BeWater

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Executive summary

While many initiatives have begun to integrate climate change in water management at multiple scales, few attempts have been made to address this issue in river basin management. The BeWater project responded to this gap by developing River Basin Adaptation Plans (RBAPs) in each of its four Mediterranean case study areas. A further objective was to move away from the traditionally expert-dominated approach to adaptation planning and instead facilitate a bottom-up co-design process with local stakeholders and actors. This deliverable thus presents the four case studies' finalized RBAPs, representing the outcome of the ongoing collaboration between societal and scientific community representatives in each basin over the last three years.

The present deliverable follows a modified version of the outline presented in Deliverable 2.3 and integrates the results of Work Packages 3 and 4 in the BeWater project, including the outcomes of interactive workshops which were held in each basin to discuss and validate the results presented.

This deliverable is structured according to the four case study river basins focused on within the BeWater project, namely: 1) Tordera river basin, Spain; 2) Vipava river basin, Slovenia; 3) Pedieos river basin, Cyprus; 4) Rmel river basin, Tunisia. Each river basin adaptation plan presented consists of two parts. The first part includes an *introduction* to the river basin, information on the *current and future state of the basin*, the *participatory development of the plan*, an overview of the developed *water management options* followed by *bundles of these adaptation actions,* and *recommendations* for the basins. The second part of the plans present more detailed information on each of the *water management options*.

Contents

Introduction

Climate change is increasingly being recognized as a crucial consideration in many policy areas, not least of which is water management. While many initiatives have begun to integrate climate change in water management at multiple scales, few attempts have been made to address the issue in *river basin management*.

The BeWater project responded to this gap by developing river basin adaptation plans in each of its four Mediterranean case study areas. A further project objective was to move away from the traditionally expert-dominated approaches to adaptation planning and instead facilitate a bottom-up co-design process with local stakeholders and actors. This deliverable thus presents the four finalised case study river basin adaptation plans, the outcome of the ongoing collaboration between societal and scientific community represenatives in each basin.

As a first step towards drafting the plans presented here, a review of existing examples and related experiences (deliverable D4.1) was conducted to (1) learn from initiatives integrating climate adaptation into water management planning processes at river basin or sub-catchment level, (2) identify and illustrate key areas of interest for the preparation of BeWater plans and (3) lay the foundation for a collective discussion within the consortium on the appropriate content of the river basin adaptation plans and suitable methods to be used in developing them.

Building on this review, a protocol (deliverable D2.3) was written to guide the development process. The protocol aimed to homogenise the considerations, information and activities included in the plans across the case studies and accordingly consists of two main parts: a step-by-step guidance on how to prepare the plans (Part A) and a draft outline of the final BeWater river basin adaptation plans (Part B). The steps and outline were then refined in an iterative exchange with the case study partners throughout the drafting process of the plans, in order to have a clear shared methodological approach, while also leaving some room for river basin-specific considerations to be accommodated.

Four draft river basin adaptation plans were then elaborated (deliverable 4.2). which include the results of a policy and stakeholder review (step 2.1 in the protocol), Work Package 3 and Task 4.1 in the BeWater project. The remaining steps as outlined in the protocol were subsequently drafted, then discussed and validated by stakeholders in an interactive workshop in each basin, adapted to take feedback into account, and finally inserted into the respective plans included here.

This deliverable is structured according to the four case study river basins focused on within the BeWater project, namely: 1) Tordera river basin, Spain; 2) Vipava river basin, Slovenia; 3) Pedieos river basin, Cyprus; 4) Rmel river basin, Tunisia. Each river basin adaptation plan presented consists of two parts. The first part includes an *introduction* to the river basin, information on the *current and future state of the basin*, the *participatory development of the plan*, an overview of the developed *water management options* followed by *bundles of these adaptation actions,* and *recommendations* for the basins. The second part of the plans present more detailed information on each of the *water management options*.

Subsequent steps within the BeWater project will include activities aiming at the dissemination of these plans and raising interest for policy uptake in locally relevant arenas, such as the organisation of a local policy forum in each of the four river basins and a European level policy forum at the European Parliament in early 2017. A handbook for drafting participatory adaptation plans will also be developed (deliverable 4.4), outlining the lessons learnt in developing the four plans and providing the user with guidelines on the steps and considerations involved.

1 Tordera River Basin, Spain

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Preface

Global change projections for the Mediterranean region predict an increase in water scarcity and drought episodes, as well as other extreme events such as heat waves and violent sea storms. There is a high likelihood that these events will entail substantial socioeconomic losses and adverse environmental impacts if no action is taken to support territories' adaptation efforts. Furthermore, changes in population patterns and land use, such as urban expansion or the abandonment or intensification of agriculture, also affect the response of territories to these events. In this context, sustainable water management strategies are urgently needed as they will enhance the resilience of socioecological systems.

Current water management practices focus on the river basin level as the natural geographical and hydrological unit. Resilient water management strategies focusing on the river basin can respond to pressures within this unit in an appropriate way, while trying to minimise disruption to socioecological systems.

The BeWater project ('Making Society an Active Participant in Water Adaptation to Global Change') is funded by the European Union through the 7th Framework Programme, and aims to address the above challenges by promoting dialogue and collaboration between science and society for sustainable water management and adaptation to the impacts of global change. The BeWater project, taking place from 2013 through 2017, focuses on the design of adaptive water management approaches at a river basin scale in the Mediterranean region. More specifically, the project aimed to develop a River Basin Adaptation Plan (RBAP) for each of four pilot case studies, namely, for the Tordera (Spain), Pedieos (Cyprus), Rmel (Tunisia) and Vipava (Slovenia) river basins. These basins are representative of different Mediterranean settings in terms of climate, topography, environment, socioeconomic and political conditions, land use, and water demand.

The adaptation plans were developed in a collaborative process according to a common approach developed within BeWater, and utilising existing information on the local dynamics of global change. Over the course of the project, the plans were co-produced by experts and stakeholders in the respective river basins as well as with scientists and experts from within the BeWater consortium.

The four River Basin Adaptation Plans (RBAPs) aim to foster adaptation to global change within the four basins and to serve as a reference for other basins, within the Mediterranean region and beyond, that wish to increase their resilience and undertake such a participatory co-creation process. To facilitate the transferability potential, the BeWater project is also producing a handbook presenting lessons learned throughout the development process.

This document presents the river basin adaptation plan for the basin of the Tordera river in Catalonia, Spain.

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Executive summary

BeWater project promoted an iterative dialogue and mutual learning collaboration process engaging with stakeholders in discussions on current water uses and their related problems, raising public awareness of the importance of sustainable and adaptive water management, with particular focus on the expected global change impacts at River Basin scale.

By means of interactive workshops and ad hoc interviews BeWater was able to set the scene and define current and future challenges combining available scientific information and stakeholder knowledge. This intense stakeholder consultancy process led to the elaboration of a narrative of the basin and the identification of 4 main challenges, synthesizing the wide range of relevant aspects detected. According to stakeholders consulted, the main challenges that the Tordera basin has to face are improvements of water body's quantitative status, water quality, health of ecosystems and integrated water management.

To address these challenges, stakeholders were invited to contribute to the formulation of potential water management options. A set of 33 options were identified – most of which are 'soft' measures – indicating that the main challenge in the basin is to improve inappropriate water management practices and legislation in the face of adaptation to global change, as for example the negotiation of direct agreements, the creation of deliberative spaces and fostering improved collaboration between authorities. The 33 options were then structured in 4 bundles, based on the identification of key options and potential co-benefits between these and the rest. For each bundle, considerations on the timing of implementation were formulated as well as implementation opportunities. Besides, specific tables describing individual options in detail and, for each bundle, synthetic factsheets were developed.

This intensive collaboration resulted in the basic input for the redaction of the plan presented. The process allowed to highlight crucial actions to face the identified challenges within the river basin:

- The implementation of environmental flow regime (WMO29) is considered by all participants by far the most important action needed in the Tordera basin.
- Creating a Permanent Participation Centre (PPC) (WMO12) is considered crucial to improve integrated water management of the Tordera Basin.
- Conclude adaptive forest management agreements (WMO33), reached the highest score of the whole Tordera set of water management options evaluation process, and answers to the challenge to improve current forest management in the basin.
- To "Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)" (WMO16) is considered an important process to reach better resilience to global change in the basin, by improving the health of water and forest related ecosystems. In order to assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial. The plan presents some indications on synergies with existing monitoring schemes regarding the identification of suitable indicators for measuring the output.

Moreover, the implementation of the Tordera River Basin Adaptation Plan or of key elements of it requires strong political will, as the transition to more resilient societies implies to overcome rooted trade-offs and socioeconomic inertia. Overall policy recommendations to facilitate this transition are presented, which aim to address leverage points that could enhance the integration of adaptive principles in current normative, legal and political practices.

Resum executiu

El projecte BeWater ha promogut un procés de col·laboració a través del diàleg iteratiu i l'aprenentatge recíproc entre els actors implicats, centrant-se en els usos actuals de l'aigua i problemes relacionats. El procés ha incrementat la sensibilitat pública respecte a la importància de la gestió sostenible i adaptativa de l'aigua, centrant-se especialment en els impactes previstos del canvi mundial a nivell de conca fluvial.

Es van celebrar tallers interactius i entrevistes puntuals per definir l'escenari de partida i identificar els reptes actuals i futurs conjugant la informació científica disponible amb els coneixements dels actors implicats. A partir d'aquest procés intensiu de consulta a les parts es va generar una narració de la conca i es van perfilar quatre reptes principals: call millorar el volum dels cossos d'aigua, la qualitat de l'aigua, la salut dels ecosistemes i la gestió integrada de l'aigua.

Per tal d'abordar aquests reptes, es va convidar els actors de la conca a participar en un procés de formulació de possibles opcions de gestió de l'aigua (OGA). En va sortir un total de 33, la majoria en forma de mesures "toves" (és a dir, no infraestructurals). Així, la principal tasca general per al conjunt de la conca és millorar tant les pràctiques actuals de gestió de l'aigua com la normativa aplicable, ja que no són idònies per adaptar-se al canvi climàtic mundial. Això es pot fer, per exemple, negociant acords directes, creant espais deliberatius i fomentant una col·laboració millor entre les autoritats competents.

