.3.1. Description of measures

The Portuguese research site addresses climate change adaptation of two key sectors, public water supply and agriculture, to the potential water resources deficit hazard.

In the agriculture case study of Sorraia Valley Public Irrigation Perimeter (Sorraia PIP) water reduction losses in the irrigation transport and distribution system (internal vulnerability) is the major concern, due to infrastructures aging and degradation.

In the remaining case studies, agriculture in Leziria Grande de Vila Franca de Xira Public Irrigation Perimeter (LGVFX PIP) and EPAL, the main the public water supply utility, the water resources management (WRM) improvement is a key major concern in the region (external risk factor), when water bodies are shared for multiple purposes.

Measures 1 to 3: Efficiency of water conveyance in Sorraia PIP

Being intervention on the collective irrigation supply network a top priority in order to reduce potential water deficit, either by reducing water losses in the transportation system or by enhancing operational efficiency, three measures, concerning the infrastructures rehabilitation and modernization, were defined by the Irrigator's Association (ARVVS) oriented for different hierarchical infrastructures levels: Measure 1 - the main transport canal (primary network); Measure 2 - the secondary transport/ distribution system of Erra (secondary level of transport and tertiary level - distribution) and Measure 3 - tertiary distribution network level, with pressurization for water-energy nexus improvement.

The purpose of this analysis is not only to compare the relative cost-effectiveness of intervention according to each hierarchical infrastructures levels, but also to understand and allow prioritization of types of intervention if a limited budget is available for investment. DGADR, the regulator entity, in charge of supervising this and other national public irrigation schemes, is also interested in using the outcomes of this analysis in order to plan interventions on other schemes, as many of them present equivalent state of degradation by years of usage.

As water stored in the two PIP's reservoirs are allocated to farmers, proportionally to the respective area, the rehabilitation measures benefit all the farmers supplied by the Sorraia irrigation scheme.

Measure 4 Tagus water resources management model

Stakeholder engagement is crucial when developing management plans and operational practices for water resources usage in river basins. Recognised as being an important inexistent tool, this measure concerns the development of a Tagus water resources management framework, aiming to support integrated water resources analysis, planning and management of Tagus river basin. It will allow defining solutions for problems of water allocation; optimization of reservoirs operation, water uses management and evaluation of water quality indicators during the exploration. This tool will not only allow to outline strategies to adapt to the challenges posed by the various simultaneous uses of water resources, mainly during periods of water resources deficit, but will also allow to analyse the occurrence of extreme meteorological phenomena, assessing their impacts on the basin and the selection of adequate prevention and control options. Nevertheless, the present focus relies mainly on the planning process related with: multisector solution alternatives to water allocation and water shortage problems; climate change impact assessments on water resources availability and quality; exploration of conjunctive groundwater and surface water usage; optimisation of reservoir and hydropower operations; agricultural water use efficiency and integrated water resources management (IWRM) studies.

4.4. Foreseen consequences of the proposed adaptation measures

4.4.1. Effectiveness as regards risk reduction

Measures designed for the Sorraia PIP are specifically oriented for water use efficiency in the Sorraia conveyance irrigation scheme, and therefore to water availability increase either through water losses reduction or through operational efficiency enhancement. The gain introduced is significant, reducing the imbalance of water storage and agricultural water demand in the Sorraia Valley. It will also allow DGADR to extrapolate this analysis to other public irrigation perimeters in the country, aged approximately the same. This adaptation benefit comes with a high cost

The Tagus water resources model, by allowing to enhance transparency and helping to design a water resources allocation operational policy, has a large potential to reduce uncertainty about water resources availability, to improve Tagus flow regulation to fulfil all the conflicting uses; to allow discussion of multisector solution alternatives to water allocation and water shortage problems; to explore conjunctive groundwater and surface water usage and to perform climate change impact assessments on water resources availability and quality. If duly exploited, this measure can be highly effective in reducing risk by reducing exposure to water resources deficit.

4.4.2. Socio-economic impacts

Sorraia PIP has two reservoirs assuring storage for its own irrigation consumption. Measures analysed assure the continuity of the existing irrigation scheme and agriculture sustainability in the Sorraia Valley, along with the improvement on water use efficiency and contribute to improve the water-energy nexus. It is a closed system, but the overall research site benefit of these measures, besides their real local effectiveness, is the demonstration that climate change adaptation comes with a high cost. This is an important point when sharing water resources, to be integrated in the water resources oriented measure.

The Tagus water resource management model is of utmost importance, as a communication tool among all the stakeholders and the Water Authority.

This measure is already under development by BINGO team, the model will set up till the end of 2019, but its effectiveness will depend upon the level of use that the Water Authority will promote. Hopefully, this measure will promote transparency among stakeholders while assisting on the analysis of water-sharing issues at international, national or local river basin scale, investigating options and making reliable decisions. By reducing the presently existing vulnerabilities in WRM, this measure aims to enhance resilience to cope climate change It has the modes ambition of contributing to support the establishment of a missing operational water allocation policy, based in fair and equitable principles and in the socio-economic sectoral values of water uses and the big ambition of promoting to evolve from a top-down water resources management approach to a water resources governance model.

The main existing barriers are lack of important information to fully set and calibrate the model, related with financial limitations, and uncertainty about the Water Authority willingness or ability to promote and lead the necessary alterations.

Once the present WRM weaknesses are overcome, climate change can deeply be addressed. As an example, a debate on whether water allocation strategies and water resources tariffs should reflect water use efficiency, is an important issue, to help promoting adaptation. Sorraia measures cost effectiveness analysis is quite relevant to support this debate. In the future, during water resources deficit periods, the allocation of water among conflicting uses should take into consideration water use efficiency, and reward efforts developed to achieve it.

4.5. Governance requirements of the proposed adaptation measures

Table 7 contains the governance requirements for the selected adaptation measures.

Requirements	Irrigation conveyance network rehabilitation	Tagus Water Resources Management Model
Knowledge requirements	Technical hydraulic and mechanical engineering knowledge to design rehabilitations and modernization solutions (canals coating, drainage, weirs, pumping stations, outlets, etc.); Water losses estimation; water and energy efficiency; Geographical distribution of types of crops and related water requirements and irrigation techniques; remote SCADA operating, etc. Sufficient agricultural knowledge exist at ARBVS and engineering skills are contracted. Climate change predictions and impacts on basin water resources. Knowledge about constraints imposed by different EU legal framework (directives) and PT Water Law; European Common Agriculture Policy (CAP) and national PDR (Rural development programmes)	*Modelling skills*: Hydrological, groundwater and water quality modelling; water resources management. *Modelling data*: Catchment design, hydro-meteorological data (precipitation, potential evapotranspiration, and temperature, flows, solar radiation, number of hours of light/day); soils (parameters for soil moisture content and groundwater recharge); reservoirs (storage capacity, water heads, operational rules); water quality data (monitoring data: oxygen, carbon and nutrients cycle parameters; phytoplankton biomass); water uses (abstraction volumes, regime and location; discharge volumes and associated pollutant loads); economic data. Requires: fulfilment of administration obligations of quality and quantity monitoring, as well as of self-control emissions monitoring obligations by stakeholders; Public available cadastre of the water resources uses; Easy, transparent and fast access to the most updated data and information, and sharing and of existing information produced by stakeholders. – SNIRH and SILIAMB Platforms. Climate change predictions. Knowledge about constraints imposed by different EU legal framework (directives) and PT Water Law.
Organizational requirements: Responsibility structure	Involved actors are the Irrigators Association (ARBVS), DGADR, the Directorate General of Agriculture, Farmers	Important actors are: The Water Authority (APA/ ARH Tejo); Water users: farmers; irrigator associations; agriculture associations (CAP, FENAREG, etc.); public water supply utilities; municipalities; industry; agriculture advisory entities; diversified administrative entities (DRAP LVT; CCDR, CIM LVT; CIM LT; AML), Water resources Commissions (CRH Tejo – that integrates all the above entities); scientific support.
Organizational requirements: Administrative resources	Project organization must be set accordingly with DGADR requirements	Measure implementation is led by the Water Authority that should dispose of skilled and sufficient human resources to perform this task. CRH should assume a more eminent role Engagement of stakeholders in the planning process rather than consultation of already elaborated plans; Equal treatment for equal rank/role entities A governance model of cooperation between administration and water user's entities should be implemented.
Legal requirements	Compliance with national and European legal framework. Adequate existing blind CAP policy to climatic, geographical and soils type characteristics	Simplification and harmonization of existing legislation would assist on solutions design. Missing an operational water resources management policy and practices concerning water uses allocation and Tagus flow regulation criteria; Revision of related licencing legislation.

Financial requirements	Investment for infrastructures rehabilitation. More transparency in what concerns criteria for accessing national (FPRH) and EU funds (e.g. EAFRD)	Investment costs depend mainly on the m3 of water transported and the distance. Operation and maintenance costs are mainly the energy costs. Vitens and Province, who will generate resources through taxes and water pricing.
Relational Requirements: Culture and ethics	Cultural heritage can be an issue for a small percentage of farmers in the region, but no obstruction to change is expected.	Different ethical or cultural positions may appear in solutions design, but it will stir some long in place practices.
Relational requirements: Public accountability, communication, and participation	DGADR follow up of measure implementation	Public accountability and transparency need to be improved by the Water Authority (APA / ARH Tejo), Channels of better communication between the administration and water users need to be improved.
Key governance challenges	*No particular challenges*	Shifting from a top-down water resources management model to a governance model is the key challenge. Provide the necessary means and tools to achieve it, is a set challenges! A concrete example of a challenging issue is the establishment of a regulated flow in Tagus River, suitable for all users. Integrate water use efficiency in water allocation policies and practices during water resources deficit periods is also a challenge. It also requires understanding the cost of CC adaptation, debate on water allocation versus efficiency, as examples. Challenges go far beyond technical requirements.

Table 7: Governance requirements for Irrigation conveyance network rehabilitation and Tagus water resources management model

Content

This Tagus water resources management model measure has two phases, the first is model set up and the second is model exploitation and development of WR management solutions. The 1st phase requires modelling skills (hydrological, groundwater and water quality modelling) and a large amount of data. The second phase corresponds to the water resources management process, requiring an integrated holistic vision and participation of all the related actors.

Model set up requires: catchment design, hydro-meteorological data (precipitation, potential evapotranspiration, and temperature, flows, solar radiation, number of hours of light/day); soils (parameters for soil moisture content and groundwater recharge); reservoirs (storage capacity, water heads, operational rules); water quality data (monitoring data: oxygen, carbon and nutrients cycle parameters; phytoplankton biomass); water uses (abstraction volumes, regime and location; discharge volumes and associated pollutant loads); economic data.

Requires fulfilment of administration obligations of quality and quantity monitoring, as well as of self-control emissions monitoring obligations by stakeholders; Public available cadastre of the water resources uses, allowing understanding of the relative contribution of each water user to the water bodies' status.

Requires easy, transparent and fast access to the most updated data and information, and sharing and of existing information produced by stakeholders. – SNIRH and SILIAMB Platforms. The Institute of Water, presently integrated in the Portuguese Environment Agency (APA), had a quite evolved and updated information system, SNIRH – Sistema Nacional de Informação dos Recursos Hídricos (National Water Resources Information System), with meteorological, hydrological and water quality data. In the last decade, due to financial difficulties, the information system reduced significantly the level of updated and validated data.

Requires more human resources to upload data proceeding from the water users entities that monitor water quality data (as public water supply entities, irrigators associations, etc.) and submit it to APA (the Water Authority) in order to comply with the Water Framework Directive and the Portuguese Water Law, but this relevant data is not being introduced in SNIRH.

To exploit the model is also required knowledge about constraints imposed by different EU legal framework (directives) and PT Water Law.

Requires knowledge about climate change predictions and local impacts.

Institutional

The water legislation in Portugal could benefit from simplification and harmonization. The codification of all the legislation into a single Water code that could be less persecutory and more conciliatory would be welcome.

Legislation should be complemented with a clear and transparent operational water uses policy and strategy (hydropower, agriculture, public water supply, etc.). It should be established based on an improved economic analysis of water uses (recognizing the economic, social and environmental importance of different types of uses). Once set, it would provide the basis for a revision of licensing procedures and for the improvement of the water economic regime in place (polluter-pays principle; water resources taxes and recovery of costs) and definition of rules for exceptions, among others.

Reduction of the existing WRM vulnerabilities will allow focus on climate change adaptation requirements and reduce adaptation efforts.

Relational

The top-down approach does not promote enough and effective engagement of stakeholders. Channels of communication between the administration and water users should be improved. The involvement of stakeholders in all the planning and decision process would very effectively improve water resources governance in order to achieve the environmental objectives and a sustainable, balanced and equitable water use. The work/intervention of the Hydrographic Region Council (CRH) should be enforced and published. It would allow a clear and workable definition of the roles and responsibilities as well as of the administration as of the water users, in particular in the design and implementation of measures for water body's protection and sustainable, balanced and equitable water use.

4.6. Key governance challenges and recommendations for improvement

4.6.1. Key governance challenges

Shifting from a top-down water resources management model to a governance model is the key challenge in the Tagus basin in order to improve water body's protection and sustainable, balanced and equitable water use. Provide the necessary means and tools to achieve it, is a set challenges. A concrete example of a challenging issue is the establishment of a regulated flow in Tagus River, suitable for all users.

Integrate water use efficiency in water allocation policies and practices during water resources deficit periods is a challenge that may require rupture with long in place practices.

It also requires understanding the cost of CC adaptation, debate on water allocation versus efficiency, as examples. Challenges go far beyond technical requirements.

4.6.2. Recommendations for improvement of the policy and governance situation and overcoming implementation barriers

Some key governance recommendations are provided.

Content

Allocate more human and financial resources to improve knowledge of basic data to fill the existing gaps (water bodies monitoring, anthropogenic pressures and their impacts over the water bodies), Sharing of monitoring responsibilities between administration and water users needs to be improved in a fair and realistic way. Water uses is usually a missing or incomplete relevant information, not allowing understanding the relative contribution of each water user to the water bodies' status. It is necessary to update public available cadastre of the water resources uses (abstractions and rejections) and to improve the self-control emissions monitoring obligations by stakeholders.

Access to information is recognised to play a key role. Assure an easy, transparent and fast access to relevant updated data and information to all parties interested, allowing decisions and performance to be questioned and to get more legitimacy. In this line, integration of existing platforms and information systems is a possibility, providing geographic information accessible to the public and stakeholders along with relevant information of licensed titles (water uses), existing constraints, etc.

Should be provided training to the administration staff and strengthening it with more human resources, allowing better performance of all the necessary steps of water resources management. Use and exploit integrated simulation models tools to support decision-making and conflicts management. Assure more supervision, control and inspection and follow-up of programs of measures are also necessary.

Keep articulation with scientific community in order to continue developing studies concerning climate change predictions and impacts in the water resources.

Institutional

The water legislation in Portugal could benefit from simplification and harmonization. The codification of all the legislation into a single Water code that could be less persecutory and more conciliatory would be welcome.

Legislation should be complemented with a clear and transparent operational water uses policy and strategy (hydropower, agriculture, public water supply, etc.). It should be established based on an improved economic analysis of water uses (recognizing the economic, social and environmental importance of different types of uses). Once set, it would provide the basis for a revision of licensing procedures and for the improvement of the water economic regime in place (polluter-pays principle; water resources taxes and recovery of costs) and definition of rules for exceptions, among others.

Reduction of the existing WRM vulnerabilities will allow focus on climate change adaptation requirements and reduce adaptation efforts.