Les 33 OGA generades s'han aplegat en 4 grups, cadascun estructurat al voltant d'una OGA clau i en funció dels cobeneficis que comportaria combinada amb les altres. Per a cada grup s'han enunciat, per separat, les consideracions de calendari a tenir en compte i les oportunitats d'aplicació. Les OGA han quedat descrites detalladament una per una en taules específiques, i per a cada paquet s'ha elaborat una fitxa informativa de síntesi.

L'intens procés de col·laboració entre els actors ha estat la font principal per a l'elaboració del pla que aquí es presenta i s'hi van perfilar com a fonamentals les intervencions següents:

- la implantació d'un règim de cabal ecològic (OGA 29), valorada per part de tots els participants com a l'acció de lluny més important que es necessita a la conca de la Tordera;
- la creació d'un centre de participació permanent, que es considera fonamental per tal d'integrar la gestió de l'aigua a la conca;
- la formalització d'acords de gestió forestal adaptativa (OGA 33), l'opció més valorada pels participants (va rebre la puntuació més alta en el procés d'avaluació) i que aborda el repte de millorar l'actual gestió forestal a la conca; i
- la creació d'un Pla Integrat de Protecció del Delta de la Tordera (OGA 16), que es considera important per assolir més resiliència davant del canvi climàtic mundial a base de millorar la salut dels ecosistemes aquàtics i boscosos de la conca.

Per tal d'executar amb èxit les opcions i els paquets proposats, és fonamental disposar d'un pla de monitorització amb indicadors sòlids. El Pla de Gestió de la Conca de la Tordera (elaborat per l'Agència Catalana de l'Aigua) identifica algunes sinèrgies potencials amb sistemes de monitorització existents, però cal desenvolupar-los més.

Finalment, per tal d'aplicar el Pla d'Adaptació de la Conca de la Tordera, o com a mínim alguns dels seus elements clau, caldrà una forta voluntat política: per dur a terme la transició cap a unes societats més resilients, caldrà remoure alguns acomodaments molt arrelats i superar inèrcies socioeconòmiques. Les recomanacions polítiques generals per facilitar la transició busquen incidir en determinats punts d'efecte multiplicador que podrien facilitar la incorporació dels principis adaptatius en els actuals usos normatius, jurídics i polítics.

Glossary of key terms

- **Acceptability (as criteria for water management options) -** an option is considered as acceptable if there is not significant reason a priori for actors in the basin to reject the option, e.g. because of its design [1].
- **Adaptation pathway -** portrays a sequence of actions and their implementation prioritisation over the short, medium and long-term, with regards to achieving a set of pre-specified objectives [2].
- **Adaptive management -** an approach to reduce ecological uncertainty and increase resilience by emphasising that management regimes should be regularly adjusted in accordance with the resulting impact and effectiveness, a process underpinned by participatory co-creation (see below).
- **Bottom-up approach -** entails the participation of societal actors in decision-making about the selection of the priorities and actions to be pursued in their area of interest; the approach can interact and be combined with top-down approaches from national and/or regional authorities [3].
- **Bulk water** - water obtained from the source and provided to a water service entity for distribution to end-users.
- **Carrying capacity** - the maximum capacity of the natural environment in a certain area to provide ecosystem services (e.g. water, fertile soil for the production of crops, growth of natural vegetation or a healthy interplay between species that controls pests and diseases) to sustain the development of human activities; overriding the carrying capacity of a territory means disrupting its functionality
- **Citizen participation** - a process in which society takes part – whether on a voluntary or obligatory basis and whether acting alone or as part of a group – with the goal of influencing a decision that will affect their community; this can take place within an institutional framework, and may be organized either by members of civil society or by decision makers [4].
- **Challenge -** something that by its nature or character serves as a call to a special effort; the RBAP focuses on the challenges related to the impacts of global change in the river basin - now and in the years to come.
- **Climate change -** any long-term change in climate over time, whether due to natural processes or as a result of human activity [5].
- **Climate change adaptation -** appropriate action to prevent or minimise the damage that climate change impacts can cause, or taking advantage of opportunities that may arise due to climate change [6]
- **Climate change scenario -** the difference between a climate scenario (i.e. a plausible and often simplified representation of the future climate) and the current climate [7].
- **Co-benefits (as criteria for water management options) –** options are considered to have co-benefits when their combined implementation amplifies the total impact-related benefits, as compared to the benefits that would arise from implementing each option individually.
- **Environmental flow regime** - describes the amount of water that is needed by the river ecosystem to sustain its natural functioning. In EU countries this concept

is underpinned by specific legislation and management references, indicating the environmental flow regime of a river has to guarantee its good status (see below).

- **Extreme weather event** - an average of a number of weather events over a certain period of time (e.g. rainfall over a season) [8] above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable.
- **Feasibility (as criteria for water management options) -** an option is considered as feasible if physical, technical, regulatory or organizational obstacles do not exist or can be easily overcome during option's implementation[9].
- **Flexibility (as criteria for water management options) -** an option is considered flexible when it can be adjusted/ complemented or reversed when it turns out to be inadequate or inappropriate in practice [10].
- **Fuzzy cognitive map -** a tool to graphically represent the knowledge about or the perception of a given system; can be converted into simple mathematical models to run simulations and calculate outcomes of possible scenarios to facilitate the discussion and exploration of complex issues [11].
- **Global change** - changes in the global environment that may alter the capacity of the Earth to sustain life, encompassing climate change as well as other critical drivers of environmental change that may interact with climate change, such as land use change, population trends, the alteration of the water cycle and changes in ecosystem functionality [12].
- **Good status (of a water body)** – a term to describe a condition under which water bodies have the biological and chemical characteristics expected under sustainable conditions [13]. In EU countries this concept is underpinned by specific legislation and management references, indicating concrete standards to be fulfilled.
- **Governance -** the way rules, norms and actions are produced, sustained, regulated and held accountable; it refers to the processes of interaction and decision making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions [14].
- **(Invasive) alien species –** plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health [15].
- **Impact assessment –** a method to identify the environmental, social and economic impacts of an action or project prior to decision-making.
- **Implementation barrier or opportunity -** elements deriving from the implementation context influencing the foreseen or ideal development of an action.
- **Knowledge transfer –** the process of engaging with researchers, decision-makers or the community and decision-makers to generate, acquire, apply and make accessible the knowledge necessary to successfully develop and enhance evidence-based initiatives which enhance human, material, social and/or environmental wellbeing [16].
- **Land use mosaic -** spatially heterogeneous geographic area characterized by diverse interacting patches or ecosystems, ranging from relatively natural terrestrial and aquatic systems such as forests, grasslands, and lakes to human-dominated environments including agricultural and urban settings.

- **Multi-criteria analysis -** a tool for supporting complex decision-making situations with multiple and often conflicting objectives (e.g. economic, ecological and social) that stakeholder groups and/or decision-makers value differently [17].
- **Mutual learning -** a learning process experienced and shared by different actors developed through direct interactions; the process is conducive to adaptive water management and includes the exchange of information on technical features of river basin management, scientific findings, as well as political aspects, so as to arrive at a shared understanding of issues and possible solutions.
- **Participatory co-creation -** an approach which integrates all stakeholders in the entire design process of an action, i.e. problem definition, solution generation, evaluation of proposed solutions during development, and implementation of solutions, to help ensure the result are effective and increase acceptability.
- **Policy framework -** a broad set of laws, regulations, or processes that structure political, social, cultural or economic activities in a society; these policies form an interacting web and therewith impact the functioning of existing policies as well as new policy developments and policy amendments [18].
- **Pressure -** anthropogenic factors inducing environmental change (impacts), including for example the release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities [19].
- **Resilience -** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change [20].
- **River basin -** the area of land from which all surface water runs off through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta [21]. It is a natural geographical and hydrological unit that is used e.g. by the European legislation to manage a single drainage area [22].
- **River Basin Adaptation Plan -** management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.
- **River Basin Management Plan -** document including the objectives for a given river basin district and the programme of actions required to meet these objectives; the aim is to protect, improve and sustainably use the water environment; these plans are a requirement of the European Water Framework Directive.
- **River Basin District** - the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters [23].
- **River space** - the area including the main river stream, the riverbanks and riparian areas until the limits of flooding zone. Zonification of the river space is determined by the regulations of public water domain.
- **Robustness (as criteria for water management options) -** an option is considered robust to uncertainties if it can maintain its effectiveness under different climatic and socio-economic development scenarios [24].

- **Sediment management -** Organized and coordinated actions to reduce the impact of human activities or natural changes on the quantity and quality conditions of solid material that is or can be transported by or deposited from the river's water.
- **Socio-ecological system –** consists of 'a bio-geophysical' unit and its associated social actors and institutions; delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context [25].
- **Stakeholder** - any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome; the term is usually reserved for well-organised and active groups and organisations, thus making a distinction from the general public.
- **Water management option –** activity developed within the scope of the BeWater project which aims to impact the interactions between water uses and the water body; can be characterised as nature-based approaches (enhancing natural regulation of ecosystem functionality), soft approaches (acting on management or policy norms and regulations) or technical approaches (developed through engineering)
- **Water scarcity –** a lack of sufficient available or safe water resources to meet water needs within a region; this can involve water stress, water shortage or deficits, and water crisis as a result of climate change, increased pollution, or increased human demand and overuse of water [26].
- **Watershed -** the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater; this area is typically smaller than a river basin, meaning that several watersheds may comprise a single river basin [27].

PART 1

1.1 Introduction

1.1.1 *Contextualisation of the Plan*

The Tordera river basin is a small watershed, rich in natural heritage and of great geostrategic importance for Catalan socioeconomic development. Impacts of global change may have a particular relevance in this territory, affecting the regional as well as the local population due to the crucial role of this basin in the connection between northern and southern Catalonia.

The development of a River Basin Adaptation Plan (RBAP) complements existing regulation relevant to this territory in terms of **urban, agricultural, water and forest management planning**. These existing plans and regulations take global change only partially into consideration and possible impacts and related factors are not sufficiently integrated in sectoral planning processes. **Adaptive management** is a means of reducing ecological uncertainty and **increase resilience**, bridging interdisciplinary gaps among scientists and managers, and acting as a vehicle for participation of those outside the management institution through **participatory co-production processes** [28].

Much effort is still needed to merge adaptive management principles, such as flexibility and ability to adjust to changes in the face of uncertainty and complexity, into decision making at all levels. Thus, to implement adaptive management, an **increased coordination** effort between governmental departments is needed so that consistency and co-benefits between policies can be enhanced. Complexity in the interrelation between water, land use, population and climate dynamics in the territory needs to be tackled in an integrated manner both at local and regional levels.

Adaptive management also calls for increased **knowledge transfer** between the scientific community, local society, and authorities, as well as improved information management in general, including technical, scientific and cultural perspectives. Therefore, active stakeholder participation allows the integration of all these aspects into the development of proactive solutions that help tackle current and future challenges.

Within the context of the BeWater project, a process was started to promote **iterative dialogue and mutual learning** as a collaboration between science and society in order to establish plans for sustainable water management that would tackle the challenges posed by global change. By actively engaging local communities in the basin, the project was able to discuss current water uses and their related problems and **raise public awareness** of the importance of sustainable and adaptive water management, with particular focus on the expected **global change impacts at River Basin scale**.

Developing a river basin adaptation plan for the river Tordera constitutes a very important step forward in collaboratively facing the impacts of global change and learning to manage water in a changing environment.

Box 1

Definition of River Basin Adaptation Plan (RBAP)

The BeWater River Basin Adaptation Plans (RBAPs) are management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.

1.1.2 *Objectives and vision*

Actions to face global change necessarily need to be developed **acknowledging the complexity and variety of society's vulnerabilit**y to all kinds of impacts. Issues and concerns related to facing the impacts of global change in the Tordera basin range from improving the state of water bodies and local water cycle functionality (taking into account interactions between continental and coastal dynamics) to highly valuing conservation of biodiversity and the functions of ecosystems in an extremely fragmented territory.

Within this context, the Tordera River Basin Adaptation Plan's main **objectives** are:

- To **engage stakeholders** from different sectors, as well as the general public, in the identification of the main water-related challenges in the Tordera river basin.
- To **identify crucial leverage points** to enhance societal resilience.
- To promote knowledge transfer and co-production of innovative proposals to face the impacts of global change based on a **bottom-up participatory approach**.

The river basin adaptation plan for the Tordera basin aims to be:

- A means to include an **integrated and consistent view** of the challenges at stake, stressing their importance and urgency.
- A contribution to the **understanding of global change–related impacts** in the Tordera basin.
- A reference for **participatory water management planning**.
- A stimulus for building the **intersectoral, inter-departmental and multidisciplinary framework** needed to tackle water management challenges in the face of global change.
- A useful **instrument for stakeholders** involved in adaptive water management planning at local and regional levels.

1.1.3 *Overview of contents*

The Tordera River Basin Adaptation Plan is structured to describe the activities carried out, methodologies used and findings made throughout its development in a synthetic manner and is divided into two parts. The first part describes the plan's context, its development process, and presents summarily outcomes and recommendations. It is divided in **five chapters**.

Following this introductory chapter, chapter 2 provides a brief overview of the participatory co-creation of the plan, the main groups of stakeholders involved and an overview of the methodological steps undertaken, including supporting visual material for a clearer perception of the processes.

Chapter 3 provides a description of the basin, as well as an overview of the current state and expected future state of land, water, biodiversity and people in the basin. In addition, relevant legislation and policies for the set of water management options are listed and described, and the chapter concludes giving an overview of the main challenges identified for tackling global change in the Tordera basin. Chapter 4 briefly introduces the main features of the set of options and describes the whole set of adaptation proposals, structured in specific factsheets where options are bundled seeking maximum co-benefits. It also presents a section describing some main features about the monitoring and evaluation of the impacts expected from the implementation of the water management options. Finally, Chapter 5 indicates some key policy recommendations.

The **second part** of the Plan includes more detailed information about each option, aiming to serve as a practical reference tool for interested audiences. All background information is additionally available in the form of specific deliverables on the BeWater project website.

For ease of reference, a **glossary** of the plan's terminology is included, as well as a list of acronyms.

Annex 1 outlines the events and activities performed during the **awareness-raising** campaign in the basin.

Annex 2 outlines a list of acronyms and Spanish-English equivalents used to refer to Catalan names.

1.2 Participatory Co-creation of the River Basin Adaptation Plan

1.2.1 *Development Process*

Throughout **participatory co-creation** of the river basin adaptation plan, different stakeholders were integrated in the process through **interviews, expert consultations, and direct participation** in project activities. Their participation extended beyond mere consultation: it served to **identify, formulate and evaluate management options** to tackle challenges in the basin. The information obtained from stakeholders was taken up in the project in different ways, allowing structured integration of the contributions made by all the different perspectives within the methodological development stages of the river basin adaptation plan (exposed in Section 2.3).

Stakeholders were involved in both **problem scoping and problem solving**. The development process included a diagnosis of the basin's vulnerability to global change based on available **scientific information and stakeholder knowledge**. Interactive workshops and ad hoc interviews were used to set the scene was set and define current and future challenges. Stakeholder involvement improved the detail of the analysis and allowed the integration of **local narratives** that reveal causal effects that mere scientific or indicator-based estimations cannot register.


Development of river basin
2014
January–March
April–June
1st general project meeting in Barcelona
Identification and mapping of river basin stakeholders and key actors
1st stakeholder workshop on identifying the current and desired status of the river basin
Review and analysis of river basin adaptation plans and strategies from around the world
2015
January–March
April–June
Stakeholder consultation on draft narratives and the basin's graphical representation (fuzzy cognitive map)
Finalisation of river basin narrative, fuzzy cognitive map, and main challenges
Formulation of water management options to tackle challenges
2nd stakeholder workshop on evaluating water management options
2016
January–March
April–June
Characterisation of policy and stakeholder basis of water management options
Assessment of water management option synergies and co-benefits
Design of draft bundles of water management options
3rd stakeholder workshop on desired content and implementation of the River Basin Adaptation Plan
Finalisation of adaptation pathways and bundles of water management options


adaptation plan
BeWater
Society Adapting to Global Change
July–September
Stakeholder interviews on the river basin context and challenges
October–December
2nd general project meeting in Nicosia
July–September
Finalisation of water management options
Impact assessment, multi-criteria analysis and economic assessment of water management options
October–December
Stakeholder consultation event to present and gather opinions on final water management options
3rd general project meeting in Barcelona
Finalisation of impact assessment, multi-criteria analysis and economic assessment
July–September
Completion of River Basin Adaptation Plan
Next steps
Development of policy recommendations to support river basin adaptation
Compilation of lessons learned during the River Basin Adaptation Plan development process
Local policy forum to present river basin adaptation plan and highlight potential paths forward
European policy workshop in Brussels to highlight BeWater outcomes and key messages for policy makers
River basin adaptation conference and final project meeting in Nova Gorica, Slovenia

Engagement of stakeholders at the problem-solving level was achieved through workshops, interviews and expert consultation. This process enhanced overall mutual understanding and generated high acceptance of the actions proposed. As a result, proposals are characterised by an **intersectoral perspective** that includes a wide range of considerations referring to different aspects of the challenges at stake. The participants representing authorities contributed to understand how the proposals could be formulated to **complement or enhance existing plans and programmes**. Local stakeholders, on the other hand, had their voice heard at a regional level, thanks to their attendance and active participation in the official participatory process for the revision of the current river basin management plan in the frame of the **EU Water Framework Directive**, under the responsibility of the Catalan Water Agency[1]. Furthermore, proposals that came up during the river basin adaptation plan development were submitted to the river basin management plan revision process, so they were thoroughly analysed and commented on by the relevant experts working for the Catalan Water Agency.

In addition to the workshops, activities organised as part of an **awareness and dissemination campaign** allowed the involvement of the general public, and were designed in such a way that the comments, discussions and opinions of the participating citizens fed into the development of the basin's narrative and challenges. Annex 1 lists the main awareness-raising activities, and further information is available on the BeWater website.

Mutual learning and stakeholder engagement were also pursued during **internal project meetings**. Key stakeholders from the case study river basins were invited to participate in specific project workshops intended to fine-tune the BeWater approach.

The collaborative approach led to **stakeholder ownership** of the proposals, fostering the creation of an active implementation framework for the actions proposed and calling stakeholders to further pursue the project's findings after its conclusion.

Stakeholder engagement involved the application of a **Stakeholder Integrated Research (STIR)** approach designed to address the challenges by providing a structured method for stakeholder engagement in adaptive management projects [29].

Following the STIR approach, the first step was to identify the main **reference stakeholder groups**, such as farmers, municipalities, non-governmental organisations, and so forth. Subsequently, BeWater established direct contact by mail, phone and face-to-face meetings, to bring together a group of actors representing multiple sectors and based in different areas of the basin, as well as different administrative levels and profiles; the Tordera database includes 148 contacts. Most participants developed a strong commitment to the project and were steadily engaged over the sessions. Nevertheless, new participants were brought on board through the whole project duration, thanks to growing local interest in intermediate results, as well as the communication and awareness campaign. The

[1] Agència Catalana de l'Aigua

following figure (Fig. 1) depicts the stakeholder map of the main participants during the BeWater project.