Relational

The top-down approach does not promote enough and effective engagement of stakeholders. Channels of communication between the administration and water users should be improved. The involvement of stakeholders in all the planning and decision process would very effectively improve water resources governance in order to achieve the environmental objectives and a sustainable, balanced and equitable water use. The work/intervention of the Hydrographic Region Council (CRH) should be enforced and published. It would allow a clear and workable definition of the roles and responsibilities as well as of the administration as of the water users, in particular in the design and implementation of measures for water body's protection and sustainable, balanced and equitable water use.

In order to achieve these goals some barriers need to be overcome in what concerns some installed operational practices (e.g. hydro electrical production). Communication and joint stakeholder's collaboration can ease the way.

Improved articulated planning and management with Spain is also considered essential.

A holistic vision must be assured. Besides top guidance, improving an interinstitutional cooperative attitude among Administration agencies is important.

Provide a more stable, transparent and fair access to funding. The application of the national Water Resources Protection Fund (FPRH) should be oriented to finance necessary and useful measures to a good water resources management and their destiny need to be transparent to stakeholders and equally/ fairly accessible. If a fair framework is provided, it could be considered as the implementation of water services recovery costs preconized in Water Law and the adjustment of rates (TURH /tariffs/ permit fees).

The applications and procedures provided in European funds can be improved. For, example, by enhancing the allocation of RDP2020 funds, if possible and necessary using alternative sources of funding (e.g. Juncker Plan). In what concerns access to structural, cohesion EU funds remove exiting uncertainty, defining clearly who can apply to these funds (in the current programme funding allocation appears to be too based on legitimacy of the applicants).

For rationalization of water use in agriculture The Common Agriculture Policy (CAP) and direct support to farmers needs to be improved. The EU policy is blind to geographical realities and types of soil. Either at European or national level restrictions could be established. As an example it is arguable the use of very good quality soils in rice production, a crop highly water demanding and soil and aquifer polluter. As it is blindly funded by the EU there is a tendency to produce it. This EU policy does not promote CC adaptation.

These improvements would allow making the River District Basin Plans less evaluative and more strategically operational, and with measures defined according to objectives and agreement of all the intervenient actors, that would result in a better operational implementation.

In summary, the definition of the missing implementation polices, a better joint articulation among the various planning instruments, along with the involvement of the stakeholders in the planning processes and the allocation of more resources, allowing for better monitoring and control and measures implementation, would allow Portugal to embrace the WFD challenges for an sustainable, balanced and equitable water use, while achieving the environmental objectives.

Solving the water resources management basic issues will allow focus on climate change adaptation. Therefore, the next step towards a climate change adaptation requires linking of efforts in an integrated strategy and an optimization of water resources management among all parties interested in the same resources.

A way to overcome the disruption between top and bottom (administration and sectors of activity) needs to be found. As sectorial entities are already finding their paths, as far as possible within their own fields of activities, it misses a governmental ability to overcome the gap between the top and bottom, starting by setting a real water management policy, including a water use policy, by establishing water resources allocation priorities according to the different types of uses.

ENAAC revision should promote and assist the various sectors, the central, regional and local administration and policymakers, and find the means and the tools to turn theoretical plans into action operational plans, promoting integration in the various sectoral policies and territorial planning instruments. Table 8 shows a summary of the recommendations for the Tagus case.

Summary of recommendations
1. Climate change adaptation requires **shifting from a governmental regulatory model to an effective governance model**, with all levels of society participating.
2. **Improve channels of communication between the public administration and users**. Effective engagement of stakeholders in the planning processes, prior to decisions, needs to be worked out.
3. **Ensure greater stability of the institutional framework** with an improved efficient model, eliminating overlapping competences among entities, and improving an inter-institutional cooperative attitude among government agencies.
4. **Establish a water use policy** based on an improved economic analysis of water use.
5. **Provide a more transparent and fair access to funding.**
6. **Increase training of government staff and strengthen the administrative resources** at human, technical and logistics levels with for example integrated simulation models tools to support decision-making.

Table 8: Summary of recommendations for Tagus case

5. Troodos, Cyprus

5.1. Outline of the case study

The Peristerona Watershed (112 km^2) is located along the northern slopes of the Troodos Mountains in Cyprus. The Peristerona River flows from the northern flank of the Troodos Mountains into the Mesaoria Plain (Figure 2).

Figure 2 Google Earth image (4th April 2015) of the Peristerona Watershed (green), Panagia Bridge Station (light blue), the community boundaries (pink), the UN buffer zone (red) and the research focus area (yellow).

The Peristerona River is an ephemeral stream, which does not flow in summer. Surface runoff is highly variable. The average long-term annual stream flow at Panagia Bridge station in the foothills of Peristerona Watershed is 11.75 Mm^3 (1980-2010). Lowest annual flow was 1.85 Mm^3 (2008) and the maximum was 25.94 Mm^3 (2002). The streamflows from the Troodos recharge the groundwater formations in the Mesaoria Plain. Gabion check dams have been established across the riverbed to slow the stream flow and increase groundwater recharge in the downstream areas of the watershed.

Agricultural cropland, including fallow, in the Peristerona Watershed’s communities covered 3,407 ha in 2010 (Cystat, 2014). In 2013, lands in good agricultural conditions, which were submitted and qualified for Single Area Payment support, totalled 3,546 ha

(Cyprus Agricultural Payment Organization datasets). In the foothills and downstream areas, both rainfed and irrigated crops are grown. Throughout the watershed there are diversions from the stream, which supply irrigation water to the fields by gravity through a system of open channels. Groundwater pumping is also common, especially in the alluvial river aquifer. Agricultural water demand exceeds sustainable supply, especially in dry years (Zoumides et al., 2013). Streamflow does not reach the downstream communities during dry years. Downstream, the research system is defined by the boundaries of the communities of Kato Moni, Orounda, Peristerona and Astromeritis. The community of Astromeritis lies outside the watershed boundaries but receives irrigation water, diverted through open canals, from the Peristerona River. The downstream area of the Peristerona Watershed is very narrow, but the land of the communities also covers the neighbouring plains.

5.2. Summary of first assessment of policy and governance situation at the research site

This section provides a summary of the first assessment of the policy and governance situation at the Cyprus research site, focusing on the strenghts, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

Water governance in Cyprus is guided by a clear and legally embedded policy framework, which is based on a good understanding of the contemporary condition of the water system. This is reflected in a strong institutional capacity. Roles and responsibilities for daily management practices are clearly defined and divided between different authorities. Also, the necessary reporting requirements have been set up to ensure accountability. In the governance of domestic water supply, administrative and financial resources are well-arranged.

In the subdomain of irrigation, end-users are actively involved in water governance. This facilitates the development of governance solutions that are tailored to the specific needs of end-users in a certain area.

Weaknesses

The content of the policy framework is focused on the contemporary situation, not taking long-term developments such as climate change sufficiently into account. While the impacts of climate change are well understood on a general level and the first adaptation measures are already in place, the impacts are only known crudely. Because of this, adaptation is mainly incorporated under existing policy approaches (dealing with droughts for example) but new risks remain under-addressed. As a result of this lack of understanding about detailed impacts, the policy framework for adaptation is not accompanied by clear institutional arrangements. It is for example not specified who is responsible for anticipating which impacts, who is responsible for taking precautionary (e.g., who will pay for the infrastructural improvements in the domestic water supply and irrigation networks) and emergency (e.g., who is responsible for ensuring the water supply in cases of prolonged drought) measures, and who will carry the burden of potential negative consequences (e.g., higher drinking water prices, crop damages) caused by the impacts.

Governance needs (what can be improved)

To improve the current situation, more knowledge could be generated about the specific and regional-level impacts of climate change on the local water cycle. However, a better understanding of interactions in the local water system is still needed. In the current situation, surface water diversions and groundwater abstractions are for example not always sufficiently monitored, and because of this, the consequences of these abstractions on groundwater levels – which will interact with the impacts of climate change – are not known. More insight into these kinds of interactions will help to develop robust policy solutions for adaptation to climate change.

In addition, the institutional arrangements supporting these policy solutions could be improved. Roles and responsibilities of different parties have to be clarified, to make sure that every party is aware of its responsibility for taking precautionary, emergency and coping measures, and can be held into account for acting on this responsibility. The institutional arrangements could potentially be developed in the subdomain of domestic water supply, as this domain is already characterized by a strong institutional framework. For the subdomain of irrigation governance, however, this could be more difficult to develop, as the financial and administrative arrangements in this subdomain are more fragile.

Yet, at the same time, the governance structure in the irrigation subdomain does display an important quality for adaptation to climate change: a decentralized responsibility structure (with irrigation divisions) in which end-users participate and through which policy solutions can be generated based on the specific characteristics of an area. Such solutions are generally seen to be of great importance for adaptation to climate change, which has different impacts at different localities and therefore requires the development of tailor-made solutions by involving stakeholders in the policymaking process. This mode of governance also allows to develop more (strategic) linkages with other sectors.

5.3. Proposed Adaptation Measures

Water Desalination

The desalinization measure focusses on the connection of the downstream communities of the Peristerona Watershed to the water supply grid. The desalinization plant is yet at work, however, not all communities are currently connected to its supply. To complete the measure a conveyor pipeline, two storage reservoirs and three pumping stations will be installed by 2021. The main objective of the measure is to ensure a reliable and continuous potable water supply for the downstream communities of Peristerona

Watershed, as low groundwater recharge was identified as one of the main climate change hazards for the domestic supply.

Groundwater recharge systems

This measure relates to the proper maintenance of check dams along the Peristerona River for groundwater recharge. The measure includes: (a) the removal of sediment (once a year in wet years), and (b) the maintenance of gabions, from seven check dams that have been constructed across the river streambed in the downstream area of Peristerona Watershed. The main objective of the measure is to improve the quantitative and qualitative status of groundwater and ensure sufficient domestic water supply under climate change and expected drought years. The socioeconomic analysis (see Deliverable 5.3) revealed that this measure is the most cost effective in terms of ‘‘water saved’’ compared to alternative adaptation measures.

Use of Treated Sewage Water for Irrigation

The measure requires the construction of an water supply network for treated sewage water to be used in irrigated agriculture. The treated water will be transferred from the recently established waste water treatment plant in Astromeritis through a pipeline network to irrigate the agricultural land of the Astromeritis community. The main objective of the measure is to ensure sufficient agricultural water supply, and reduce unsustainable groundwater use, under climate change. The main advantage of the measure is that it provides a low cost water supply for irrigation, which can reduce the production costs and alleviate the pressures on groundwater resources. However, the long-term impacts of emerging contaminants, which are present in the recycled water, on groundwater, ecosystem and human health are not known.

Irrigation scheduling technologies

This measure includes the installation of soil moisture sensor units and meteorological stations, with a decision support App to advise farmers when and how much water to apply to a field at the right time and in the right quantity. It specifically includes the installation of soil moisture sensor units and three meteorological stations in the downstream areas of the Peristerona Watershed, which will schedule the irrigation needs of the total land under tree (fruit, citrus, olives) orchards.

The extent to which the measure is established depends on the willingness of farmers to adopt the technology. Based on past experience of similar systems on pilot basis (e.g., Siakou et al., in press), it is assumed that the adoption of the measure can result in water savings of 10-20%, as well as reduced fertilizer use. The adoption of the measure can improve the quantitative and qualitative status of groundwater and enhance the financial viability of local farm holdings.

5.4. Foreseen consequences of the proposed adaptation measures

The uptake of irrigation scheduling technologies and the use of treated sewage water for irrigation were selected by stakeholders for ensuring a sustainable management of irrigation water supply in Peristerona Watershed, while the use of desalinated water for the downstream communities of the Peristerona Watershed and the maintenance of groundwater recharge systems along the Peristerona River were selected for ensuring the continuity of domestic water supply to rural households.

The combination of the cost-effectiveness analysis and the multi-criteria analysis revealed that stakeholders' preferences are to a large degree aligned with the results of the economic analysis. The maintenance of the check dams along the Peristerona River is the most cost-effective solution to mitigate the effects of climate change on groundwater recharge and the most preferred option by stakeholders. The largest divergence between stakeholders' preferences and cost-effectiveness analysis results was noted for the treated sewage water measure and the irrigation scheduling technologies. Although the implementation of the treated sewage water option can result in large use of recycled water per euro invested, the measure was the least preferable by stakeholders mainly because stakeholders were sceptical about the impact of emerging contaminants, which are present in the treated wastewater, on ecosystems and human health. On the contrary, although irrigation scheduling technologies was the least cost-effective measure, it was highly preferred by stakeholders, who identified the high cost as the main barrier for the uptake of these technologies, and stressed the need for subsidizing this measure.

5.4.1. Effectiveness as regards risk reduction

The cost-effectiveness analysis revealed significant differences across the four adaptation measures as regards risk reduction. Groundwater recharge check dams is in total the most cost-effective solution corresponding to 1,250 m^3 of groundwater recharge per euro spending in the maintenance of the check dam. The water desalination option corresponds to 1.5 m^3 desalinated water consumed per euro invested in this specific measure.

For the irrigation sector, the use of treated sewage water for irrigation corresponds to 32.6 m^3 recycled water used per euro invested in this specific project (farmers will buy the recycled water at a rate of 0.12€/m^3). Finally, the use of irrigation scheduling technologies is the least cost-effective option; it corresponds to 0.90 m^3 water savings per euro invested in those technologies. The results of the cost-effectiveness reveal the need of subsidizing the irrigation scheduling technologies for farmers not having access to recycled water (a) in terms of social justice between farmers having and not having access to recycled water and (b) in terms of improving groundwater resources protection and management.

5.4.2. Socio-economic impacts

The multi-criteria analysis revealed that for the domestic water supply sector, groundwater recharge systems received the highest final MCA score (14.6) compared to the use of water desalination (13.3). For the irrigation sector, irrigation scheduling technologies measure had the highest MCA score (13.5) compared to the treated sewage water option (12.1). Stakeholders' preferences on uptaking irrigation scheduling technologies versus the use of treated water for irrigation were also revealed through the original, i.e., the unweighted, scoring of the measures. Across the four selected measures, the maintenance of the groundwater recharge systems received the highest ranking followed by the irrigation scheduling technologies, the use of desalinated water and the use of sewage water.

5.5. Governance requirements of the proposed adaptation measures

Table 9 and Table 10 show the governance requirements for the proposed adaptation measures, following the expert analysis of the three-layer-framework. The colours indicate whether a certain condition is met (green), partially met (light red) and not yet met (dark red).

Table 9: Governance requirements for Desalinization and Groundwater Recharge Systems

Requirements	Desalinization	Groundwater recharge systems
Knowledge requirements	Knowledge is required on: hydrological processes; existing and projected water supply (quantitative); water demand data; impacts of climate change; design and construction of pipelines, storage reservoirs, pumping stations; the price elasticity of water demand by households; financial and cost-benefit analysis (to ensure the viability of the measure).	Scientific knowledge and long-term monitoring of the hydrological processes in the watershed are required. As well as, scientific knowledge on the functioning of the check dam. Also, quantitative information on the climate change impacts on the water cycle is needed. Finally, technical knowledge on the maintenance of the gabion structures is required.
Organizational requirements: Responsibility structure	With the implementation of the desalination measure, the WDD[1] will sell water to community councils in bulk quantities at a price of 0.82Euro/m3. Community councils will remain the local water supply authorities as they will be responsible to select the source of water, i.e., groundwater or desalinated water, for domestic use.	Institutional/governance maintenance framework for the check dams is not clear. Local communities are responsible for the removal of sediment and the WDD[1] for maintenance of the gabion structure. However, the communities don't have sufficient financial resources, and when interventions in the riverbed are required they need to ask permission from the WDD.