Catalan level

Authorities	• Catalan Water Agency (Agència Catalana de l'Aigua) • Catalan Office for Climate Change (Oficina Catalana del Canvi Climàtic) • Catalan Agriculture Department (Departament d'Agricultura Ramaderia i Pesca) • Catalan Department for Territory and Sustainability (Departament de Territori i Sostenibilitat) • Montseny and Montnegre Corredor Park Authorities (Xarxa de Parcs Naturals - Diputació de Barcelona) • Network of Municipalities for Sustainability (Xarxa de Ciutats i Pobles cap a la Sostenibilitat - Diputació de Barcelona)
Research Community	• Superior Council for Scientific Research (Consejo Superior de Investigaciones Científicas) • Institute for Agrarian Research and Technology (Institut Recerca i Tecnologia Agroalimentàries) • Catalan Institute on Water Research (Institut Català de Recerca de l'Aigua) • Polytechnic University of Catalonia (Universitat Politècnica de Catalunya) • University of Barcelona (Universitat de Barcelona) • Centre for Ecology Research and Forestry and Applications (Centre de Recerca Ecològica i Aplicacions Forestals - Universitat Autònoma de Barcelona) • Institute for Environmental Science and Technology (Insitut de Ciència i Technologia Ambientals - Universitat Autònoma de Barcelona) • Department for Animal and Food Science (Departament de Ciència Animal i dels Aliments - Universitat Autònoma de Barcelona)

Local level

Authorities	**Municipalities (Municipis)** • Sant Celoni • Santa Maria de Palautordera • Hostalric • Santa Coloma de Farners • Riudarenes **Agriculture Department (Departament d'Agricultura Ramaderia i Pesca)** • Forestry and Rural Guards (Agents Forestals i Rurals) • County Agriculture Departments Vallès Oriental and La Selva (Oficines Comarcals Vallès Oriental i La Selva) • Hunting and Fishing Sub-Directorate (Subdirecció General d'Activitats Cinegètiques i Pesca Continental)
Private Sector	• CRODA Ibérica and NYLSTAR (chemical industries – indústries químiques) • Costa Brava Consortium (Consorci Costa Brava - water utility) • Touristic industry (hotel, restaurant, camping) • Forestry Consortium (Consorci Forestal de Catalunya) • Association of Montnegre Corredor Forest Landowners (Associació de Propietaris Forestals del Montnegre i el Corredor) • Association of bottling industries (Associació Catalana d'Envasadors d'Aigua) • Association of Gardening Centers of Girona (Associació de Viveristes de Girona) • Sant Esteve and Santa Maria de Palautordera irrigation associations (Comunitats de regants de Sant Esteve i Santa Maria de Palautordera) • Social and Economic Circle for Baix Montseny (Cercle Econòmic i social del Baix Montseny) • Professional Association of Mining Engineers (Col·legi Oficial d'Enginyers Tècnics de Mines de Catalunya i les Balears) • Professional Association of Forestry Engineers (Col·legi d'Enginyers Tècnics Forestals de Catalunya)
NGOs	• Tordera Observatory (Observatori de la Tordera) • Platform in Defense of Montseny (Coordinadora per a la Salvaguarda del Montseny) • Platform in Defense of Arbúcies (Plataforma Salvem les Valls d'Arbúcies) • Emys Foundation (Fundació Emys) • Network for a new Water Culture (Xarxa per una Nova Cultura de l'Aigua)
Other	• Agriculture and Forestry high school in Santa Coloma de Farners (Escola Agrària i Forestal deSanta Coloma de Farners) • Montseny Ethnològic Museum (Museu Etnològic del Montseny) • Centre for Pedagogical resources Vallès Oriental (Centre de Recursos Pedagògics Vallès Oriental)

Figure 1: Stakeholder map of main participants during the BeWater project in the Tordera basin.

1.2.2 *Methodological steps*


BeWater · Society Adapting to Global Change
EVALUATING OPTIONS
To evaluate the water management options, the stakeholders select the criteria on which the options will be evaluated, as well as the relative weight of each criterion. The information from the multi-criteria analysis is combined by scientific experts with the outcome of the options' impact assessment and results in the identification of options that have a desirable impact on the river basin, according to the local stakeholders.
Which options have desirable impacts on the river basin?
Assess the impacts of the options through the qualitative model
REVIEWING THE POLICY FRAMEWORK
Policies and programmes on the local, national and EU level can hinder or support the implementation of the options. Their potential role is determined by a scientific expert evaluation of whether the policy objectives, targets and timescales are in line with those of the options, what funding is available, and if eligibility or selection criteria create barriers to adopting the options. This evaluation was then complemented with additional information from the stakeholders.
How do the options fit within the relevant policy and decision-making frameworks?
Evaluate the options based on multiple decision criteria
IDENTIFYING POLICY ACTORS
As local stakeholders and policy actors will be directly involved in or affected by the implementation and maintenance of the options, their willingness and capabilities to support implementation are important to inform the selection and design of options.
How could stakeholders be involved in the implementation of the options?
Evaluate the role of existing policies in the implementation of the options
BUNDLING OPTIONS
Implementing multiple options together can result in different impacts than the individual options would produce on their own. These potential interactions are assessed using scientific expert judgment and validated via interactive exercises with the local stakeholders. Using these outcomes and taking key options as reference, the options are grouped into bundles.
Which synergies or conflicts arise between the options and how can they be grouped together?
Identify key stakeholders and their potential roles in implementing the options
DEVELOPING AN IMPLEMENTATION TIMELINE
The timeline for implementing each of the options within a bundle is based on their effectiveness over time, local stakeholder preferences and the policy framework. Developing the timeline for implementation takes into account factors such as the time lag between implementation and effectiveness, feasibility, acceptability, the policy cycle, associated costs, and the availability of funding. The initial scientific expert assessments were verified by the local stakeholders.
When should the options be implemented?
Assess co-benefits and conflicts arising between options in order to group them in bundles
FINALIZING THE ADAPTATION PLAN
Based on existing examples of adaptation plans in other river basins and an open dialogue between stakeholders and academics, the content and design most relevant to the local reality in the river basin are determined and integrated into a tailored river basin adaptation plan.
How can all this information be integrated and presented in the most effective way?
Assess the optimal timing for implementing the options
River Basin Adaptation Plan

As shown in the flowchart illustrating section 2.2, in the first stage of the process stakeholders from the Tordera basin were brought on board with the aim of eliciting the current state of the basin's vulnerability to global change and future expectations. Table 1 provides the list of workshops, indicating the number of participants, objectives and outcomes.

Setting the scene: desired state and challenges

During the **first workshop** stakeholders developed the reference information on which the whole subsequent process was based. In this workshop, updated information was provided on the results of scientific research on the impacts of global change in the basin with a 2030 horizon. Much of the data came from an earlier project, ACCUA [30], which assessed the territorial vulnerability of the Tordera basin to the effects of global change. Building on this background knowledge, stakeholders contributed their perception of the **current status of and pressures on water bodies** for specific parts of the basin. In the light of their prior considerations, discussions were then guided into formulating of a **common vision on the future status** of the river basin and structuring some first ideas on ways forward.

The analysis of the workshop results helped identify **information gaps**, which were later tackled through specific interviews with relevant actors to complement the outcomes with additional information.

This intense stakeholder consultancy process allowed the **identification of four main challenges** that condensed the wide range of relevant issues detected and the drafting of a **narrative of the basin**. According to the stakeholders consulted, the main challenges that the Tordera basin has to face are improvements of its water bodies' quantitative status (A), the health of its forest and water ecosystems (B), water quality (C) and integrated water management (D). The general impression according to the stakeholders consulted is that current monitoring and control measures applicable to existing plans and programmes that aim to restore territorial resilience to global change is insufficient, so there was a call to strengthen local government and promote inclusive management practices as a cross cutting challenge.

By clustering and refining this information it was possible to develop a narrative of the basin, both in the form of a text and visually represented through a **fuzzy cognitive map** (FCM – see text box 2) [31]. This map was composed of a simplified representation of relevant factors that define the **current status, pressures and drivers in the basin and their interrelation**.

Text Box 2

Fuzzy Cognitive Map

To help evaluate the water management options against the challenges identified by the stakeholders, a method called Fuzzy Cognitive Mapping was applied. A fuzzy cognitive map is a graphical representation of a system – in this case, a river basin – where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the direction and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system

based on the understanding of individuals. Fuzzy cognitive maps allow all the information available on the basin to be organised in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them, and their relationships in the system. The maps were constructed with input from stakeholders from different backgrounds. In addition to clearly describing the river basin, the map was used to assess the impacts of the water management options. In this way, the BeWater team was able to produce a semi-quantitative estimate of the impacts of water management options and their ability to effectively face the challenges of the basin, as input to a multi-criteria analysis that was conducted in a series of Stakeholder Workshops.