Organizational requirements: Administrative resources	Civil servants and hourly employees will perform the administrative tasks of the project including the operation and maintenance (technical support, accounting and monitoring services).	Employees of local communities are responsible for the removal of sediment and of WDD[1] for the maintenance of the gabion. Better coordination is required between these actors.
Legal requirements	The design and implementation of the project will be in accordance with the Cyprus legislation and regulations concerning the procurement and contract procedures (in line with European Directives and Regulations). The objectives of the project are consistent with those set by the Republic of Cyprus for the Water Policy, described in the 1st River Basin Management Plan.	The objectives of the measure are aligned with the objectives of the groundwater conservation policies in the WFD[2]. The implementation of the project is in accordance with the Cyprus legislation and regulations concerning the procurement procedures.
Financial requirements	Investments include costs of infrastructure (storage reservoirs and pumping stations), and the purchase and installation of pipelines (incl. expropriations of land and supporting infrastructures). The measure will be co-financed by the European Investment Bank. The WDD[1] will sell the water to community councils at a price that covers financial and environmental cost. The sale to community councils is the sole revenue for the project; community councils will add a fee for the supply of water to households.	The implementation of the measure includes: the cost of removing the sediment (every two years), the maintenance cost of the gabion structure (every five years). Downstream communities in the Peristerona Watershed bear the cost of the maintenance of check dams along the Peristerona River.
Relational Requirements Culture and ethics	The implementation ensures a reliable potable water supply for the downstream communities, whilst also causing significant increase of water prices (from 0.30 €/m3 to over 1€/m3). The increase might trigger maintenance (as losses are expensive). Community councils remain the local water supply authorities and will be able to select the source of water (groundwater vs desalinated water) for domestic use. This may negatively affect the financial feasibility of the project as they may continue to abstract groundwater. However, communities are aware of the problems with the aquifer.	The measure reduces existing inequalities between the upstream and downstream communities of the Peristerona Watershed as it increases the groundwater recharge and subsequently the water availability for the downstream communities.
Relational Requirements Public accountability, communication and participation	During the planning phase of the project there was a continuous communication of WDD with all competent authorities affected by the project (i.e., governmental departments, water board of Nicosia, communities, municipalities) to ex-ante identify and solve possible difficulties in the proposed implementation plan. The estimation of the cost of expropriation of land was made after consultation with the Department of Lands and Survey and was calculated at 100% of the subscribed land value. The final water charges of each community are checked by the district administration and are approved by the WDD, while the accounts of community councils are checked annually by the Auditor General of the Republic of Cyprus.	A better coordination between the WDD and local community councils is required to attain a proper and regular maintenance of the check dams along the Peristerona River.

Table 10: Governance requirements for Irrigation Scheduling Technologies and Treated Sewage Water

Requirements	Irrigation Scheduling Technologies	Treated Sewage Water
Knowledge requirements	The development and the implementation of the measure require that farmers have the technical knowledge to use the information provided by the meteorological stations and the soil moisture sensors in the field; knowledge of equipment to consult these on a daily basis; knowledge of plant species.	Knowledge is required on existing and projected sewage water generation and irrigation water demand; on climate change impacts; on hydrological processes in the basin; on design and construction of the pipelines and pumping stations; on financial analysis and cost-benefit analysis (to ensure the viability of the measure); on Cyprus' regulation on treated sewage water use for irrigation; further research required long-term impacts on soil, groundwater and crops.
Organizational requirements: Responsibility structure	Farmers will install and operate the technologies with the active support of research institutions, agricultural extension and advisory services. Communication and collaboration channels have been established between these actors. Researchers installed and tested technologies on pilot farms. Extension services advise farmers on water use and management.	The SB[3] manages and operates the wastewater treatment plant, and develops and operates the pipeline supply network for irrigation. The SB[3] consists of two members from each of the three communities. Agricultural land will use the recycled water. The WDD[1] was responsible for the design of the wastewater treatment plant. Cooperation between the SB[3] and WDD[1] on the Sewage Water Treatment Plant is required, as well as cooperation between the SB[3] and the agricultural sector on the quantities and charges for the use.
Organizational requirements: Administrative resources	The farm manager will be responsible for the installation, operation and maintenance of the technology with the active involvement and support of one researcher.	SB[3] employees will perform the administrative tasks of the project including the operation and maintenance of the project (technical support, accounting services, monitoring services).
Legal requirements	The implementation of the WFD[2] has led to the increase of irrigation water prices, providing incentives for irrigation technologies and water-saving practices. The EU Regulation 1303/2013 supports investments in modern irrigation technologies for enhancing farm viability. No additional legal standards are required.	The design and implementation of the project will be in accordance with the Cyprus legislation and regulations concerning the procurement and contract procedures, which are fully in line with the European Directives and Regulations, and the water quality standards and given codes of practices.
Financial requirements	Implementation costs of the measure include the installation of three meteorological stations (15,000€) and soil moisture sensor units (3,000€ per field); and annual maintenance costs (500€). Farmers bear the cost of installing and maintaining the irrigation scheduling decision support systems.	The investment costs of the measure include the cost of the irrigation pumping station and the cost of the irrigation network. Communities bear the cost of the construction of the treated sewage water supply network for irrigation; farmers will pay an extra charge (i.e., 0.05 €/m3) on top of the irrigation water cost to pay off the construction and maintenance costs.
Relational Requirements Culture and ethics	Structural, institutional and political rigidities negatively affect the adoption of irrigation scheduling technologies. There is a lack of political will to implement prices covering full costs; the ageing farm population, low training, high installation costs (financial & labour), and small holding size (no economies of scale) do not favor adoption of the technological innovation.	Recycled water provides a reliable, low cost water supply for irrigation. It can alleviate the pressures on groundwater resources. However, only a small share of the Astromeritis agricultural land (6%) can be irrigated with treated sewage water. Thus, the measure benefits the farmers having access to recycled water. Moreover, the long-term impacts of emerging contaminants such as pharmaceuticals, present in the treated sewage water, on soils, groundwater, ecosystems and human health are not known.

Relational Requirements Public accountability, communication and participation	Awareness raising for the benefits of the irrigation scheduling technologies, including on-farm testing and demonstrations, can alleviate farmers' uncertainty regarding the adoption of the technology. It is also important to increase awareness on the available measures of the Rural Development Programme 2014-2020 that support (directly and indirectly) investments in irrigation scheduling infrastructure.	The Sewage Board, which is responsible for the management of the plant, consists of two members from each of the three communities (Astromeritis, Peristerona, Akaki) and is chaired by a District Administration officer. Raising awareness amongst farmers about the Cyprus legislation on the use of treated sewage water for irrigation (restrictions on crops and harvests) is required.

Content layer

The adaptation measures analyzed in the Cyprus case require a broad range of technical and administrative knowledge such as on hydrological processes, infrastructure design and construction, water supply and demand and impacts of climate change. In most cases, these knowledge requirements are being met.

For the use of *treated sewage water* for irrigation it is noted that the long term impact of this measure on the crops, the soil and the groundwater is still unknown. This is also related to uncertainties regarding emerging contaminants in waste water, such as pharmaceuticals and nano-particles. Further research on this issue is required.

For the implementation of *irrigation scheduling technologies* the knowledge requirements are only met to a limited extent. This measure requires farmers to have the technical knowledge to operate the systems and to interpret and apply the knowledge generated by the systems in their daily decision making. This knowledge is generally not present with famers and due to their relatively high age and the low level of farming training, this will be difficult to acquire.

Although the knowledge requirements are sufficient to implement most of the adaptation measures, it is still a challenge to incorporate the knowledge on long term climate change impacts in the daily water management practices, which are mostly based on empirical knowledge. Also, issues related to climate change (or the implementation of measures) such as health and water quality issues, are currently not sufficiently addressed.

Institutional layer

With regards to the organizational requirements, for most measures the necessary actors are involved and their roles have been identified. The notable exception being the measure on *groundwater recharge systems*. In this case there is an inadequate coordination of responsibilities and financial means between the actors involved. Especially relating to the removing of sediments from the check dams the responsibilities are diffuse. The WWD is responsible for the maintenance of the gabion structure, while the local communities are responsible for the removal of sediments. However, the local communities often lack financial means to perform the maintenance and when interventions in the riverbed are required they still need permission from the WWD.

With regard to the legal and financial requirements there are no notable issues with regard to implementation. All measures fall within existing Cyprus and EU legislation.

With regard to the financial requirements for the measures, there are some points of concern. First, for the measure *groundwater recharge systems* the local communities are responsible for the removal of sediments. It became apparent during one of the BINGO workshops that they lack the financial means to perform the required maintenance. A second point of concern is the demand for desalinated water. As the price of desalinated water is higher than that of groundwater, community councils may decide to use local groundwater instead of buying water from the desalination plant, in non-drought years. Since this is the sole source of revenue for the plant, this may seriously decrease its financial feasibility. Third, it was noted that farmers can't always bear the high costs of the *irrigation scheduling technologies*.

Relational layer

A number of cultural and ethical issues are raised with regard to the adaptation measures. For the use of *desalinized* water, the main concern relates to the price of the water. Desalinized water is more expensive than groundwater and community councils may decide to increase groundwater drilling instead of purchasing the desalinated water. This could decrease the financial viability of the measure and poses the ethical dilemma between short term cost reduction versus the long term sustainability of the aquifer.

The use of *treated sewage water* for irrigation raises two important ethical concerns. First, only 6% of the farm land can be irrigated this way, substantially benefitting the farmers that can use this cheap water source. Second, the long term effect of the use of treated sewage water are unknown, particularly with regard to the emerging of new contaminants, such as pharmaceuticals and nano-particles.

With regard to the *irrigation scheduling technologies* a number of cultural issues are mentioned that do not favor the implementation of this measure, namely structural, institutional and political rigidities. Also, there is a lack of political will to implement prices covering the full costs of groundwater irrigation and so decreasing the necessity to reduce water consumption. Finally, the ageing farm population, low training, high installation costs (financial & labor), and small holding size (no economies of scale) do not favor adoption of this technological innovation.

Public accountability, communication and participation poses different challenges for the different adaptation measures. In the case of *desalinization* the primary focus is on public accountability with regard to the expropriation of land (which was refunded at 100% of its value) and the potential increase in water prices, which will be audited and monitored at the regional and national level. Also, all relevant stakeholders participated in the planning phase of the measure, to ex ante address barriers to implementation.

In the case of *groundwater recharge systems*, it is again stressed that to ensure a proper maintenance of the check dams, the participation of the local communities needs to be ensured and the communication and coordination between the WDD and the local communities needs to be improved. For both the *irrigation scheduling technologies* and the use of *treated sewage water* awareness among the end users is a crucial issue.

5.6. Key governance challenges and recommendations for improvement

5.6.1. Key governance challenges

For *desalinization* the key governance challenge is financial viability. Local households will pay a higher price for the desalinated water but it is assumed that they will be willing to pay due to access to continuous and good quality water supply. Yet, as community councils will be responsible for selecting the source of water there are concerns regarding the prioritization of a cheaper source.

For *groundwater recharge* systems the key governance challenge is the coordination between actors. This measure is a cost-effective option for improving groundwater recharge and water quality. However, a better coordination between WDD and local community councils is required to attain the proper maintenance of the check dams.

Structural, institutional and political rigidities negatively affect the adoption of *irrigation scheduling technologies* in Cyprus. The lack of political will to charge irrigators with water prices that cover the full costs, i.e., financial, environmental and resource, does not provide an incentive to invest in water saving technologies.

The ageing farm population and the low farm training in Cyprus also do not favor the adoption of irrigation scheduling technologies because farmers may not understand the benefits of the technology or may have problems managing and operating them.

Finally, the high cost of installing irrigation scheduling technologies in terms of both financial investment and labour requirements negatively affect the uptake of the technology. The presence of small and split-up holdings in Cyprus and the small economic size of the holdings do not create the adequate economies of scale for the uptake of the technology. The low level of farm investment in Cyprus can explain to some degree the low potential for the adoption of this technology in the country.

For the use of *treated sewage water* for irrigation, the primary challenges lie in the potential inequalities it creates. These could arise between farmers with and without access to recycled water. Production costs will be higher for farmers not having access to recycled water than farmers with access to it.

5.6.2. *Recommendations for improvement of the policy and governance situation and overcoming implementation barriers*

In the first assessment of the policy and governance situation for Cyprus, two recommendations for improvement were made:

1. **Generate more knowledge about the specific and regional-level impacts of climate change on the local water cycle and the associated uncertainties**. There is a large uncertainty attached to climate change projections and their modelled impacts on the local water cycle. An integrated probabilistic hydro-economic analysis could improve the sustainable implementation of adaptation measures.
2. **Improve institutional arrangements supporting adaptation policy solutions.** Roles and responsibilities of different parties have to be clarified, to make sure that every party is aware of its responsibility for taking precautionary, emergency and coping measures, and can be held into account for acting on this responsibility.

The following paragraphs will elaborate on these recommendations, linking them to the implementation of the proposed adaptation measures.

The key governance challenges have been addressed with local stakeholders as part of the actionable research work in WP6. With regard to the issues with *desalinization* it was argued that citizens should be more aware of the impacts of climate change on water resources to better appreciate the importance of securing the domestic water supply. The WDD could play a role in raising awareness by organizing workshops with local communities about the risks and challenges of climate change. The WDD should also provide technical support to the local communities to ensure the proper management and operation of the measure.

With regard to the potential increase in groundwater use, this could be discouraged (fees or restrictions on the drilling of new boreholes, etc.) . It is advisable to make a detailed plan on how to communicate the increase in water prices with the community and community councils to get their consent and support.

An alternative solution could be the establishment and operation of a district-level water supply authority by the Water Board of Nicosia to overcome the barriers and allow an integrated management of water supply. In this case, local community councils would be unable to increase the use of groundwater at the expense of desalinated water. This district-level water authority could also play a role in improving the coordination of local communities and the WDD in the proper maintenance of the check dams as part of the *groundwater recharge systems.*

Creating awareness can also be the way forward for the application of *irrigation scheduling technologies*. Education activities can be directed at becoming familiar with the technology used and the application of the systems information in day to day decision making. Awareness can also be increased by addressing the long term effects of climate change and the long term effects of inefficient groundwater use in irrigation. A way to establish connections with farmers could be through the CoP's or through expanding the pilot studies that have been performed. Due to the decentralized nature of water management in Cyprus, a local approach might be best fitting to establish a relationship with and commitment of the farmers. Existing community groups could potentially help in doing so.

The financial issues regarding the implementation of *irrigation scheduling technologies* can be addressed in different ways. The price of irrigation water could be increased to reflect the environmental costs of using groundwater. This would not increase the financial means to apply new technologies, but would improve the business case for these technologies, as water savings would save more costs.

To increase the financial means, two solutions were suggested: (1) the increase of subsidy rates from the Rural Development Programme of Cyprus to provide financial incentives for the uptake of new technologies or (2) setting up a collective financing system for sharing the high costs, such as a fund. Such a collective financing system could also play a role in reducing the inequalities that come from the unequal access to *treated sewage water* as a source for irrigation. Table 11 shows a summary of the recommendations for Cyprus.

Summary of recommendations
1. **Generate more knowledge about the specific, regional-level impacts of climate change on the local water cycle**.
2. **Improve institutional arrangements supporting adaptation policy solutions.** Roles and responsibilities of different parties have to be clarified, to make sure that every party is aware of its responsibility for taking precautionary, emergency and coping measures, and can be held into account for acting on this responsibility.
3. **Maintain regular interaction** between local community leaders, farmers, government officers and researchers (CoP) to increase our understanding of water-climate risks and **the implementation of adaptation options** in the region.
4. **Strengthen cooperation** between researchers and the water authority to develop **information material on climate change impacts on water resources**.
5. **Raise awareness about climate change impacts on water resources** by organizing information events with local communities, educational activities in schools, and the broadcasting of cartoons on local TV.
6. **Establish a district-level water supply board** to ensure the efficient, integrated management of water supply, and minimize the losses of desalinated water, which comes at high environmental cost.

7.	Investigate the **effects of climate and land use change on water quality** to maintain the **sustainable supply of groundwater resources** for rural communities.
8.	Continue **participatory research** on the development of affordable, farmer-friendly irrigation scheduling technologies.
9.	**Build the capacity of farmers to use irrigation scheduling technologies** by expanding pilot projects and CoP activities.
10.	**Provide financial incentives for the uptake of irrigation scheduling technologies** by increasing the subsidy rates from the Rural Development Programme of Cyprus.

Table 11: Summary of recommendations for Cyprus

6. Bergen, Norway

6.1. Outline of the case study

The city of Bergen is Norway's second largest city and one of Europe's most rainy. It is located in between several mountains at the west cost of the country and is characterized by steep slopes and surrounding city fjords. Due to the pronounced topography stormwater generally finds its way to receiving water bodies instead of causing flooding. The main concern in Bergen is that the collection system for safely transporting the stormwater out of urban areas is dominated by combined sewers in parts of the city. During heavy rainfall events the amount of stormwater entering the system exceeds the combined sewers' capacity and an untreated mixture of stormwater and sewage is discharged to receiving water bodies through combined sewer overflows (CSOs). This causes pollution of the city fjord, which in turn pose a risk to the marine environment and the health and safety of people engaged in nearby activities.

Within the BINGO project, a specific part of the city of Bergen has been chosen as case study. The Damsgaard area is located close to the city center, has a combined sewer system with several CSOs discharging the to the subjacent fjord, Puddefjorden. The district is currently undergoing a huge transition from heavy industrialized areas to new and modern residential and leisure areas along the Puddefjord, as part a municipal commitment and effort to improve living conditions for inhabitants at Damsgaard.

As part of this investment, an upgrade of the stormwater system is scheduled. The traditional approach is to separate the combined sewers such that stormwater and sewage don't enter the same pipes. This is a highly effective measure but is related to high costs both in monetary terms and social disadvantages during implementation. The municipality is there for looking into other measures that solves the same challenges. To form a decision basis for the municipality, a selection of relevant measures has been compared. The measures are compared in terms of the current governance situation and future requirements, effectiveness of CSO-reduction and socio-economic implications.

6.2. Summary of first assessment of policy and governance situation at the research site

This paragraph provides a summary of the first assessment of the policy and governance situation at the Bergen research site, focusing on the strenghts, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

Key strengths of the Bergen policy and governance context lie first of all in the content layer of water governance. Information on water-related risks is well-organized and much effort has been put in disseminating this information to local governance levels where the main responsibilities for water management are allocated. Second, in the institutional layer, responsibilities for water management are well-arranged, with general guidelines specified at the national level to ensure a basic quality, which can be tailored to local-level characteristics and needs by county and municipal governments. Third, in the relational layer of water governance, strong links have been created between water management and spatial planning.

Weaknesses

Key weaknesses of the Bergen policy and governance context are threefold. First, the information on weather-related risks is based on historical data recordings. Less is known about the future conditions, and the threats these conditions pose on (the different regions in) Norway. Second, information that is available is not translated in the existing policy framework on water management. While information on climate-related impacts is increasingly collected and analyzed, this information is not linked to binding actions in official policy documents and laws on water management in Norway. Up to now, climate change adaptation is merely incorporated in strategic plans at all levels (white papers, master plans), but actual responsibilities for adapting to the impacts have not been assigned. Consequently, third, the actual implementation of adaptation solutions is difficult to realize. There is huge regional variation in adaptation governance throughout Norway and because of a lack of enforced implementation, the necessary links between water management and other sectors that are affected by climate change are not made. Because of this, opportunities to develop and implement effective integral solutions for climate change adaptation are currently missed.

Governance needs (what can be improved)

In summary, there are three main governance needs (which are linked) to improve the organization of climate change adaptation in Bergen's policy and governance context. First, there is a need for better risk and vulnerability assessments that provide insight into the future risks climate change poses to the water system in Bergen. Second, adaptation policies need to be included in the policy framework on water management, especially for stormwater. While responsibilities for water management are decentralized in Norway, respondents identify a need to take on some responsibility for adaptation at the national level. At the national level, the NVE could include adaptation governance in its guidelines for water management. The NVE has recently received funding from the government to build competence on stormwater and they have put together a stormwater group that will work on this. Also, information about the impacts of climate change could be provided on a less voluntary basis, for example by requiring communities to take appropriate adaptation measures based on the information they receive. To support such actions, Norway could greatly profit from its decentralized responsibility structure in water governance, where management guidelines are formulated at the national level to ensure equal starting conditions, but which can be adapted to local conditions to support the development of effective regional solutions.

At the level of Bergen city, respondents recommend to develop a strategic stormwater plan and include it in the municipal master plan. Besides, when responsibilities for climate change adaptation have been better addressed in the policy framework for water governance, connections between different policy fields may also be strengthened. Such increased bonds will increase knowledge and cooperation, through which effective adaptation solutions can be developed and implemented.

6.3. Proposed Adaptation Measures

Through stakeholder involvement and workshops, four adaptation measures have been selected for in-depth analyses. One measure, public involvement, is an indirect measure aimed at information-gathering necessary for planning of the three remaining technical measures; sewer separation, safe flood ways, and sustainable urban drainage systems.

Public involvement

To adapt the urban drainage system to a changed climate, the municipality in Bergen is collecting information on their existing system. The information they are collecting can help identifying bottle-necks and problematic parts of the system. The public involvement measure is a digital platform where the public can share information on the existing system and water courses using pictures and geotagging. By involving the public, the measure serves two purposes: gather the necessary information for technical planning and to raise public awareness. Also, the measure is easy to implement and not too costly.

Sewer separation

Sewer separation involves unlocking rainwater from the sewage system. It requires the construction of separate collection systems for municipal wastewater and surface run-off. The separate collection prevents the overflow of sewer systems and treatment stations during rainy periods and avoids the mixing of relatively little polluted surface run-off with chemical and microbial pollutants from the municipal wastewater. As such it deals more effectively with periodic and potentially large volumes of urban runoff which occur under storm conditions than traditional systems. Irrelevant for Bergen, but crucial in other areas, a separate system unlocks the surface run-off from the sewage system allowing it to easily return to groundwater aquifers, thus increasing the supply of groundwater. Sewer separation is highly effective and widely used.

Safe flood ways

To deal with capacity restraints of combined urban drainage systems, urban streets can be used to route storm water away from the combined sewer system during extreme events. The idea is to bring storm water from rural areas directly to the fjord, avoiding it to mix with sewage and storm water generated in urbanized areas. This will relieve the burden on the combined system, resulting in reduced occurrence of CSO activation and sewer surcharge. Moreover, considering the large uncertainty in design values (future climate), routing the water above ground adds more flexibility than traditional, buried solutions. Also, basing the measure on existing infrastructure adds multi-functionality and reduces material use and need for new constructions.

Sustainable Urban Drainage Systems

SUDS (Sustainable Urban Drainage Systems) are drainage systems that mimic natural drainage by managing potential flooding and protect watercourses and rivers by using natural treatment processes. There are four main benefits that can be achieved by SUDS: water quantity, water quality, amenity and biodiversity. SUDS can take many forms, both above and below ground. Yet, SUDS provide also a nature-based solution to approach other necessities of the city such as: the increase of green areas and biodiversity (with the corresponding ecosystems services implying economic and community benefits); the improvement of urban air quality, the reduction of noise or the regulation of building temperatures; the mitigation and adaptation to climate change; the recreational an educational value of the SUDS, the increase of energy efficiency in buildings developing SUDS such as green roofs; the increase of groundwater reservoir (due to rainwater infiltration), etc.

6.4. Foreseen consequences of the proposed adaptation measures

The three technical measures sewer separation, safe flood ways and SuDS have been analyzed and compared in terms of effectiveness in reducing CSOs, costs and socio-economic impacts. As a first step, the potential effectiveness of adaptation measures was estimated by a sensitivity analysis of the subcatchments of the system. The sensitivity analysis was performed by disconnecting the subcatchments of the system one-by-one and running the urban drainage model for an extreme event such that the potential CSO reduction of subcatchment disconnection was quantified. These results were further used to identify possible locations for measure implementation and formed the basis for a qualitative assessment of the measures' cost/effectiveness ratio. Quantitative assessments of the cost/effectiveness ratio is still work in progress. The following sections is a summary of the results and the reader is referred to BINGO D5.3 for detailed descriptions.

6.4.1. Effectiveness as regards risk reduction

For sewer separation, subcatchments were identified by ranking subcatchments by their size and then disconnecting the largest contributor one-by-one until desired effect was obtained. The safe flood ways measure is based on avoiding stormwater generated in upstream mountainous areas to enter the urban drainage system downstream, and the effectiveness of the measure thus equals the effectiveness of disconnecting these upstream subcatchments of the drainage basin. For SUDS implementation in a built-up area, a few more considerations than solely the potential effectiveness of disconnecting a subcatchment were considered. A decision support table where each subcatchment was scored for several indicators of successful SUDS implementation was developed. The indicators for successful implementation of SUDS included in the decision support table were: 1) potential CSO reduction of subcatchment disconnection (stormwater volume, m3), 2) Municipal owned property in subcatchment (% of total subcatchment area) and 2) Non-built up area (i.e. green spaces) in subcatchment (% of total subcatchment area). The scores of each indicator were weighted and combined to an overall score. This resulted in a selection of subcatchments eligible for SUDS implementation.

In Norway, stormwater is usually managed by a three-step approach:

a. Management of small rains (everyday rain) should be based on natural infiltration and retention
b. larger events (e.g. design rain, varies from municipality to municipality and local conditions such as concentration time) should be delayed through detention to more evenly distribute the load on the existing drainage network
c. for extreme events, where retention and detention is not possible, the stormwater should be safely transported to receiving water bodies to avoid flooding

The selected measures are all aimed at CSO reduction, but have varying functionality for the different levels of the three-step approach. This is accounted for in a qualitative assessment of the measure effectiveness, where each measure is given a rank relative to the other measures (Table 12) and a total score based on all event levels is calculated.

	Step 1 Everyday rain	Step 2 Design rain	Step 3 Extreme rain	Average in Total
M1 + M2 combo	3	3	3	3.0
M1 SuDS	3	3	1	2.3
M2 Safe flood ways	1	1	3	1.7
M3 Sewer separation	3	3	2	2.7

Table 12: Relative effectiveness score: 1=Low, 2=Medium, and 3=High

Subsequently, the effectiveness score was combined with a qualitative cost score, also based on relative costs when measures are being compared to each other Table 12. Sewer separation is by far considered the most expensive solution, and SUDS the cheapest. Using roads as safe flood ways is not considered very costly due to the use of existing infrastructure, but the impacts of this measure in terms of deterioration of road and maintenance costs are still very uncertain and subject to further research. There for, this measure obtains a medium cost score. The effectiveness and cost analysis were combined by calculating the ratio CER = costs/effectiveness Table 14. By definition, a low CER value indicate a best 'value-for-money'-solution. As seen in Table 14, the best CER value is obtained for the SUDS measure. However, this measure only solves parts of the problem, and is assessed to be ineffective for extreme rainfalls. There for, the CER value for the combination of SUDS and safe flood ways is also calculated. By combining these to, a higher effectiveness is achieved. The combo-solution and sewer separation are both effective at all levels of the three-step approach, but by the CER-calculations, the combo-solution is superior.

	Capital expenditures	Operational expenditures	Average in total
M1 + M2 combo	2	2	2.0
M1 SuDS	1	1	1.0
M2 Safe flood ways	1	1	1.0
M3 Sewer separation	3	2	2.5

Table 13: Relative cost score: 1=Low, 2=Medium, and 3=High

	CER
M1 + M2 combo	0.7
M1 SuDS	0.4
M2 Safe flood ways	0.6
M3 Sewer separation	0.9

Table 14: CER=Cost/Efficiency ratio

In addition to the qualitative cost assessment, cost data for the SUDS measure have been prepared for future quantitative assessments as these data was not directly available for Bergen. For several types of SUDS-measures data was available as annualized investment expenditures as well as annual operational expenditures from a German project on SUDS from 2017 (Strehl et al. 2017). To convert these cost figures to appropriate figures for Norway in 2019, three adjustments have been conducted based on the original data:

- To mind inflation from 2017 to 2019 for construction work costs the German price indices for construction works have been applied (Statistisches-Bundesamt 2019) to the cost data from KURAS.
- Additionally, the figures haven converted to Norwegian price levels using Eurostat data on comparative price levels among European countries, based on the purchasing power parities concept (eurostat 2019).
- Exchange rates between the Norwegian currency NOK and the European currency EUR have also been applied in a third step. Therefore the average exchange rate from 2019 (avg. for 1.1.19-24-6-19: 9.73 NOK/EUR) according to exhange-rates.org have been used (exchange-rates.org 2019).

6.4.2. *Socio-economic impacts*

In order to account for all positive and negative effects not captured by the CER approach, an analysis of social justice have been performed for each measure. The following sections summarize the results.

Social justice analysis – Safe flood ways:

Apart from the main aim, to route the water in a controlled manner during very extreme events, rather than letting the water flow freely and uncontrolled, the side effects of roads as emergency flood ways during extreme precipitation events is supposed to benefit the society as a whole and strengthen the social equalities. The measure benefits the whole system and thus the society. A large portion of the costs should be paid by the Agency for Water and Sewerage Works (AWSW), because they have a leading role in the planning and implementation. These costs are indirectly shared with the public, due to the fact that the AWSW are fully financed by public fees. In addition, road owners and the municipality, depending on who is considered as the owner of the measure, have to pay for the implementation and the upkeep of the measure. The Norwegian Road Authority should be provided with the investigations and evaluations necessary to develop guidelines, regulations and a design for the roads, which leads to costs for this authority too. Another monetary burden for the inhabitants or municipality could be the costs after an extreme precipitation event such as damages to cars (drivers), pedestrians and cyclists or damaging effects such as clogged drains/intakes, erosion, fractures in the road and reduced life expectancy of the road cover. In this case the municipality would be responsible for regulating the floods paths safely. However, overall the costs of the municipality will be reduced as the measure involves adding functionality to existing infrastructure (road). The inhabitants could be confronted with a temporal parking restrictions or an early warning system to mitigate the damage before a flooding of the streets occurs. The benefit for the public and the municipality is a low level of physical intervention (public works), compared to traditional measures and it will help maintaining the reputation and image of the municipality.

Social justice analysis - Separation of sewer system:

Apart from main aim, mitigating CSO spills to receiving water bodies, the aim of a separated sewer network is to provide the same service (safe transportation of sewage and storm water) to all inhabitants and therefore strengthens the social equalities. Private owners may be requested to separate their private sewers due to the municipal system being separated. The sewer system is owned by the municipality and governed on behalf of the municipality by the municipal Agency for Water and Sewerage Works (AWSW). AWSW is responsible for planning and initiating of the measure but the maintenance is performed by the municipal owned company Bergen Vann (Bergen Water) upon request from AWSW. Thus, AWSW is also responsible for all the costs related to the measure. The implementation and also the costs of a separated sewer system on private properties is paid by the property owner. The general public is effected through construction work related to new sewers and trenches which causes noise and lowers mobility for pedestrians, bikers and drivers. This burden can be mitigated by the contractor responsible for the construction work. The choice of equipment will impact the noise level and a proper logistical plans can countervail the lowered mobility. The benefits for the public and also for AWSW are a reduced risk of flooded basements during extreme precipitation, a decrease of the load on treatment facilities, on pumping stations, and thus reduced operation and maintenance costs and an upgrade of the capacity of the storm sewer such that climate change and increased area of impermeable pavements may be accounted for.