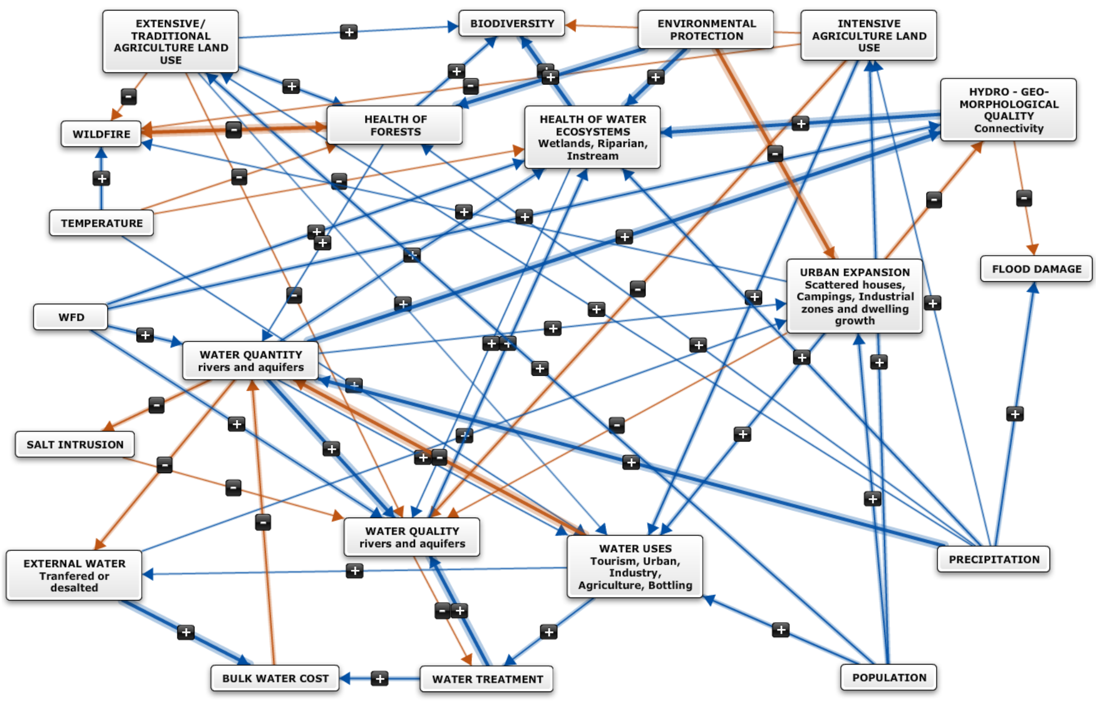

Figure 2: Fuzzy cognitive map of the Tordera river basin

As shown in figure 2, the narrative of the basin expressed through the graphical tool of the fuzzy cognitive map enables **representation of specific socioeconomic dynamics in the basin**. For example, there is a composition of relationships and weights between the factors “water treatment”, “bulk water cost” and “external water” which indicates a specific water management framework of the Tordera river basin, but the general nature of the relationships conveyed common to any water basin in the world. Thus, degradation of water quality always entails a reduction of water quantity available at local level and increased cost of water treatment. Bulk water costs increase accordingly and induce a trend by which growing scarcity is addressed by integrating local resources with non-conventional water production, such as desalination plants, and recycling strategies. High bulk water costs affect the choices of water supply operators, who will increase the quantity of water extracted

from local water bodies and/or import water from other rivers, through inter-basin water transfers.

Another example is the weighting and relationships depicted between forest management and water quantity and quality, reflecting the belief that thinning and clearing the forests would increase water availability in the basin. Workshop discussions revealed that this assumption is not generally shared by all actors, many of whom believe that forest management would not deliver water flows that would feed water bodies, but certainly would improve forest ecosystem health and the forests' ability to regulate local climate. It is worth mentioning that the "health of forests" factor is very strongly related to the "wildfire" factor, as well as the "biodiversity" indicator, intensifying and multiplying the effects of options that address the ecological state of forests. These assumptions and dynamics depicted in the fuzzy cognitive map have a strong influence on the impact assessment analysis of the different options identified.

Development of the water management options

Information related to the early ideas on how to tackle challenges identified was analysed in depth, and deskwork led to a first draft of **concrete water management options**. These were again presented to stakeholders in order to pin down and **characterise water management options**, as well as identify opportunities to integrate these new proposals into the local socioeconomic and political context. This process mostly involved the authorities responsible for water, agricultural, and climate change policies, as well as local councils through direct interviews and specific events.

The results of this process were presented to a broader range of stakeholders in a **complementary workshop**, where stakeholders went through two exercises: on the one hand they contributed to a list of proposed water management options linked to the challenges identified and validated the list; on the other, they helped to improve the mapping of the main factors.

The set of options identified seeks to answer the basin's challenges with particular emphasis on an **integrated management approach**, with increased citizen participation in decision making, policy design and implementation. The vast majority of options listed are soft measures, indicating that the most important challenge in the basin is to improve inappropriate water management practices and legislation to deal with adaptation to global change. In fact, participants in the different workshops and consultations all suggested water management options intended to optimise focused actions, provide flexibility allowing adjustments to changing conditions, and pursue collaboration between relevant stakeholders and authorities, for instance through the negotiation of direct agreements, the creation of spaces for deliberation, and the fostering of improved cooperation among authorities.

The information collected was then formatted for ease of inclusion in the methodology developed to design and evaluate the water management options. More precisely, the fuzzy cognitive map was finalised and the design and characterisation of 33 water management options was consolidated. All this information was structured according to a **modelling exercise intended to produce**

an impact analysis of the effectiveness of the different options in terms of facing the challenges of the basin.

Evaluation of the options: impact analysis and multi-criteria analysis

The impact assessment analysis, based on the interaction between the set of water management options and the fuzzy cognitive map, allowed for verification of how individual options may impact the basin. For example, all options have been linked to concrete challenges with a **cause-effect rationale**. The interaction between the basin's factors in the fuzzy cognitive map helped reveal how an option might have an effect on other challenges too, indirectly. This was especially noticeable in the case of challenge C, "water quality", where the strongest improvements are obtained by through the indirect impact of three options initially designed to have a direct impact on other challenges (challenge B, "health of forest and water ecosystems", and challenge D, "integrated water management").

The **fuzzy cognitive map impact analysis** was useful also in terms of identifying if a given factor was sensitive to a certain action. For example, options aiming to increase society's awareness of the impacts of global change show an overall positive effect on the river basin's development, but especially on forest and water ecosystem health and on biodiversity in general. Other crucial factors linked to water availability for different uses, such as "external water", "bulk water cost" and "salt intrusion", are less sensitive to awareness raising, as water use patterns are very resistant to change.

The results of the above deskwork were presented in a **second workshop**. This time, participants were required to select and characterise suggested criteria needed to evaluate the water management options by means of a **multi-criteria analysis (**MCA – see text box 3**)**.

In particular, participants commented on the **criteria** used as a reference for this exercise. Regarding the general nature of an option under discussion, stakeholders clearly indicated that **water demand management** and **environmental protection** are better approaches than supply-oriented options, and called for a water management model that prioritises **self-sufficiency of the basin**, taking into account the limits of water availability in all water bodies, both inside and outside the basin as such. Participants also highlighted the importance of **transparency of information** and sound communication to explain interventions designed to enhance adaptation to global change; they pointed out that these qualities enhance the acceptability of the options involved.

Participant engagement thus enriched the information and reviewed project outcomes for local implementability and accuracy by gathering ideas on specific places where these options would best be implemented, as well as data on similar experiences.

Text Box 3

Multi-criteria Analysis

Water management options have quite different characteristics and impacts on the river basin and the local communities. Selecting the specific options that should be included in the river basin adaptation plan is a complex endeavour. To support this process, a participatory multi-criteria analysis was conducted. During a workshop, stakeholders were asked to select the evaluation criteria to decide how well options perform, as well as the importance of each of these criteria in relation to each other. Criteria referred to both the design of the water management options and their expected impacts on the river basin, as estimated with the fuzzy cognitive map. The scores and weights of the criteria given by the stakeholders were combined with the characterisation of the water management option and the outcomes of the impact assessment to evaluate the water management options prepared by experts and the research team. The evaluation results are presented on a scale of 0-100 with a 0 indicating the least preferred evaluation outcome and a value of 100 as the most preferred evaluation outcome.

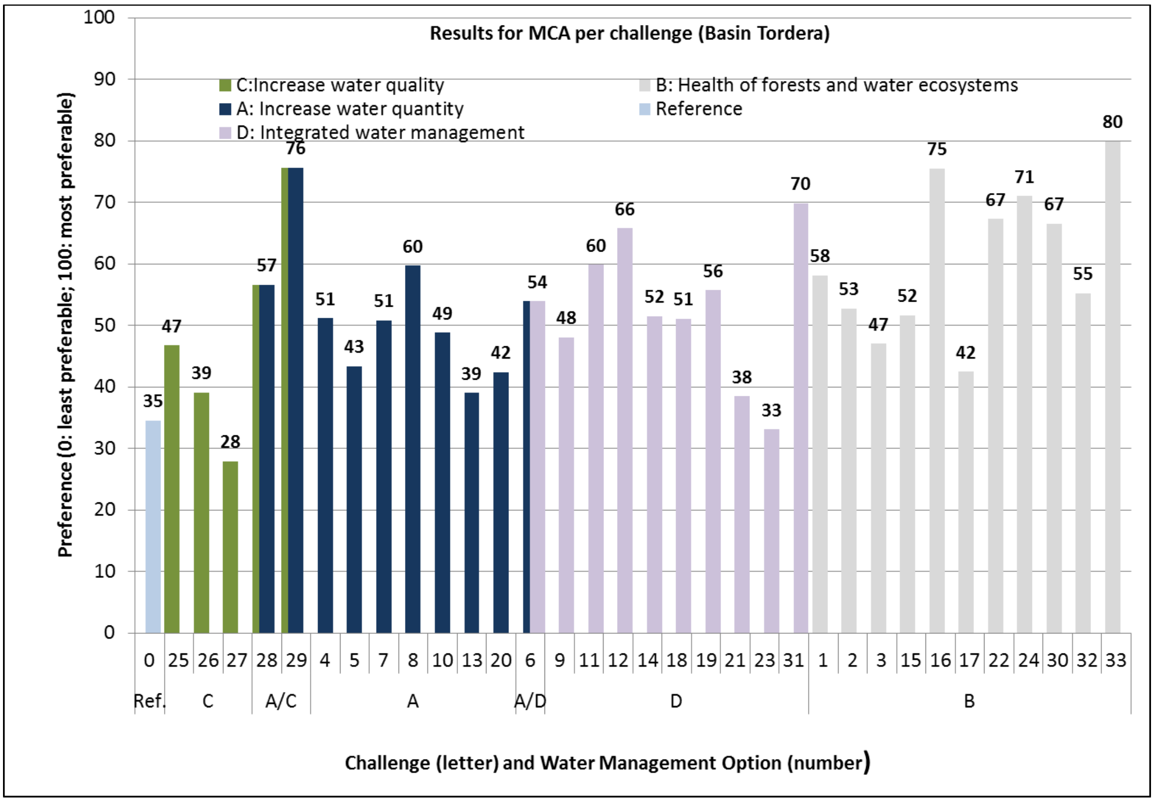

Figure 3: Outcome of the multi-criteria analysis based on criteria (and their changes) derived from the fuzzy cognitive map and the impact assessment. Numbers refer to the water management options in Table 2 and letters to the challenges reported in section 3.3.