Social justice analysis - Sustainable urban drainage systems (SUDS):

Apart from main aim, to improve the stormwater management, the side effects of the Sustainable urban drainage systems (SUDS) enhancing the social justice for the public, if designed as multi-functional solutions and/or located in places where the public can enjoy them. Depending on where the measures are built either the municipality or the private owners of the measure have to pay for implementation and maintenance. In addition, it is possible that private developers could be imposed by the municipality to manage stormwater at-site through SUDS. In this case the private developers would pay for the implementation and the future owners of the measure would pay for the maintenance. Because the Agency for Water and Sewerage Works (AWSW) is fully financed by water and sewerage fees, a possible extension of the sewer network could lead to higher prices for the inhabitants. Beside these monetary burdens the measure could also start some positive side effects, for actors and suppliers of the SUDS industry. As positive side effects for the general public it is reported that blue-green SUDS may incur effect such as pollution control, noise reduction, CO2- capturing, better air quality and biodiversity. In addition, it is expected the green environment resulting of some SUDS (e.g. open rivers and creeks, dams, and open, vegetated dry basins) invite to recreational activities that are positive for mental and physical health. Traces of natural elements (such as running water or water mirrors) can have positive effects on children's learning and development. These positive side effects also outweigh the non-monetary negative effect, The SUDS measure requires surface area, so the measure owner has to give less priority to other wishes and proposals within this context.

6.5. Governance requirements of the proposed adaptation measures

Table 15 and Table 16 show the governance requirements for the proposed adaptation measures, following the expert analysis of the three-layer-framework. The colors indicate whether a certain condition is met (green), partially met (light red) and not yet met (dark red).

Table 15: Governance requirements for Sewer Separation and SUDS

Requirements	Sewer Separation	SUDS
Content layer - Knowledge requirements	This measure requires mostly technical, infrastructural and hydrological knowledge. The municipality has separated most of the sewers already. The knowledge gained here can be applied in Damsgård.	Recent research and pilot projects have provided insights to the performance of SUDS in cold and varying climates conditions. It also demonstrated current sub-optimal placement of SUDS, and wrongful implementation. This is all still under study.
Institutional layer - Organizational requirements: Responsibility structure	In Bergen combined sewer systems are governed and operated by the local water agency: the Water Utility. Private owners are responsible to finance separation of private pipes when the municipality is separating the municipal system. Sewer separation has previously been successfully implemented and there exists a good basis for collaboration between relevant actors.	As no financial incentives for private property owners are in place, conditions are most suited to implement SUDS at municipal owned properties. Yet, SUDS are highly encouraged in property development projects. Also, SUDS are area-demanding and associated with a high need for stakeholder involvement. Through the BINGO CoP a high-level involvement of stakeholders has been achieved.
Institutional layer - Organizational requirements: Administrative resources	The Agency of Water and Sewerage works is a large organization with the necessary administrative resources to implement this measure. A separate organization, Bergen Vann (demerged from the Agency in 2004) is responsible for operating and maintaining all Water and Waste-water infrastructure.	Many of the administrative resources are already available or currently being addressed by the BINGO project, such as design guidelines /codes/standards, long-term planning, public/private responsibilities and collaborative leadership.
Institutional layer - Legal requirements	Legal measures may be needed to require property owners to reconnect their individual waste water infrastructure to the separated sewer system. In general requirements are being met.	Legal requirements are being met in Bergen.
Institutional layer - Financial requirements	The necessary financial resources are available. The Agency of Water and Sewerage Works is fully funded by water and wastewater fees. On a political level, adding a storm water fee is being discussed.	Financial requirements are in place, however there is a lack of financial incentive for private property owners to implement SUDS.

Relational Layer	In Bergen, the public is kept informed on sewer separation plans though various platforms. Strategical plans concerning sewage and sanitation are available online. The municipality is continuously working on maintaining good communication and is currently working on increasing public involvement.	Other studies in Norway have showed that the public are well aware of the benefits of SUDS and that willingness to implement and pay for SUDS at private properties is high in certain city-areas. However, in the more dense urban areas where surface area is a scarce resource, it is more difficult to argue the use of SUDS and dispensations from current regulations are more common.

Table 16: Governance requirements for Public Involvement and Safe Flood Ways

Requirements	Public involvement	Safe flood ways
Content layer- Knowledge requirements	This measure requires the development of a digital platform, (which has been set up: www.vannveier.no). Experiences with the existing website, and a workshop (BINGO M28, November 2017) provided improvements for implementation and resulted in a detailed implementation plan.	This measure requires knowledge of the contributing area (origin/redirection of water); optimal hydraulic criteria (technical); and the allocation of responsibilities after adding a functionality to roads (administrative) need to be determined. Also, knowledge on public responses and perceived risks (by e.g. pedestrians) is needed. There is an ongoing feasibility study.
Institutional layer - Organizational requirements: Responsibility structure	The responsible actor for development and implementation of the measure is the Water Utility in Bergen. However, technical expertise and development of the digital platform needs to be outsourced. Communication of the platform should be the responsibility of the water utility, by qualified staff.	The Water Utility and the road authorities (municipal, national) have functional requirements to the infrastructure (road) and should be involved in the development/implementation. Considering the behavioral knowledge required, actors representing pedestrian safety should be involved as well.
Institutional layer - Organizational requirements: Administrative resources	In Bergen, the staff is responsible for communication of the digital platform and for processing received information. On an administrative level a database is created for storing and accessing received information. The implementation is on a city level and is expected to take 6-12 months. Hereafter the campaign will run as long as deemed necessary.	Staff (design and physical implementation) and financial resources are available. Standards that fulfill both the water utility and road authorities' technical requirements for emergency flood way roads need to be developed. Once implemented, a monitoring system, preferably also a warning system for traffic and pedestrian safety, should be developed.
Institutional layer - Legal requirements	Not applicable	The EU standard for bathing is the main motivation for implementation, striving for reduction/elimination of CSO discharge into the Puddefjorden.
Institutional layer - Financial requirements	Main costs made are the development of a digital platform, salaries to staff and campaign resources. The municipal water utility (Agency for Water and Sewerage Works) is the responsible actor and delivers the financial resources.	The water utility bears the financial responsibility for implementation. Yet, financial responsibility of maintenance should be coordinated with the roads authorities (routing water on roads may cause higher maintenance costs).
Relational layer	There are no known cultural or ethical issues obstructing implementation. It is aspired that implementation contributes to minimizing gaps between the public and municipality and engages the public in water governance in the city. The main reason for implementation (reducing future risks caused by climate change) should be communicated with caution. It is necessary to balance communicating risks and the social benefits of reducing these.	Implementation assigns infrastructure a functionality outside the owner's responsibility, and it could be challenging to find willingness for this multi-functionality. Besides, it involves routing water above the surface and water levels and velocity might pose a risk to the public (pedestrians, etc.) in extreme events. Risk levels might vary with social aspects (disabilities, age, etc.) and should minimized such that the measure –meant to protect the environment- does not cause increased public safety risks.

Content layer

As was also found in the general study on the implementation capacity at these sites (D 5.4), in Bergen there is a wide range of well-arranged knowledge available. This is also reflected in the evaluation of the different measures. Only for the implementation of *safe flood ways* the required knowledge is not (yet) available. The *sewage separation* measure on the other hand, can build on previous experiences in these fields, as this measure has already been implemented at other sites in Bergen. The implementation of *SUDS* is still under study, as the implementation in Bergen requires tailoring to the Norwegian climate. With regard to *public involvement*, there is technical knowledge available with regard to designing and running a platform, but the behavioral knowledge on how to succeed with public evolvement is still developing. This has been specifically addressed in the actionable research in WP6 (D6.6, D6.7).

Institutional layer

As was also found in D5.4, the implementation of new measures, such as *safety flood ways* seems to be most challenging, since the administrative resources and responsibility structure necessary for implementation are still lacking. The division of responsibilities between the road authority and the water utility appears to be the main challenge. Also for the implementation of *SUDS* the coordination with private parties appears to be challenging. Whilst, institutional requirements have been met, having individual property owners take responsibility for the implementation of *SUDS* on their own site, is still difficult. For the implementation of *public involvement* and *sewage separation*, a responsibility structure and administrative resources are yet in place. For the implementation of *sewage separation* this is mainly because the measure has yet been implemented in parts of the city and experiences have been built.

For all measures discussed legal requirements are met, as most measures require no, or very little, legal steps to be taken. Finally, considering the financial requirements these seem to be covered for *sewage separation* and *public involvement,* whilst being more challenging for *SUDS* and *safety flood ways.* The financial requirements for the latter differ substantial as the issues for the implementation of SUDS mainly derive from the private property owners being unwilling to invest in their own systems, while the issues relating to the *safe flood ways*, are mainly rooted in the additional costs expected for the road authorities. For the latter, it is the coordination of cost sharing which is the main challenge.

Relational layer

For the measures *sewage separation* and *public involvement*, all relational requirements are found to be in place. Yet, for *SUDS*, which are area demanding, there is less support in the urban areas. Moreover, as was pointed out before, convincing private property owners of implementing *SUDS* and investing in this measure seems challenging. Also the relational requirements of *safe flood ways* are not being met. Especially handling the risks accompanying the implementation of this measure is found to be something in need of more attention. Besides, the coordination of responsibilities with the road authorities is still found to be lacking (as was also the case with the allocation of costs). Relating this back to previous findings, it can be concluded that although responsibilities are well-arranged between different actors, adding new responsibilities to the spectrum (multi-functionality of roads in *safe flood ways*), creates a gray area.

6.6. Key governance challenges and recommendations for improvement

6.6.1. Key governance challenges

The key challenge in separating the sewer system is the scale of the actual implementation. Separating a sewer system in a large area requires great efforts in planning and sufficient funding. As the measure includes construction of a new system within established urban areas, implementation is not completed over night and negative impacts for the public during the implementation period are expected.

With regard to *SUDS* three key challenges are identified: (1) Land use: SUDS require surface area that is often privately owned. Since storm water management traditionally has been located underground in buried systems, the emerging demand for surface area creates conflict with other sectors and complicates land-use regulation. (2) Lack of financial incentives: financial incentives for prioritizing SUDS are lacking, resulting in a large gap between wanted and actual practice. (3) Lack of guidelines: more information (guidelines for proper implementation, construction and maintenance) is needed.

Public involvement requires appealing communication. It is a challenge to find a digital solution and lay out that appeals to a wide range of groups in society. A first test of the platform among Bergen students has revealed that the current platform was not appealing and cumbersome to use. Secondly, successful implementation of the measure requires continuous efforts and campaigns to motivate the public to use the platform, this requires detailed planning.

The implementation of *safe flood ways* faces three key challenges: (1) There is a large knowledge gap to fill before any technical solution can be implemented. This concerns technical knowledge about the hydrological aspects of flood ways as well as administrative knowledge about how to divide roles and responsibilities among the different actors. (2) To this aim, multidisciplinary collaborations need to be established between the water authority and the road authority, which are currently not collaborating much. (3) Since water will be flowing through the streets, the public needs to become aware of and adapt to the new situation in the urban environment, to minimize any risk arising from implementing the measure.

6.6.2. *Recommendations for improvement of the policy and governance situation and overcoming implementation barriers*

In the first assessment of the policy and governance situation for Bergen, three recommendations for improvement were made:

1. **Obtain a better risk and vulnerability assessments** that provide insight into the future risks climate change poses to the water system in Bergen.
2. **Include adaptation policies in the policy framework** on water management, especially for stormwater, both at the municipal and at the national level.
3. **Develop a strategic stormwater plan** and include it in the municipal master plan.
4. **Strengthen connections between different policy fields** to increase knowledge and cooperation, through which effective adaptation solutions can be developed and implemented.

The BINGO project has already contributed to the first recommendation (WP4) and the second to fourth recommendation (WP5 & 6). The following paragraphs will elaborate on these recommendations, linking them to the implementation of the proposed adaptation measures.

Although it is an large scale operation, the separation of sewer systems in the Damsgaard area does not require changes in policy and governance. The legal and financial requirements can be dealt with within the current framework, although public involvement and support should be minded. The increase in water fees, the investments that property owners have to make to connect their own system to the central system and the disruptions that large scale infrastructural operations cause, are not likely to fall well with the general public. Good planning is important, and collaboration with other infrastructure owners can be sought, to avoid keeping streets opened up longer than necessary. Awareness can be raised by linking the measure to concrete issues of climate change and communicate clearly about the planning of the work.

The challenges regarding *SUDS* are more substantive. *SUDS* require changes in the urban environment that often fall beyond the scope of the municipal government, since much of the land of roofs are privately owned. The low hanging fruit in this case are the properties that are being owned by the municipality. When starting developing SUDS here, they can provide good showcases for the private property owners.

To convince private owners to participate in developing SUDS, awareness can be created about the positive side effects of SUDS. In the Amsterdam (the Netherlands) this is being done in the Amsterdam Rainproof project, where citizens are encouraged to design green gardens (instead of paved gardens), green roofs, and green pavements. An online platform keeps track of all initiatives and provides ideas, tips and guidelines to the citizens. A similar initiative is Operation Stonebreak (the Netherlands) in which the positive effects of SUDS are emphasized (such as Urban Cooling, Bio-diversity, Improved Air Quality, and Health) and where citizens are advised on how they can contribute to developing SUDS.

Public involvement has been a central issue in the actionable research of WP6 (D6.6, D6.7). The digital platform that initially was developed proved cumbersome to use and not very appealing to a young test audience. Therefore it was recommended to change the functional requirements and the objectives of the digital platform. There are good examples available of digital applications that allow citizens to monitor and report on the current (visible) state of the urban infrastructure. SeeClickFix, for example, allows individuals to send in photos of problems in the urban environment with a geotag and a classification of the issue, to which municipal services can than respond. Such a design could benefit this measure as well.

The issue of public involvement is not limited to water governance. Collaboration can be sought with other municipal services to develop a digital platform that is suitable for a range of issues in the urban environment. This enhances coordination between different parts of the municipality and increases the appeal and reach of the digital application. The *public involvement* measure could greatly improve the implementation of SUDS, as a digital platform can also be used to share ideas and practices.

As was noted, developing a digital platform requires a long term commitment of all stakeholders to operate the digital platform and process and store the data that is shared. But when the public is actually involved by using the platform, it is important to also be clear about what is and can be expected from both the public and the municipal government. It should be clear in what way the government will respond to the uploaded information. For instance, if people send in pictures of broken infrastructure, will the municipality act on this information or not and in what time frame?

The implementation of *safe flood ways* faces three key challenges: a lack of knowledge, a lack of multidisciplinary collaboration and a lack of public awareness. The lack of knowledge is being mended by a continuing feasibility study. The design of *safe flood ways* does not fit within the existing institutional context in Bergen, which is characterized by institutional fragmentation. Integration of storm water plans in the municipal master plan can be useful to link the storm water objectives to other municipal objectives. From there, multidisciplinary collaborations can be set up to support the design of safe flood ways.

The design of safe flood ways can be combined with design for exceedance, in which storm water temporarily stored in the urban infrastructure. It is recommended to make the most of multi-functional infrastructure and shared space, such as playing fields and large roads to store water. To create awareness among the public, demonstration and pilot projects can be conducted to show how safe flood ways work in practice and to provide confidence and inspire practitioners. Table 17 shows a summary of recommendations for the Bergen case.

Summary of recommendations
1. **Obtain better risk and vulnerability assessments** that provide insight into the future risks climate change poses to the water system in Bergen.
2. **Include adaptation policies in the policy framework** on water management, especially for storm water, both at the municipal and at the national level.
3. **Develop a strategic storm water plan** and include it in the municipal master plan.
4. **Strengthen connections between different policy fields** to increase knowledge and cooperation, through which effective adaptation solutions can be developed and implemented.
5. **Communicate the risks of climate change and the benefits of adaptation** to get broader public support for investments in adaptation measures.
6. **Increase awareness with property owners** of the broad range of benefits of SUDS to increase their collaboration efforts.
7. **Seek collaboration with other municipal services** to co-develop an appealing and easy-to-use digital platform for public involvement.
8. **Develop a vision and strategy on data management** related to the digital platform for public involvement.
9. **Combine the safe flood ways with design for exceedance** to make the most of multi-functional infrastructure and shared spaces.
10. **Develop demonstration and pilot projects** to show how safe flood ways work and to provide confidence and inspire practitioners.

Table 17: Summary of recommendations for Bergen

7. Badalona, Spain

7.1. Outline of the case study

Badalona city is located along Spain's northeastern coast. It belongs to the province of Barcelona, which lies in the region of Catalonia. Over the years, as the city of Barcelona extended its space claim, this megacity has grown onto Badalona and now it is part of the Barcelona Metropolitan Area. Badalona lies directly adjacent to the Mediterranean Sea, it is bordered by the Besos River in the west and surrounded by the steep Serra de la Marina Mountains in the northeast. The city covers over 21 square kilometers with an altitude difference of almost 500 meters running from the mainland down to the sea. It is the 3rd most densely populated city in Catalonia with 220.000 inhabitants. Its almost 5km of Mediterranean beaches offer a popular tourist destination. Together with income from commerce and shipping at the harbor, tourism is an important economic driver of the city.

Characterized by steep differences in altitude (high slopes in the upper parts and flat areas in the lower parts), Badalona is vulnerable to problems with drainage. Urban flash floods and combined sewer overflows (CSO's) already resulted in more than 125 million euros of claimed insurance damage in 1999 and present a major threat to water quality and tourism. Being a sea-front city makes Badalona also susceptible to coastal flooding. In 2000, 80 million euros was claimed after a coastal flood. At the same time, the city faces risks related to periods of drought. Its water resources are limited and drought not only challenges the supply of water (scarcity) but also the quality of the water sources. Climate change may increase all these risks in Badalona city.

7.2. Summary of first assessment of policy and governance situation at the research site

This paragraph provides a summary of the first assessment of the policy and governance situation at the Badalona research site, focusing on the strengths, weaknesses and possible improvements. For a complete report on the first assessment see D5.4.

Strengths

Badalona has a strong and well-defined policy framework for water management. The policy framework covers all relevant aspects of water management. Policy framework is backed by a strong legal and administrative planning structure, with well-defined responsibilities for current water management tasks.

Moreover, in each of subdomain, existing problems are well known and the context is well understood. Policies therefore outline appropriate tasks to deal with these problems. Also, technical knowledge about the current water system is available to responsible parties and actors are aware of their responsibilities in water management. However, actors not always have the resources (financial and technical) to act on this.

Weaknesses

Yet, despite its well-defined policy framework, Badalona also faces a fragmented governance structure and incomplete funding, especially for urban drainage systems. Responsibilities are clearly defined and assigned, but they are fragmented over different governance levels and actors and there is little oversight or monitoring on the sector as a whole. Existing water management practices are underpinned by an incomplete financial structure, because it lacks a municipal sewerage tax and also because financial contributions to water sanitation have been sharply reduced in recent years.

Moreover, current water management practices focus on the existing situation and structural consideration of the potential future changes and how to instigate climate change in a governance context, is lacking. As a consequence, no responsibilities and resources (financial, administrative, knowledge) are assigned to deal with future risks. If something goes wrong, no one can be held responsible and parties look at each other to provide a solution.

Governance needs (what can be improved)

In Badalona, there is a need for more knowledge about the impacts of climate change on the different sub-sectors of water management and the water system as a whole. This would help to increase awareness about the possible detrimental effects on the water system and help to better anticipate these effects by developing new adaptation policies. Moreover, there is a need for more coordination in Badalona's water management. This coordination would not only help to create better links between the different sub-sectors of water management at different levels of governance (city, metropolitan and regional level), but also to establish important links between the water sector and other sectors, such as spatial planning. Thirdly, new governance styles are required that are anticipatory rather than reactive, and, in a similar fashion, there is a need for policy measures that target long-term developments rather than the existing situation. Increased awareness and better coordination could be the first steps to realize this change. Finally, there is a need for a suitable funding framework (that nowadays is not enough) to cover all the necessities arising from the water cycle management, especially to those related to the urban drainage system.

7.3. Proposed Adaptation Measures

Early warning system

The early warning system is a technological solution to reduce vulnerability (particularly the exposure) and to anticipate problematic situations (floods and Combined Sewer Overflows (CSOs)) and to automatically launch the corresponding emergency protocols to avoid impacts on citizens, beaches or public assets of Badalona. This measure includes weather forecast, automatic flood risk mapping, estimation of beaches' affection by pollution, communication interfaces, mobile applications, etc. Implemented emergency protocols could imply: closure of beaches, traffic restrictions, building's protection, etc. The implementation of an *early warning system* is target at reducing the risks of (flash) floods, as well as dealing with a decreasing water quality due to increased precipitation. The measure can be characterized as being both technical and informational and as aimed at the protection of people and property.

Increased of inlet, drainage and retention capacity

In order to increase the inlet capacity to the drainage system, conveyance and retention of storm water runoff, the number of inlets and the capacity of the existing sewer system must be increased by adding new inlets, new pipes (sewers) and some retention tanks. This includes 12.427 new inlets; 9.478 m of new pipes; 4 mixed (anti-flooding + anti CSO) retention tanks with a total volume of 150.000 m^3; and 10 anti-CSO retention tanks with a total volume of 82.000 m^3. The main advantages of the measure is that if completely applied the measure will result in a consistent reduction of flooding and CSO events. This is the traditional measure applied in all the drainage systems with limited capacities so the measure is robust and efficient technically speaking. As such the measure can be characterized as being focused on engineering and the build environment. It aims at the protection of people, property and the environment from (flash) floods and a decrease of water quality due to increased precipitation.

Sustainable Urban Drainage Systems

SUDS (Sustainable Urban Drainage Systems) are drainage systems that mimic natural drainage by managing potential flooding and protect watercourses and rivers by using natural treatment processes. The implementation of SUDS contributes to the protection of the environment, people and property from flash floods, as well as decreased water quality due to increased precipitation. There are four main benefits that can be achieved by SUDS: water quantity, water quality, amenity and biodiversity. SUDS can take many forms, both above and below ground. Yet, SUDS provide also a nature-based solution to approach other necessities of the city such as: the increase of green areas and biodiversity (with the corresponding ecosystems services implying economic and community benefits); the improvement of urban air quality, the reduction of noise or the regulation of building temperatures; the mitigation and adaptation to climate change; the recreational an educational value of the SUDS, the increase of energy efficiency in buildings developing SUDS such as green roofs; the increase of groundwater reservoir (due to rainwater infiltration), etc.

7.4. Foreseen consequences of the proposed adaptation measures

The following sections summarize the results of the cost-benefit analysis performed in task 5.2 with regards to the implementation of the 3 selected adaptation measures in Badalona.

It includes a summary of the main benefits of each measure in terms of risk reduction: flooded area (for urban flooding) and polluted area (for CSOs).

On the other hand it also includes a summary of the direct and indirect socio-economic impacts resulting from each measure: structural measures (increase of sewer capacity); Sustainable Urban Drainage Systems (SUDS) and Early Warning Systems (EWS), specially designed to reduce flood risks or CSOs.

7.4.1. Effectiveness as regards risk reduction

Regarding the effectiveness of the adaptation measures for urban flooding risk reduction it can be concluded that:

The structural measures are the ones reducing the most the flood risk (for pedestrians, vehicles and for monetized damages). Particularly, they can almost eliminate the high risk area derived from 10-year design rainfalls. Secondly, the EWS also significantly reduces flood risk. In this case the risk reduction is rather uncertain and conservative assumptions were made when simulating the EWS impacts on high risk areas. Finally, the proposed SUDS are the least flood risk reducing measures. This is mainly because their implementation only affect 2% of the actual impervious area of Badalona.

Regarding the effectiveness of the adaptation measures for CSOs risk reduction it can be concluded that:

The structural measures (anti CSO retention tanks) are the ones reducing the most the annual wet weather CSO volume (46% reduction) and thus the percentage of bathing season time with insufficient bathing water quality (from 3.6% in the BAU scenario to 1.6% with retention tanks). SUDS just reduces a 4% de annual CSO volume and EWS just affects the vulnerability of citizens and the final consequences on risk reduction are still under analysis.

7.4.2. Socio-economic impacts

Results from the CBA performed in task 5.2 show the net socio-economical-environmental benefits for each of the adaptation measure. The net benefits can be used as an indicator to rank and prioritize the different adaptation measures.

Regarding the adaptation measures to urban flooding it can be concluded that:

The EWS is the most beneficial measure among the analyzed ones. Indeed, the EWS can significantly reduce flood vulnerability (not hazard), expected annual damage (EAD) and risk for limited costs. SUDS are the second most beneficial measure. Despite the fact that the analyzed SUDS can only slightly reduce flood hazard (not vulnerability), EAD and risk, they have lots of other socio-economic- environmental benefits (i.e., CO_2 depletion, heat island reduction, ecosystem services, aesthetic value, etc.). The structural measures proposed are the least convenient from a CBA point of view because the flood EAD reduction is not high enough to compensate the high investment and annual costs of structural measures. Note that, this CBA of structural measures do not include intangible damages due to flood, however the conclusions are likely not to change. Implementing all the structural measures from a Master Drainage Plan (that design measures for 10 year design storms) seems to have negative socio-economic-environmental net benefits. Instead, CBA of selected (not all) structural measures can lead to positive benefits.

Regarding the adaptation measures to CSOs it can be concluded that:

SUDS are the most beneficial measure in terms of net benefit. They involve high socio-economic benefits mainly derived from the ecosystem services they provide (habitat creation, leisure/social spaces, etc.) but also from heat island reduction or air purification. On the other hand, structural measures do not provide net benefits given that the investment and operational costs are not compensated by the socio-economic benefits they provide.

7.5. Governance requirements of the proposed adaptation measures

Table 18 and Table 19 show the governance requirements for the proposed adaptation measures, following the expert analysis of the three-layer-framework. The colors indicate whether a certain condition is met (green), partially met (light red) and not yet met (dark red).

Table 18: Governance requirements for Early Warning System and Increase of Inlet, Drainage and Retention Capacity

Layer-Requirements	Early warning system	Increase of inlet, drainage and retention capacity
Content layer - Knowledge requirements	Weather forecasting models, urban drainage models, marine models, automatic maps, sensors integration, etc. are needed. Accordingly, high level of technological knowledge is necessary. Additionally, emergency protocols should be established, if possible in the most automatized way. Aquatec has enough knowledge to offer a solution such as the early warning system being suggested. Furthermore, the city council has some protocols in the case of flooding and CSOs events that can be improved thanks to BINGO's results.	Badalona already has an Urban Drainage Master Plan from 2012 that includes this measure. The master plan consists on a diagnosis of the existing sewer system (current behavior), the identification of deficiencies, and a proposal of solutions to avoid flooding and CSOs, including their associated budget. The suggested structural measures are the ones considered in this BINGO measure.
Institutional layer - Organizational requirements: Responsibility structure	A technology provider for weather forecasts, models, IT, etc. and the Badalona City Council should be included. The key issue is the proper definition of the emergency protocols to coordinate all the involved actors.	The Badalona City Council must approve the Urban Drainage Plan to prioritize the measure and to allocate the corresponding budget. Some public funding (to supra-municipal public administrations) could be requested for implementation.
Institutional layer - Organizational requirements: Administrative resources	Technical expertise is needed to develop the measure, as well as good coordination (human and technical resources) to implement the corresponding emergency protocols.	The necessary measures must be approved and the corresponding budget must be allocated. Decisions are not made yet.

Institutional layer - Legal requirements	No legal standards need to be developed.	Municipal land use
Institutional layer - Financial requirements	CAPEX for the development of the measure (sensors, data loggers, connection, etc. and manpower) and OPEX (manpower) for the operation and maintenance of the measure are required. Municipal budget might be used (depending on the available budget and local prioritization). The city council is the paying actor. Also extra municipal taxes could be imposed. Citizens would in that case be the paying actor.	CAPEX derived from the planning and project (man power) and construction (material, land, labor, equipment) phases to implement the measures. OPEX to ensure operation and maintenance, including: maintenance tasks, cleaning, etc.
Relational layer Culture and ethics	An early warning system is a communication technology in support of the citizen's safety and wellbeing. Accordingly it should receive a positive public support.	The development of the measure will imply more works in the city and this can mean disturbances to citizens, traffic, etc. so that not everybody would support this measure.
Relational layer Public accountability, communication, and participation	It's an example of transparency for the general public, given that the city council is giving information on how the drainage of the city is behaving under specific situations (such as moderate to severe rains). It is also an example of communication tool where actors must be coordinated to give a proper service to citizens.	It is crucial to inform the citizens about the benefits of the measure in terms of flooding (citizen's protection) and CSO (citizens and environment protection) this is the main way to obtain a public support.

Table 19: Governance requirements for Nature Based Solutions (SUDS)

Requirements	Nature based solutions (SUDS)
Knowledge requirements	At the site, there is limited experience how to develop and implement SUDS. Yet, there are some examples at the regional scale (Area Metropolitana de Barcelona). The Drainage Master Plan in the city, establishing the objectives for flooding and CSO minimization, could be the basis to establish the design objectives and criteria. Finally, the know-how of Aquatec (supporting the management of the urban drainage system in Badalona), can provide relevant knowledge for the future implementation.
Organizational requirements: Responsibility structure	Opportunities for SUDS will be maximized through collaboration between, and early engagement of, stakeholders. The Badalona City Council should be the coordinator of such group of actors, levels and sectors. Since SUDS are not yet implemented the required actors are not yet interacting. But it is expected that the city council, supported by regional administrations can assume such a role and, meet the requirements.
Organizational requirements: Administrative resources	Technical expertise; design guidelines/codes/standards; and guidelines for public/private responsibilities (ownership, maintenance, etc.) are needed. Only international manuals (best practices guidelines) exist.
Legal requirements	Technical standards/guidelines related to the design, operation, maintenance, ownership and competences may be necessary to properly implement the measures.
Financial requirements	CAPEX include manpower and material costs, land costs, construction (labor and equipment) costs, planting and landscaping costs, erosion and sediment control, relocation of existing utility assets, etc. The OPEX include labor and equipment costs, material and/or replacement product costs, replacement and/or extra planting costs and disposal costs of e.g. contaminated sediments and vegetation. Financial means can be generated from municipal budget (depending on the available budget and prioritization); extra municipal taxes; European funding; and national/regional funding.
Relational Requirements: Culture and ethics	The use of SUDS is currently well supported by the new culture/trend of “Greening cities” and nature-based solutions. These “green” management strategies or solutions, such as SUDS, are in general well supported by citizens who are more and more aware of the effects and necessities derived from climate change. Nevertheless, we must consider that citizens need practical solutions that do not hinder their daily activities, e.g. parks must not include any infrastructure or characteristic that impedes children to play.
Relational requirements: Public accountability, communication, and participation	It is crucial to inform the citizens about the benefits obtained by the use of SUDS. Not only flood and CSO mitigation can be obtained, but also it must be highlighted the amenity value of SUDS, the contribution to climate change mitigation and adaptation, costs savings for the municipality, etc. This can be achieved by communication campaigns, assemblies, etc. and also involving citizens during the decision-making processes.

Content

Looking at the knowledge requirements for the various measures desired in Badalona, it can be stated that, there is sufficient knowledge at hand in the area, although not all knowledge is tailored to the specific situation in Badalona. The required knowledge for the different measures varies from hydrological (weather forecasts) and technical (identification of sewage system deficiencies), to more governmental (protocols) and practical (experience in implementing the measure).