The average preference score according to all the criteria applied for each option is its **final evaluation score**. Nevertheless, the specific ranking of each option resulting from the multi-criteria analysis was discussed, allowing for a shared interpretation of the options' final evaluation scores. For example, participants interestingly commented that flow regimes would be the result of the implementation of many other options tackling water uses, and shouldn't be considered as a stand-alone option because of the strong link to issues related to water quality and consequences for water use entitlements. Therefore, to restore and protect the territory's crucial ecosystems, participants called for a different approach combining economic development and natural resource management. Overall, options addressing the recovery of ecosystem functionalities, both directly or indirectly have much higher scores than the ones related to changing water and land-use patterns. **Stakeholders are aware that societal resilience to global change strongly depends on the state and functionality of ecosystems.**

The results of this process, once integrated, were presented to a group of 15 new stakeholders during an **open consultation**. This event made it possible to test whether results produced by one group of stakeholders in the basin would also be considered representative by another, different group of actors. The participants invited in this case live in the county called La Selva, near the Santa Coloma stream, a tributary of the main river Tordera, and had not participated in previous events. The findings of this exercise justify the statement that the process outcomes reflect the main perceptions of actors representing Tordera basin society.

Developing the River Basin Adaptation Plan (RBAP)

At this stage, additional information was gathered on the **policy context** related to the water management options, analysing the programme of measures included in water, agriculture, and adaptation plans and strategies, supported by direct communication with authorities (reported in section 3.3). The result of this process showed a high degree of compatibility and constituted an opportunity to raise interest in further follow-up. It also paved the way for a better understanding of how the stakeholders stood in relation to the proposed options.

The 33 options were structured in 4 bundles, based on the **identification of key options and potential co-benefits between these and the rest of options**, as described in chapter 4. This exercise was carried out by first taking into account all the information generated previously, including the priorities assigned to options according to the multi-criteria analysis. In view of the resulting bundles, considerations were formulated on the **timing of implementation**. Criteria taken into account included the estimated timeline for implementation and the time lag between implementation and effectiveness of each option, as well as the priority of the issues at stake and synergies with current policy agendas, such as the Water Framework Directive implementation calendar. Subsequently, information was compiled in a specific and structured manner for the bundles of options, developing **summary factsheets** (presented in section 4.1) and producing **tables** that describe individual options in detail (presented in Part 2).

To incorporate feedback from the Tordera stakeholders, a **third workshop** was organised, structured into two main sessions. During the first session stakeholders were presented the project's progress and they worked together to a) identify and

justify the estimated co-benefits between options included in the bundles, as well as double-check the formulation of the bundles as such; and to b) validate the implementation timeline (phasing) and the priority of the options. The second session involved a roundtable with policymakers and experts from the water, climate change, agriculture and forestry sectors, during which c) an introduction to the current policy context was discussed with the participants, brainstorming on barriers and opportunities for implementation. After this introduction, participants were invited to d) formulate more concrete contributions on this issue, as well as e) make contributions to the draft river basin adaptation plan structure. Furthermore, in this session BeWater took the opportunity to collect **feedback on lessons learned** and on the participatory experience in the project, as a first contribution to the handbook of lessons learned.

Finally, in a concluding round, stakeholders were asked to express their interest in getting involved in the **follow-up of the Tordera River Basin Adaptation Plan** beyond the activities strictly related to the project itself, and possibly as part of their ordinary job or activity in the basin. Participants expressed a positive and proactive attitude towards this request, also confirmed by the answers received in the final evaluation questionnaire. This intensive collaboration provided the main elements that fed into this plan.

Table 1: Overview of the participatory process workshops.

	Date and Place	Objective	Participants	Outcomes
1st Workshop	May 2014 San Celoni	current status and pressures on water bodies expected future status	23 participants representing municipalities, farmer associations, forest landowner associations, environmental protection NGOs, different industrial sectors, as well as authorities responsible for water, natural park areas and climate change policies.	Integrated diagnosis First ideas on how to tackle the challenges
Interviews	Between May 2014 and December 2014	Identify and overcome knowledge gaps	Those interviewed included experts on the economic development of the basin, representatives of the local water-bottling industry, agricultural development authorities and farmer associations at the county level, several environmental organisations, municipal and supra-municipal utilities, the authorities responsible for the Montseny Biosphere Reserve and Montnegre–Corredor Natural Park, tourism operators from the coastal area, and the director of the ethnològic museum.	The basin's narrative
Complementary Workshop	December 2014 Hostalric	Validate the FCM Link the WMOs to the challenges	18 stakeholders, four of whom had participated in the first workshop, and many new actors, such as researchers and public authorities covering relevant aspects which were not included during the first stage.	Integrated FCM First set of WMOs linked to challenges
2nd Workshop	June 2015 S.M.Palautorder a	Develop the MCA Formulation of WMOs	16 stakeholders. Ten had attended previous workshops, representing local and regional administrations, farmers, researchers among others; new stakeholders with a potential interest in the proposals developed were also included, like the Catalan Network for Sustainable Municipalities.	MCA results Consolidated WMOs
Complementary Workshop	October 2015 Riudarenes	Validation of the set of WMOs	15 new stakeholders representing researchers, teachers, environmental NGOs, municipalities, forest rangers and landowners	Validated WMOs
3d Workshop	April 2016 Sant Celoni	Co-benefit estimation Phasing/prioritisation Validation of bundles Policy framework RBAP structure Lessons learned	14 stakeholders. Ten had attended previous workshops and there were 4 new participants, including representatives of the Department of Territory and Sustainability, Department of Agriculture, and forest landowners.	Co-benefits Phasing/prioritisation Validated bundles Integrated policy framework RBAP structure Lessons learned

1.3 The Tordera River Basin

This section describes the Tordera basin's main features and provides an overview of the **current state and expected future state** of the Tordera land, water, biodiversity and people. In addition, **relevant legislation and policies** for the set of water management options are listed and described, and the chapter concludes with an overview of the main **challenges** identified for tackling global change in the Tordera basin.

1.3.1 *Current status and dynamics*

1.3.1.1 Biophysical description of the river basin

The Tordera river basin is located in the northern part of Catalonia, in northeastern Spain, and features Mediterranean climate conditions overall, but with a high climatic diversity, ranging from the temperate mountaintop areas at the headwaters to typical Mediterranean conditions in the delta area (Fig. 1.1).

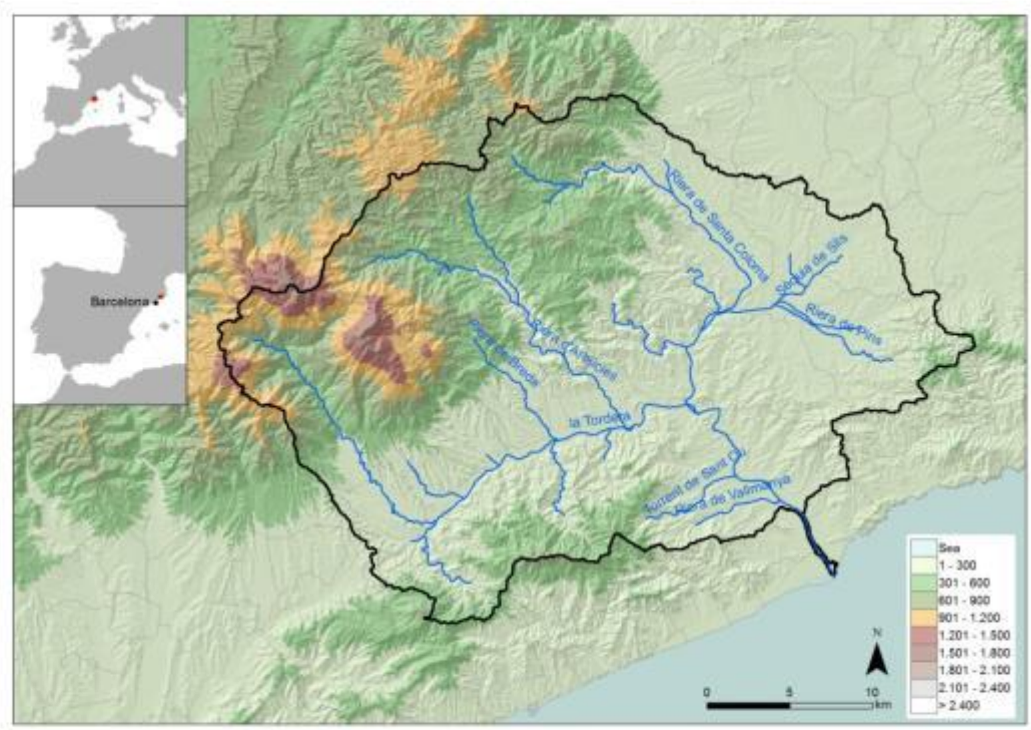

Figure 4: Geolocalisation of the Tordera river basin. Source: CREAF, 2015

The Tordera river flows for 55 km along the Catalan Pre-Coastal Range through 3 counties; Vallès Oriental, Selva and Maresme, and covers an area of 894 km^2 in the provinces of Barcelona and Girona, **81% of which is covered by forests** [32]. Different forms of environmental protection safeguard its rich biodiversity: some areas are included in the Catalan Network of Natural Protection Sites, a number of them have been declared Sites of Community Importance and there are two natural parks, Montnegre–Corredor and Montseny, the latter designated in 1978 by UNESCO as **a Biosphere Reserve**.

The Tordera river is part of the **Catalan Internal River Basin District** [33]. It has an average flow of 5 m^3/s with a torrential regime. The main course of the river receives two tributary streams: Arbúcies and Santa Coloma, located north and northeast of

the main course. The Tordera is characterised by intense flooding episodes called *Torderades*, and river dynamics lead to bends, generating fertile riparian areas often used for agriculture and short-rotation timber production.

1.3.1.2 Land use, land-use change and water demands

Historically, most agricultural land was located in the alluvial plain of the river mouth area and riparian areas along the whole river. Starting from the 1970s other activities were developed in the area of the river, such as garden centres or industrial areas as well as inter-regional transport infrastructure (highways, railways, gas, oil and water pipelines). This process led to building on the hillocks and canalisation of the main riverbed in different locations, which in turn brought about high fragmentation of the basin's territory.