For *increase of inlet, drainage and retention capacity*, most of the required knowledge is obtained, as the measure has already been included in the Urban Drainage Master Plan of 2012. Also regarding *early warning systems*, the required knowledge is yet present in Badalona, as the necessary technical and hydrological knowledge is available. In addition, emergency protocols need to be developed for this measure, however also the needed knowledge to do this is available. Only relating to the implementation of *Nature Based Solutions*, some knowledge is still lacking. Yet, although not available in Badalona itself, the knowledge on this measure is regionally accessible for the city, as similar measures have already been implemented in nearby municipalities of the Area Metropolitana de Barcelona.

These findings correspond with the previously performed general evaluation (D5.4), which already identified the knowledge base of Badalona to be well developed. Nonetheless, in D5.4 it was also noted that currently measures are mostly implemented separately, missing out on the potential to synchronize and integrate measures, as well as causing separated parts of knowledge to be scattered over different agencies. Potentially, the synchronization of measures and agencies could allow for increased knowledge sharing and measures complementing each other.

Institutional

Reviewing the institutional requirements for the selected measures, it becomes apparent that these form a key challenge for the implementation. For the *early warning system* measure the institutional conditions are partially in place. To implement the system itself, a technology provider and the city council need to be involved. This will not pose much difficulties. However, the coordination of the actors that need to respond to the 'warnings' coming from the early warning system is more challenging. This requires coordination between a broad range of actors (civil protection, sewer's operators, cleaning services, medical emergencies, citizens, etc.). To make this possible, protocols need to be developed that are as simple as possible with maximum automatization. The financial requirements for the implementation of an *early warning system* are only partly in place, as resources from the municipal budget need to be assigned.

For the other two measures most institutional requirements are currently not being met. *Increase of inlet, drainage and retention capacity* requires responsibilities to be divided between involved parties, as well as a decision from the municipality to implement the measure. The administrative resources required are partly there, however, as the political decisions are not made yet these cannot be tapped into currently. Again, also generating the required funding is a challenge. Legal requirements, however, pose no issue, as the measure can be implemented on municipally owned land.

Finally, for the implementation of *SUDS*, the required responsibility structure is also not yet in place, as the measure is not yet being implemented. However, the Badalona City Council, which would coordinate the involved actors, should be able to take up this role with the support of regional administrations. The administrative resources are also not yet acquired. While the necessary administrative resources are identified (technical expertise; design guidelines/codes/standards; guidelines for public/private responsibilities (ownership, maintenance, etc.)), currently only international guidelines exist, not specified for the Badalona case.

In short, for the institutional layer, the coordination of the involved actors and gaining the required technical expertise is needed for all measures. This poses a challenge in Badalona as, although clearly divided, responsibilities are scattered over many actors. In D5.4 it was found that even though most actors know their responsibilities, they are unaware of the responsibilities of others. This lack of integration and holistic overview challenges the implementation of new measures like an *increase of inlet, drainage and* *retention capacity* and *SUDS* and the emergency protocols related to the *early warning system*. The current lack of clear decision making by the city council could be identified as one of the reasons for the weak institutional layer. According to the analysis the city council is in the position to make the crucial decisions, coordinate the actors and arrange funding. However, they currently are not sufficiently involved to do so. An explanation for their limited involvement could be provided by the previously identified (see D5.4) reactive attitude considering climate change adaptation in Badalona. A more pro-active attitude of the city council could potentially boost the implementation of these measures.

Relational

The proposed measures vary in nature. While the implementation of an *early warning system* is relying on effective communication to the public, the other measures are more technical and spatial in nature and therefore also have different relational requirements. For the implementation of *increased inlet, drainage and retention capacity*, the required relational resources mainly refer to the communication of construction works and communicating the benefits of the measure. As the implementation of the measure will imply more work to be done in the city, and potentially also multi-functionality of infrastructure or other public places, this might yield negative responses from the public. Consequently the communication of the engineering work and purpose of the measure is of main importance for public support. This is currently not done or prepared yet.

The implementation of *SUDS,* on the contrary, is expected to be supported by the public, as it fits into the current societal trend of 'greening cities'. Nonetheless, also for this measure not all requirements are currently being met as also for this measure the communication channels to the public are not yet established. Moreover, it is suggested that the public could also be involved in decision-making on *SUDS*, which is currently also not done yet. Finally an early warning system is also expected to be welcomed by the public as it is supporting citizens' safety. Nonetheless, implementing the measure will require high transparency on the functioning of the drainage system, as well as effective communication lines. Both of these are currently not yet in place.

7.6. Key governance challenges and recommendations for improvement

7.6.1. Key governance challenges

Looking at the key challenges identified for each measure, for both *SUDS* and *increasing inlet, drainage and retention capacity*, the availability of budget, as well as the political support for the measures are the main difficulties. This relates back to the previously found general low financial resources available for climate change adaptation in Badalona. Also, the strong political basis of water management potentially hampers clear decision making. In D5.4 it was found that decision making in water management is driven by political considerations in Badalona (it has to compete with other interests and policy fields), rather than e.g. technical considerations or economic cost-benefit considerations. Due to this political nature water management is considered sometimes unclear by respondents (see D5.4). As such it can be challenging to establish prioritization and public support for specific measures, as are also mentioned as key challenges for the introduction of *SUDS* and *increasing inlet, drainage and retention capacity.*

Besides these critical factors, also the coordination of actors can be distinguished as of main importance for the implementation of the selected measures. To implement an *early warning system* for instance, the main challenge identified is the coordination of all actors involved in the emergency protocol (civil protection, sewer's operators, cleaning services, medical emergencies, citizens, etc.). All actors need to be involved with enabling a maximum automatization and simplification of the protocols to make the emergency response as effective as possible.

7.6.2. Recommendations for improvement of the policy and governance situation and overcoming implementation barriers

In the first analysis of the policy and governance situation in Badalona (D5.4) four recommendations for improvement were made:

1. **Development of more knowledge about the impacts of climate change** on the different sub-sectors of water management and the water system as a whole, to increase awareness about the possible detrimental effects on the water system to better anticipate these effects by developing new adaptation policies.
2. **Achieve more coordination in Badalona's water management.** This coordination would not only help to create better links between the different sub-sectors of water management at different levels of governance (city, metropolitan and regional level), but also to establish important links between the water sector and other sectors, such as spatial planning.
3. **Develop a more anticipatory governance style**, instead of the current, reactive style. New governance styles are required that are anticipatory rather than reactive, and, in a similar fashion, there is a need for policy measures that target long-term developments rather than the existing situation. Increased awareness and better coordination could be the first steps to realize this change.
4. **Create a more suitable funding framework** (that nowadays is not enough) to cover all the necessities arising from the water cycle management, particularly related to the urban drainage system.

The analysis of the adaptation measures reinforces these recommendations. For all three measures, substantial knowledge of impacts and risks of increased precipitation are required and the BINGO project has played an important role in establishing and improving this knowledge. It is recommended to disseminate this knowledge to a wide audience, such as politicians, decision makers, urban management professionals and citizens. This will increase awareness among those actors of the impacts of climate change and can improve their willingness to allocate funding for adaptation measures, make decisions on adaptation or get involved into climate change adaptation themselves (e.g. citizens).

Apart from the knowledge on the impact of climate change, also the broader benefits of the adaptation measures can be communicated to the public. This should not be limited to the direct effectiveness of the measures in reducing the risks of climate change, but also in their contribution to other areas of wellbeing of citizens. A special case can be made for the *SUDS* in this regard. *SUDS* have been found not only to reduce floods and CSO's, but also contribute to urban cooling, bio-diversity, improved air quality, and health and the aesthetic qualities of the urban environment. This can be achieved by information campaigns, assemblies, or linking with educational projects on schools.

The need for more coordination in Badalona's water management has also been strongly underlined by the analysis of the measures. In the case of the *early warning system* coordination should be established between the water management sector and all actors involved in the emergency response to an early warning. These coordination can already be established in developing the emergency protocols, so that all actors are fully aware of their roles, responsibilities and required actions.

The implementation of *SUDS* also reinforces the requirement for coordination between different actors and sectors. On the government level this can be the environmental regulator, sewerage undertaker and roads authorities, but also urban planning. To develop the specific solutions, opportunities can be maximized by collaboration between engineers, landscape architects, planners and local communities. It is important to note that SUDS can not only developed in publicly owned areas but also on private properties, such as gardens and roofs. Involving citizens not only in the decision making on SUDS, but inform them about and helping them with developing their own nature based solutions may greatly improve the effectiveness of the measure.

On another level, coordination between developments of the different measure can also overcome barriers and improve its effectiveness. The *increase of inlets, drainage and retention capacity* and the *SUDS* are different solutions for the same issue and can reinforce their effects. In certain areas, it may be possible to implement a nature based solution to avoid the often expensive and intrusive increasing of the sewage capacity. On the other hand, if implementation is not coordinated, redundant solutions maybe implemented, strongly reducing the cost effectiveness of the overall adaptation.

The third recommendation has to do with the style of governance and the political culture in Badalona. From the analysis of the measures it becomes apparent that the current style of governance lacks clear decision making on adaptation and therefore prevents the allocation of funding to implement measures. This is a widespread problem in political systems that have short term (usually 4-5 years) election cycles, but facing long term issues, such as climate change.

One of the recommendations is to provide decision makers with a clear cost benefit analysis of climate change adaptation measures. This helps them to prioritize, justify decision making and allocate funding. As potential benefits not only the direct risk reduction benefits should be calculated but also broader societal benefits. This may make it possible to allocate funding from different sources. The socio-economic analysis in BINGO (D5.3) has been an important instrument to establish this analysis. In convincing politicians to take action, it can also be important to calculate the 'cost of inaction': the costs to society if no action is taken on climate change adaptation. The cost of the adaptation measures can then be compared to the cost of inaction.

Raising awareness among citizens of the risk of climate change and the benefits of adaptation (see above) can also be an important instrument in getting climate change higher on the political agenda. Although it may be a bit cynical, it has been mentioned that a 'recent disaster', such as an extreme rainfall event, can be used to this effect. In the case of the Veluwe (and in The Netherlands as a whole), the dry summer of 2018 has certainly contributed to the increase of political attention to drought issues.

Finally it was found that Badalona is facing difficulties financing climate change adaptation measures and acquiring sufficient financial means to implement a measure poses a challenge for their implementation. As mentioned above, a possible way to alleviate the financial pressures is through synchronization of measures and construction costs. By coordinating and integrating measures, the implementation costs could potentially be lowered. A first step in synchronization could be the sharing of knowledge and expertise regarding different measures. This potentially this could also be expanded to integrate construction works and/or implementation areas. Also, the opportunity should be sought to combine the implementation of infrastructural measures with other activities, such as road maintenance and maintenance of underground infrastructure. This also requires coordination between different areas of government.

Different solutions to increase finances for climate adaptation have been suggested:

- Extra municipal taxes
- European fundings
- National or regional funds

Municipal taxes would be the most stable form of revenue, but it is often difficult to find public (and thus political) support for an increase in taxes. Also here, the socio-economic cost benefit analysis can be helpful, not only providing financial underpinning of the investment, but also showing side benefits of the measure, for which investments from other municipal budgets or national/European funds can be found. Table 20 shows a summary of recommendations for Badalona.

Summary of recommendations
1. **Achieve more coordination in Badalona's water management** to create better links between the different sub-sectors of water management at different levels of governance (city, metropolitan and regional level) and other sectors.
2. **Develop a more anticipatory governance style**, instead of the current, reactive style.
3. **Create a more suitable funding framework** (that nowadays is not enough) to cover all the necessities arising from water cycle management, particularly related to the urban drainage system.
4. **Increase finances for climate change adaptation** through (a) extra municipal taxes, (b) European funds, (c) national and regional funds.
5. **Disseminate information on climate change to a wide audience** to create awareness of the impacts of climate change and encourage the implementation of adaptation measures.
6. **Communicate the broader benefits of adaptation measures**, such as SUDS to broaden the support and potential funding for these measures.
7. **Assess the 'cost of inaction' of adaptation measures** to provide decision makers with a broader perspective in their decision making.

Table 20: Summary of recommendations for Badalona

8. Comparison between sites

8.1. Common measures and challenges

When looking at the measures selected by the research site, we can identify a strong focus on technical infrastructural measures (Table 21), both in the flood/cso cases and in the drought cases. This may be explained by the familiarity of the stakeholders and end users with these types of measures. Often, the knowledge and administrative resources for implementation of these measures are present at the sites, and implementation does not require the involvement of a broad range of stakeholders. Also, the effectiveness of these measures can often be modelled and is less uncertain than for instance behavioral measures.

However, technical infrastructural measures are often expensive and can take a long time to implement. Construction works due to implementation can also cause disruption to social and economic activities and the surrounding environment. The sewer separation proposed in Bergen and the increase of the sewer systems capacity in Badalona both require large investments. These funds are difficult to obtain either because financial means are lacking or they are not properly allocated for adaptation. In the Wupper River Basin, the building of a retention basin, alignment protection and new water transportation systems also require large investments and long implementation times. Artificial retention at the Veluwe also requires large investments and may cause debate about the disruption to the natural area caused by large scale construction activities. The modernization of the irrigation system in the Sorraia Valley is very costly and the same goes for the use of desalinated water and the uptake of irrigation scheduling technologies in Cyprus.

A second issue with most of the technical infrastructural measures is that they are usually not very flexible. They are often literally set in concrete and built for a fixed capacity. Although BINGO provides decadal prediction until 2025, the life time of technical infrastructural is often much longer (30-50 years is no exception). In that time frame the extent and impact of climate change is still uncertain, which makes decision on the capacity of the infrastructure very difficult. Building too much capacity is a waste of money, while building too little capacity is less effective in reducing the risks.

A third issue with technical infrastructural measures, is that they often serve a single purpose and do not create many side benefits. Particularly in situations where financial means and building space are scarce, measures that serve more than one purpose can be surprisingly efficient. However, it is often difficult to quantify these side benefits and transfer these benefits to the investors of the measures.

Research site	Technical infrastructural measures
Wupper River Basin	• Technical protection measures for property • Alignment protection • Retention Basin • Transition between reservoir catchments • Alternative water sources
Veluwe	• Artificial infiltration
Tagus	• Rehabilitation and modernization of irrigation networks
Troodos	• Irrigation scheduling technologies • Desalination • Use of treated sewage water for irrigation
Bergen	• Sewer separation • Safe flood ways
Badalona	• Increase of sewer capacity

Table 21: Overview of technical infrastructure measures selected by the research sites

This is much less the case with measures that involve the combination of multiple functions and benefits, such as blue/green solutions (Table 22). In this categories of measures, changes in the natural or build environment help reduce the risk, while also performing other functions and creating potential side benefits. The land use change at the Veluwe (changing pine forests into broad leaf forests and open areas) does not only increase the groundwater recharge, it also increases bio diversity, reduces the risks of fires and creates a more varied and attractive landscape (unless you like pine forests very much).

Research site	Blue/green solutions
Veluwe	• Land use change
Bergen	• SUDS • Safe Flood Ways
Badalona	• SUDS

Table 22: Blue/green solution

The SUDS that are analyzed by Badalona and Bergen show similar characteristics. Both measures are primarily used to decrease the risk of flash floods and CSOs by increasing the retention capacity of the built environment. These measures also have many side benefits, such as urban cooling, increased bio diversity, increase water and air quality and they can provide recreational space for citizens. The analysis in Bergen shows that the combination of SUDS and Safe Flood ways are as effective in risk reduction as sewer separation, but less expensive to implement.

Implementing SUDS, however, is more challenging from an institutional perspective. It often requires cooperation between different sectors (urban planning, water, building & construction, etc). Depending on the governance situation, this can be challenging. In Bergen, SUDS are now primary planned on government owned areas, which makes coordination less difficult. If private owners need to be involved as well, things get much more complicated. Private owners need financial incentives to make changes to their property, either in the form of subsidies, or clearly identifiable benefits, such as less flood damage, or increased energy efficiency. In the case of Badalona, SUDS have a limited effect, because of the small are (2%) that is suitable for implementation. However, due to their side-benefits, they are more cost effective than the technical infrastructural measures.

The third category of measures is aimed at behavioral change, either of individuals or institutional actors (Table 23). It is a rather broad category, but they have in common that they do not involve structural changes to the environment. In the case of Badalona, the Early Warning System provides information on expected hazards and requires a broad range of actors (emergency services, citizens, health care, police, etc.) to act on this information. It follows from the cost benefit analysis done for Badalona, that this is the most cost effective measure to reduce the impact of flash floods and CSOs. However, it is very complicated to implement. Protocols have to be set up with the involvement of a broad range of actors and once these are in place, they have to be enacted once a hazard occurs. It is always uncertain whether people will act as expected (or agreed upon) which makes this a challenging measure.

Coordination of actors is also an issue in Cyprus. To properly maintain the check dams that are part of the groundwater recharge systems, different levels of government need to be involved with sometimes overlapping jurisdictions. For the land use change measure at the Veluwe this is also an issue. A broad range of land owners need to be involved and large scale land use change in a Nature2000 area may even require the involvement of national level political actors. Coordination of different actors is also central to the Tagus water resource management model that is being developed at the Portuguese research site. It requires almost all actors involved with water use/supply in the Tagus area to be involved in the development of the framework.

Research site	Behavioral measures
Wupper River Basin	• Water Saving • Reduction of low water elevation
Veluwe	• Agricultural water restrictions
Tagus	• Tagus water resources management model
Troodos	• Groundwater recharge system
Bergen	• Public involvement
Badalona	• Early Warning System

Table 23: Behavioral measures

Changing the behavior of individuals with regard to climate change adaptation is also a common challenge across the research sites. The Public Involvement measure in Bergen was considered an important measure by the Bergen research site and has been developed in the context of "solving the unsolvable" in WP6 (see D6.7). It proved challenging to involve the public through a digital platform, particularly to make it appealing to different societal groups. In the Wupper River Basin, convincing individuals to take up water saving or private property owners to apply technical protection measures is also considered a challenge. In both cases a lack of incentives can be identified (cheap water) or a lack of awareness of individual responsibility (flood protection is considered a governmental responsibility). In the case of Cyprus and Veluwe it is the farmers who have to be involved to change their practices by either adopting irrigation scheduling technologies or stop using sprinkler irrigation.

Reduction of low water elevation is a bit of an outsider in this category. It does not really require behavioral change from a specific actor, but sets a different (lower) limit for discharge from the reservoir, so that water authorities have the option to keep more water in the reservoir. This does not require any infrastructural change or changes in the landscape.

8.2. Common recommendations

The recommendations for improvement of the policy and governance situation can be broadly put into four categories:

1. Improvement of coordination between different actors and policy fields
2. Improvement and increase of financing schemes
3. Development of new knowledge and capacity building
4. Communication and awareness raising

Improvement of coordination between different actors and policy fields

This is an issue in at all research sites. It shows that climate change adaptation often falls between and across the current division of sectors and responsibilities. For Portugal, this is at the core of the development of the water resources model. This model aims to create more stability in the institutional framework, by improving an cooperative attitude between government agencies and involve more stakeholders in policy development. This is also an important theme in Bergen. There the different municipal agencies need to work together to implement the more complicated measures such as safe flood ways, public involvement and SUDS. It also means that stormwater plans cannot exist separately but need to be an integral part of the municipal masterplan. In that spirit, adaptation policies should become an integral part of the policy framework on water management as well. For the Wupper River Basin climate change adaptation also needs to be better coordinated between different stakeholders and levels of government, such as municipalities, the water authority and property owners. It was noted there, that if no one feels responsible for climate change adaptation as a whole, efforts remain fragmented. From the experience of one of the municipalities it was suggested to appoint a climate officer, with the responsibility to coordinate the implementation of adaptation measures. In Badalona, the focus is on improving the coordination within the water management by creating better links between the sub-sectors of water management at the city, metropolitan and regional level. This is also mentioned in Cyprus, were it is recommended to establish a district-level water supply board to ensure the integrated management of the water supply. Here also the need is expressed to improve institutional arrangements to support adaptation policy solutions by clarifying roles and responsibilities and improve accountability. At the Veluwe, coordination between different actors is already at the heart of Dutch political culture, but it needs to codified and formalized, for instance in a shared vision on the future of the Veluwe.

Improvement and increase of financing schemes

In most cases a lack of financial resources or challenges in allocating funding for climate change adaptation has been reported. This has close links with the previous point about climate change adaptation being spread across different actors and policy fields. It is usually much easier to allocate funding if an policy issue is located with a single authority that has a political mandate to act. What also plays a role in funding is awareness and a sense of urgency. Climate change is often considered something of the (distant) future which makes it a tough competition with seemingly more urgent matters. This particularly pressing in Badalona, where political decisions on climate change adaptation (and thus the allocation of funds) are not being made. But even if a decision is made, infrastructural measures are so expensive, that other sources of funding need to be found, or more cost efficient measures need to be taken. Sometimes, such as in the Tagus case, the access to funding by different actors is the issue. This can be solved by making it more transparent where funding can be found and how funding is allocated. In the Wupper River Basin, there does not seem to be a lack of funds, but a lack of financing schemes to have a structural source of funds for climate change adaptation. This can be either through an increase of taxes, fees or general budget allocation. To achieve this, an increased awareness of climate change risks and a better coordination between government agencies is necessary. Funding also plays a role in Cyprus, mainly in the uptake of irrigation scheduling technologies by farmers. It is recommended to increase subsidies from the Rural Development Program. But also in other areas financing is an issue. Local communities report that they often lack the funds to perform proper maintenance of the check dams. In the case of water desalination the financial feasibility is very much depending on the demand for desalinated water as an alternative to groundwater. This has to be funded through local communities who have an incentive to switch to the cheaper groundwater. The establishment of a water supply board could prevent this.

Development of new knowledge and capacity building

Effective climate change adaptation requires a broad range of new knowledge and skills and for most research sites recommendations have been made to improve this. In the Tagus case, the integrated water governance model will be accompanied by a tool that allows the generation and disseminates information about supply, demand, climate change impacts and possible solutions. Government staff should be trained in the use of integrated simulation models and decision support system. In Bergen, a better assessment of risks and vulnerabilities to climate change is needed, although BINGO has already resulted in a significant improvement. Moreover, knowledge is needed on how to implement SUDS in the specific climatic and urban conditions in Bergen. For the implementation of safe floodways, demonstration pilots are recommended, to test in practice how they work and to provide confidence and inspiration to practitioners. In the Wupper River Basin, the capacity building of property owners is emphasized. Property owners often lack the knowledge of the potential damages that flash floods can cause to their buildings and what kind of measures they can take to protect their properties. Improving this knowledge can help in achieving a shared responsibility for flood protection between public and private actors. The knowledge development in Cyprus should continue to focus on the impacts of climate change at the regional and local level. It should particularly be focused on the impacts of climate change and land use on the ability of local communities to secure a sustainable supply of groundwater resources. In the field of irrigation, capacity building with local farmers should be improved to increase the uptake of irrigation scheduling technologies. It is recommended to continue the participatory research that was applied in BINGO. At the Veluwe there is a need for more knowledge on future land use and economic developments in the form of scenarios, since these are found to have a big impact on the area.

Communication and awareness raising

Communication and awareness raising is key to achieve more involvement of stakeholders, allocate funding and create political support for climate change adaptation. At the Veluwe, all stakeholders need to be more aware of the impact of climate change. Participation in BINGO has already improved this. As became evident from the final workshop at the Veluwe, the drought of 2018 has also played an important role in making political and private actors more aware of climate change. In Cyprus, it is recommended to organize a broad public campaign to increase the awareness of the impact of climate change on groundwater resources. This may result in more support for adaptation measures and a more responsible use of groundwater resources. Researchers and the water authority should cooperate in developing information materials to support this campaign. Awareness raising as a way of putting adaptation higher on the political agenda is also recommended in Badalona. This can be either on the impact of climate change, so that the risks and the associated costs become more evident, but also on the potential benefit of adaptation measures, such as the broad range of benefits that SUDS can have. The same recommendations are made to Bergen. Awareness raising is also recommended in the Wupper River Basin, where it can be used to support the implementation of individual level measures such as water saving and the protection of private property.

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ANNEX 1: BINGO WP5 – Template for Governance Analysis per Adaptation Measure (part of T5.3)

Introduction

This document outlines a research template for the analysis of site-specific governance issues connected to adaptation measures.

Background and aim of the site specific governance analyses

WP5 sets out to assess the current governance context at the six BINGO sites and to provide recommendations regarding the adaptation strategies that are being developed with the Communities of Practices (CoP's) at those sites. Within this Work Package, Task 5.3 focuses specifically on the governance challenges and needs connected to those strategies.

The work of T5.3 is organized in a number of consecutive steps. First, in D5.4 part 1, the regional policy and governance context has been assessed with respect to the risks identified in WP4. Second, at the M15 and M22 workshops in 2016/2017, the CoP's have identified and discussed different adaptation measures to deal with these climate risks. These measures have been incorporated in an online Portfolio (see D5.1 - Portfolio of risk management and adaptation strategies available for the six research sites in BINGO). Currently, an analysis is being conducted of the general governance needs connected to these adaptation measures based on a literature review, which will be linked to the online portfolio.

In addition to the general governance analyses, WP5.3 also wants to analyze the "local" governance needs of adaptation measures in their regional context. These site-specific analyses will focus on adaptation measures that are difficult to implement at the different research sites because of complex or "stubborn" governance issues. The assessments will be performed by the local research partners. They will be included in the online portfolio for other regions to learn from.

This template outlines the structure for the site-specific analyses of governance needs.

Framework and methods

The site-specific governance analyses will focus on adaptation measures that are difficult to implement at the research sites due to complex or stubborn governance challenges that hinder their implementation. To select which measures are in focus at the different research sites, we organized case manager calls to discuss which measures would be interesting to analyze from a governance perspective. Based on these calls, we have made a proposal for 1-2 measures to focus at each research site. The notes of these calls and our proposal for the selection of adaptation measures have been send to the local case managers, which we will discuss with them to make a final selection.

The analysis will be structured by the **Three Layer Framework for Water Governance**, which is also applied in the other WP5 analyses (see Figure 1, Havekes et al. 2013[2]), to ensure comparability across research sites and within the project.

Figure 1 - Three Layer Framework for Water Governance

The site-specific governance analyses will be performed/coordinated by the local research partners, who know their regional governance contexts and have access to relevant stakeholders to collect more information if needed. They can use their own knowledge of the regional governance system, the information gained through the CoP meetings (particularly the M22 meetings in which governance issues were discussed), and conduct additional policy analyses of interviews to answer all the quation in this template.

For questions or more information on this analysis, please contact the BINGO WP5 team.

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Content Layer

[2] https://www.uvw.nl/wp-content/uploads/Building%20blocks%20for%20water%20good%20governance%202013.pdf

The content layer comprises the first layer of water governance. Below, several indicators are formulated. The first set of indicators aim to characterize the adaptation measure. The second set of indicators assesses the types of knowledge needed to develop and implement the adaptation measure.

Characterization of the adaptation measure

Short description of the measure

Provide a short introduction to the measure: what are its main aims and characteristics?

Related BINGO objective

Mark the BINGO-risk(s) targeted by the measure in the table below with a yellow shading

Decrease of water quantity due to drought	Decrease of water quality due to drought	(Flash) Floods	Decrease of water quality due to increased precipitation

Related BINGO scope

Mark the BINGO risk-scope addressed by the measure in the table below with a yellow shading

Continuity of service	Sustainable management of resources	Protection of the environment	People and property safety	Economic management	…

Type of measure

Characterize the type of measure in terms of the IPCC´s categorization of adaptation measures using a yellow shading in the table below.[3]

Structural/physical	Social	Institutional

[3] For more information on the categorization, see the IPCC's Fifth Assessment Report , chapter 14, pages 845-849: https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap14_FINAL.pdf (October 2016).

Engineered and build environment	**Technological** (e.g.	**Ecosystem based** (using ecosystem functions to	**(Basic public) Services** (e.g. health, water,	**Educational** (e.g.	**Informational** (e.g.	**Behavioral** (e.g. changing water use or	**Financial** (incentives or direct funding of	**Laws and regulations** (e.g. protected areas, technological standards,	**Government policies and programs** (e.g.

<u>Targeted sector</u>

Indicate the sector targeted by the measure in the table below with a yellow shading

Water Resource Management	Public Water Supply	Urban drainage	Flood safety	Agriculture

<u>Knowledge requirements</u>

What knowledge is required to develop and implement the measure? What level and detail of information about the addressed risk is needed to effectively implement the measure? What types of knowledge and skills are needed to develop and/or implement the measure (e.g. about the water system, the agricultural cycle, consumer behavior, process management)?

How can this knowledge best be classified? Please highlight in yellow.

Technical knowledge	Administrative knowledge	Knowledge about behavior, interests and preferences

To what extent are the knowledge requirements met at the research site?

Institutional Layer

The institutional layer deals with the aspects that ensure an effective operation of the adaptation measure. Within the Three Layer Framework, this layer is further subdivided into an adequate organizational framework, necessary legal instruments and a good financing structure. Below, indicators are formulated for each of these aspects.

<u>Organizational requirements</u>

<u>Responsibility structure</u>

Which (constellation of) actor(s) should be involved in the development and implementation of the adaptation measure?

Are the necessary actors currently involved sufficiently?

What requirements are placed on coordination between actors, levels and sectors?

Are these requirements met at the research site?

<u>Administrative resources</u>

Which administrative resources are needed to implement the measure? For example, staff, administrative (e.g. accounting or monitoring) capacities, regulatory (e.g. independent standard-setting or adjusting) capacities, technical expertise, knowledge infrastructure, etc.

Are these administrative resources available at the research site?

<u>Implementation level or scale</u>

At which level or scale will the measure be implemented?

<u>Implementation time</u>

What is the expected time needed to implement the adaptation measure, from measure development to its implementation in practice?

<u>Life time</u>

What is the expected life time of the adaptation measure?

<u>Legal requirements</u>

<u>Relevant EU legislation, policy and directives</u>

What EU directives and regulations influence the governance of this measure?

Legal-operational requirements

Does the measure require setting legal standards (e.g. technological process-requirements, output standards) or the use of certain types of rights (i.e. land-use or taxation rights)?

Are these legal-operational requirements met at the research site?

Financial requirements

Costs

What types of costs are involved with the implementation and operation of the adaptation measure?

Financing structure

How can these financial means be generated; which sources can be used, which actor(s) should pay?

Are the necessary financial resources available at the research site?

Relational Layer

The relational layer deals with the requirements placed on the wider governance context of the adaptation measure. The Three Layer Framework makes a distinction between culture and ethics, and public accountability, communication and participation in this regard.

Culture and ethics

Which cultural or ethical issues either support or obstruct the implementation of the adaptation measure?

Public accountability, communication, and participation

Which public accountability requirements are there for the adaptation measure? Are there specific transparency requirements? What requirements does this place on communication of responsible actors and agencies, and public participation?

Are these requirements sufficiently met at the research site?

Summary

This section summarizes the key governance aspects, in terms of key advantages and governance challenges connected to the adaptation measure.

Key advantages of the measure

Shortly summarize the most important advantages of the adaptation measure; what are its key strengths, do they for example lie in technical robustness, integrative capacities, or financial security?

Key governance challenges

Shortly summarize the key governance challenges connected to the adaptation measure, e.g. in terms of costs, conflicts of interests, contested technologies, etc.