Land use has changed in the Tordera river basin over the past decades. Between 1993 and 2005 there was a slight **increase of forest land** and a reduction of farmland caused by the **abandonment of some agricultural areas**, especially pastures. As a consequence of these land-use and land-cover changes, several species that are mainly dependent on the existence of human-made open habitats have been reported to be receding. Conversely, **urban areas doubled** between 1993 and 2005, occupying around 9% of the basin, especially the delta region. The river basin has a human population of approximately 111,800 inhabitants [34], with an imbalanced distribution exacerbated by major **fluctuations in the tourism season**, when the population of most coastal towns doubles or triples. Given the richness of its natural landscape, as well as the basin's proximity to Barcelona and the Mediterranean Sea, tourism-related development is particularly intense.

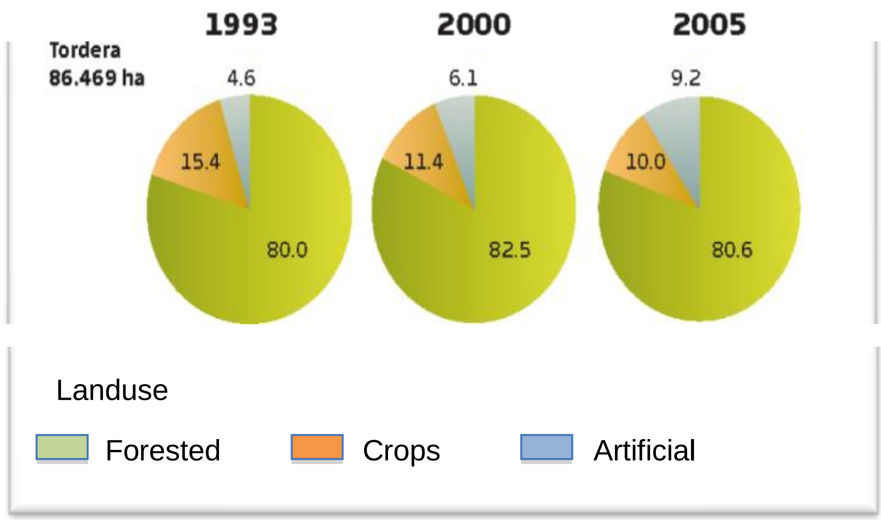

Figure 5: Land use changes in the Tordera Basin [34]

Strong water demand causes river water **uses** to **exceed availability**. Therefore, water management has been mostly supply-oriented: a desalination plant and connection to **inter-basin water transfer systems** integrate locally available water resources with external water [35]. In fact, given that there are few water-regulating

infrastructural facilities for the main course of the Tordera, **groundwater** flows are currently far more important than surface water for supplying all users.

In the central part of the basin (where water for agriculture is extracted from the river itself) and in the lower part (where it is extracted from groundwater), **agricultural water demand competes directly with urban water demand**, especially in the summer. Most agricultural water demand is concentrated in the lower part of the river basin, and the Tordera aquifers also supply water for intensive horticulture to areas outside the Tordera basin boundaries, in the coastal area of Maresme County. This coastal area is therefore included in our analysis, although formally it is not considered part of the Tordera river basin district. Falling groundwater levels in this area due to intense water extraction are currently causing strong **seawater intrusion**, and hence salinisation of groundwater for several kilometres inland.

The **lack of consistent river flows** has changed stream and sediment dynamics over time. Consequences include, for instance, **loss of connectivity** between the river and shallow aquifers in certain sites, whereas a highly permeable geological mosaic characterises the hydrogeology of the basin, where surface and groundwater are very much interconnected [36].

1.3.1.3 Climatic trends in the river basin

Historical climate analysis (1951-2000) for the Tordera basin was undertaken and future climate change impacts (2001–2100) were assessed during the ACCUA Project and related studies [37] [38] (climate projections ECHAM5/MPI-OM [39] [40] combined with the A2 and B1 scenarios developed by the International Panel on Climate Change [41]).

Historical climatic trends in the Tordera basin, similar to the rest of the Catalan coastal region, revealed that during the 1951-2000 period, **temperatures rose by around 1.25ºC**, with considerable increase in winter and summer maximum temperatures [42].

Annual precipitation trends did not reveal statistically significant changes in the period 1928 -2000, although significant **change in rainfall patterns** was recorded, with less precipitation during the months of July and March, but more precipitation in January. The figures are particularly perturbing as the month of March is a crucial time for water bodies to recharge before spring and summer, to supply natural ecosystems and agriculture.

The results of the above-mentioned ACCUA project indicate that the impact of changes in the basin’s climate could be very intense:

- Scenarios A2 and B1 predict that temperatures may rise by 0.5ºC and 0.7 ºC respectively between 2006 and 2030, and by as much as 3.6 ºC and 2.4ºC respectively by 2100. (Fig. 6 a)
- Precipitation may decrease by 6.5% and 5.4% in the period 2006-2030 for scenarios A1 and B2 respectively (Fig. 6 b).

Most important are the projected changes in yearly rainfall patterns, which show that summer, already the driest season in this climate, would be the season with the

highest decreases in precipitation for both scenarios. These projected changes in rainfall patterns may entail an **intensification of summer droughts**.

Projected precipitation data also indicate a more frequent occurrence of **extreme wet and dry episodes for the future** [43]. Due to urban expansion in the river space, the risk of **flood damage** would increase [44].

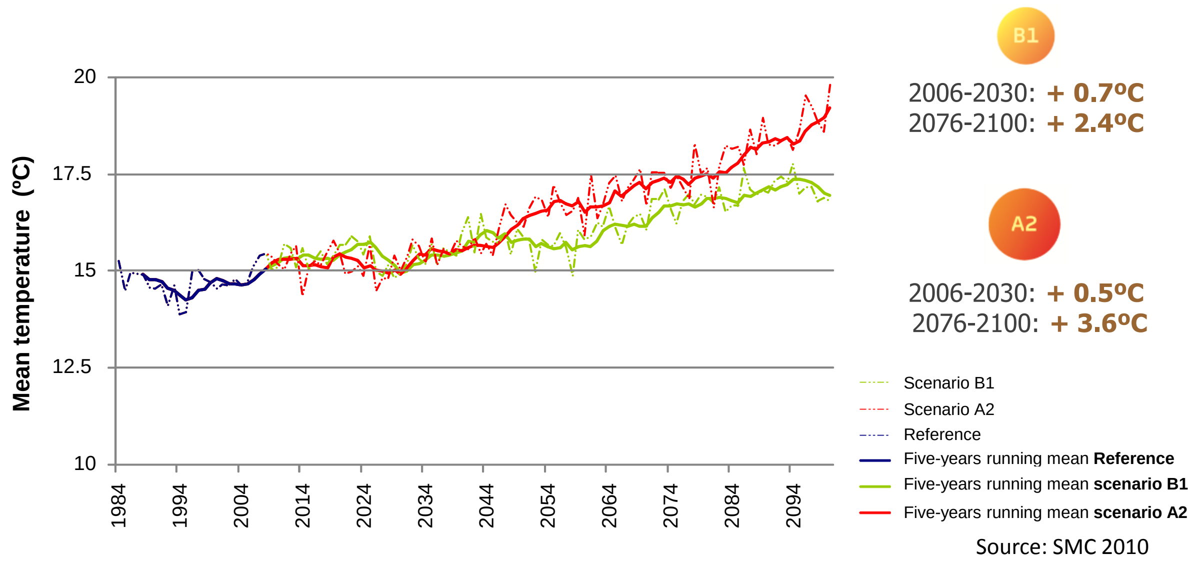

Figure 6 a: Future temperature trends [34]

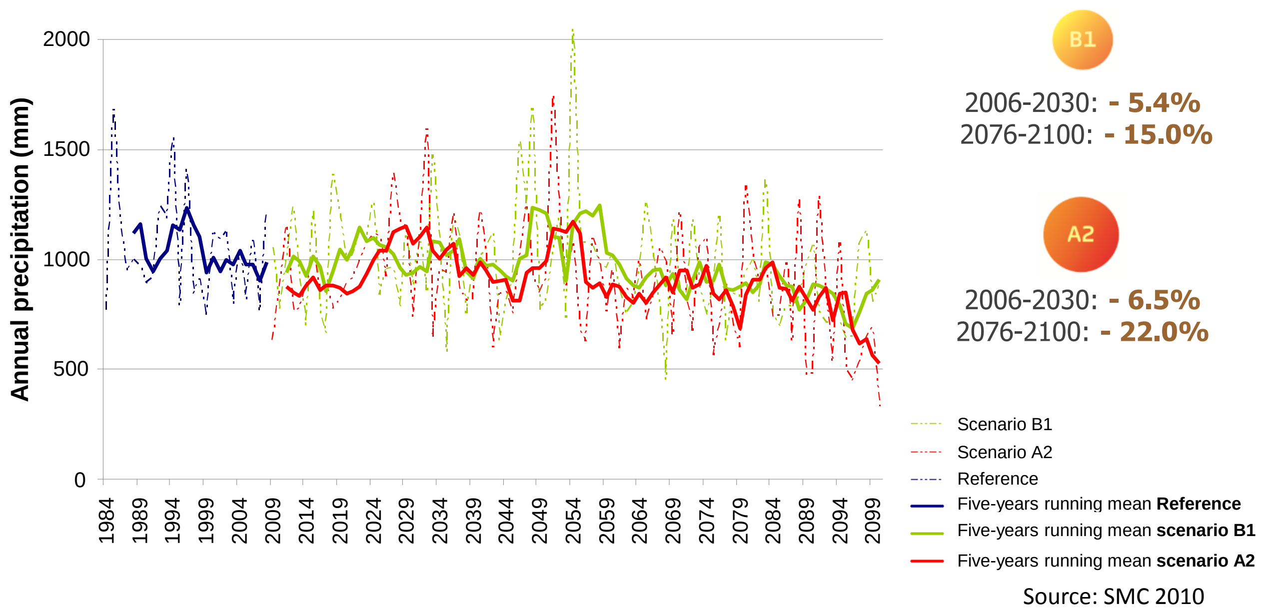

Figure 6 b Future precipitation trends. [34]

Both surface and groundwater availability would be affected by the medium- and long-term projected **reduction of natural flows**. The 152.6 hm^3/year flow that the Tordera carries today may decrease by almost 17% by 2030 compared to the reference period 1984-2008, and at the same time, groundwater recharge would decrease by almost 10%. The highest reductions of stream flow are expected in the headwaters, affecting environmental flow regimes for the whole basin under current

extraction rates. Long -term projections indicate a stream flow reduction at the river mouth by the end of the century, more severe for the A2 scenario (37%) compared to the B1 scenario (25%).

These impacts on the basin's natural hydrologic cycle are expected to increase the **disconnection between water bodies**, strongly affecting both water quality and quantity, especially **endangering wetlands and the delta area of the river**. The latter will probably face many related consequences: dropping levels of groundwater would **intensify seawater intrusion**, and disruptions of sediment dynamics would worsen the **erosion of beaches and dunes**. Moreover, **marine fish populations** and their abundance are strongly dependent on the freshwater nutrients provided by the Tordera. Therefore, the impacts of global change considered for continental waters need to be integrated with those referring to marine environments, in line with the objectives of the Marine Strategy Framework Directive (MSFD - 2008/56/EC) [45].

Temperature rise and changes in rainfall patterns will cause an **overall increase in water demand for irrigation** and reduce the productivity of heat-sensitive crops. Nevertheless, these climatic conditions may also influence the vegetative cycle of some species favourably, changing the crop management calendar and offsetting the impact in terms of water demand.

Rising temperatures will also affect people living in the basin, with **more tropical nights and heat waves disrupting personal comfort.** More diseases and extreme events will be added to the already complex composition of risks people are likely to be exposed to. Moreover, the Tordera basin population has experienced a noteworthy increase over the last decades [46] and this trend could be plausibly maintained in the coming decades. Therefore, in the future, the pressure of water demand on water bodies will increase, challenging the local population to manage resources in a way that balances economic development and environmental protection.

1.3.1.4 Expected impacts of future land use change

In addition to climate change, future land use changes may have a major impact as well: abandonment of agricultural land entails the expansion of forested areas, **increasing overall evapotranspiration of the vegetation** in the basin. Moreover, as these forested areas are not properly managed, excessive underbrush growth combined with rising temperatures due to climate change will most probably entail **higher risk of wildfires**. Projected climate change may induce important variations in forest ecological functions, such as an increase in **tree mortality** and a **redistribution of the suitability of tree species** in the area. Projections indicate that by the end of the century forests may change from carbon sinks into carbon sources, highlighting the importance of forest management in the basin to face global change.

In the future, **the strategic role of groundwater will increase**, given that underground water bodies are less susceptible to climatic variations and can offer more reliable water provision. Nevertheless, overexploitation, pollution and salt

intrusion need to be tackled to achieve increased resilience to foreseen **reductions in groundwater recharge rates**.

Similarly, **good hydrogeomorphological quality will become more important**, allowing buffering of floods, increases in sediment mobility, and enhancements of both hydrological and ecological connectivity. Nevertheless, infrastructure present in the riverbed hinders the **recovery of river space** in some areas, especially in the central section of the river. Flooding damage to such infrastructure is also likely to increase, entailing considerable risks for people (transport facilities) and for the environment (pollution due to oil and gas pipelines as well as chemical and pharmaceutical industries). Spatial development policies should take into account the impacts of industries on the basin's resilience, as well as the vulnerability of these industrial areas to climate change, like flooding and drought.

1.3.2 *Policy Context*

The Tordera River Basin Adaptation Plan has taken into account existing plans and programmes currently in force, through literature review and through the active involvement of some of the authorities in the participatory co-creation process. This section describes the policy lines relevant to this plan's water management options, without aiming to be exhaustive. A more precise account of the correlation between each option and the concrete policy lines that favour its implementation is described in Part 2 of this plan. This exercise made it possible to contextualise the options, **enhance opportunities and identify barriers** to the eventual implementation of the actions proposed.

Water management planning for the Tordera basin waters is regulated under the **Spanish water law** (TRL art. 81 [47]) and implemented by the Catalan Water Agency[2] as part of its jurisdiction over Catalan river basin districts. The Agency's area of influence comprises 17 river basins entirely located in the Catalan region. Therefore, specific water management actions relevant for the Tordera basin are embedded in the overarching **river basin management plan (RBMP)** [48] for the Catalan river basin district, including **a plan of measures** [49]**, a flood risk management plan** [50], **an urban and industrial water treatment programme** [51], **and a monitoring and control programme** [52].

While the project was under way, the agency released a draft River Basin Management Plan with a 2016-2021 horizon, in accordance with the schedule of the Water Framework Directive (and related directives) [53]. This constituted a great opportunity to promote the integration of adaptation options into mainstream water planning. The water management options put together by participants in the Tordera were included in the participation and consultation processes pertaining to this River Basin Management Plan. These water management options therefore benefited from two crucial aspects: they received formal, legally grounded feedback as part of an official procedure, and they were taken into consideration for inclusion in the new River Basin Management Plan.

[2] Agència Catalana de l'Aigua

Rural development plans, different forest management programmes, programmes for environmental protection, fishing, and hunting, as well as innovation and educational programmes, are all designed and supported by the **Catalan Department of Agriculture, Livestock, Fisheries and Food**[3] [54]. The Department's county offices in Vallès Oriental, Selva and Maresme support the processing and payment of subsidies to farmers and to all the target populations of the plans and programmes designed by the central office.

The **Rural Development Plan** [55] includes a set of measures intended to reinstate favourable conditions for improving **irrigation efficiency** [56], with plans for new areas where pressurised irrigation is to be installed in line with Spanish national policies [57]. The plan aims to sustain more resilient agricultural practices in a broad sense, fostering crop diversification, organic farming and technical advisory services in general. Of particular relevance for this River Basin Adaptation Plan is the **Livestock Development Plan** [58], containing crucial elements for the recovery of grazing activities in forested areas. Measures include fostering generational turnover, structural investments, and commercial strategies that increase the added value of products obtained through extensive livestock farming. In addition, these goals are underpinned by the **Proximity Markets Decree of the Catalan Government** [59] and the **Innovation in the Agri-Food sector** programme of the Catalan Department of Agriculture, Livestock, Fisheries and Food [60], intended to create a favourable legal framework and economic incentives for marketing of these kinds of products.

The basin's forested areas are managed by the **General Forestry Policy Plan** [61], including different strategies to improve the health of forests, such as selective thinning or encouraging biomass production to promote the economic viability of understory vegetation removal. This plan also contains the protocols for specific management plans [62] aiming at increasing and improving forest management practices. For the Tordera headwaters, forest management is also supported by the **Montseny Biosphere Reserve Conservation Plan** [63], a comprehensive document that both analyses the current biodiversity conservation needs of the natural park and formulates numerous measures aiming at harmonising local socioeconomic development with conservation objectives. In the lower section of the river, the **Montnegre–Corredor Natural Park** also develops different measures along these lines, but through specific, targeted projects.

The **System of Natural Protection Areas in Catalonia** [64], a combination of plans and programmes, also enhances measures aiming at nature and resource conservation, namely the Natura 2000 networks. These areas are managed by the **Catalan Department for Territory and Sustainability**[4] [65], a department with planning responsibilities for water, waste, urban development, transport and the environment, at different levels. This department is responsible for zonal planning in the whole region, relying on the guidelines of the **Territorial Plan for Catalonia** [66], and promotes integrated strategies for coastal protection through the implementation of the **Catalan Coastal Law** [67]. These policies are crucial for adaptive management in the Tordera: the transition zone between continental and marine

[3] Departement d'Agricultura, Ramaderia, Pesca i Alimentació

[4] Departament de Territori i Sostenibilitat

environments is on the frontline of the impacts of changing coastal dynamics and hosts one of the most developed areas in the basin.

The Catalan Energy Institute[5] [68] promotes relevant mitigation policies, and the **Catalan Energy and Climate Change Plan (2012-2020)**[69] was in force during the project development. This plan aims to coordinate energy-related strategies at local and regional level, taking into account national and European policies, as well as integrating sectoral plans and policies, especially those related to territory and environment. The Tordera stakeholders acknowledge the relationship between water and energy consumption and formulated one option to enhance the use of renewable energy sources that could be sustained by these policy lines.

Local governments have a crucial role in the implementation of the above-mentioned policies. **Municipalities** located inside the perimeter of the biosphere reserve are actively engaged in the development of management strategies to protect and maintain this area. Specific working groups are in place, where local sectoral policies are negotiated and best-practice guidance is provided. In other areas, such as the headwaters of the Arbúcies and Riera de Santa Coloma streams, municipalities are in charge of implementing different environmental protection forms to protect the habitats necessary to support the rich biodiversity of the basin, like Natura 2000, and areas of special interest for certain species.

The policy framework presented depicts the diversity and complexity of plans and programmes dealing with different aspects related to the building of resilience in Catalonia. This is one of the main goals of the **Catalan Office for Climate Change**[6] [70] in promoting the necessary adaptation policy framework and action programmes. In the course of the project, the Office released a new draft **climate change law** proposal, which was submitted to citizen participation and has now been put to the Catalan Parliament [71]. This legislation was developed through a participation process designed and organised together with the Department of Governance and Institutional Relations[7] [72], in order to collect and formulate realistic and concrete regulatory proposals aiming to integrate climate change–related dynamics into sectoral policies. The new **Catalan Transparency Law** [73] supports the consolidation of participatory practices in policy design, opening up the opportunity to consolidate adaptive management policies that rely on sustained citizen and stakeholder engagement.

Increasing knowledge on adaptation is crucial to develop suitable policies to face global change, as stressed by the **National Adaptation Plan** [74]. Therefore, the legislative process is also underpinned by the development of a **Catalan Adaptation Strategy** [75] supporting the adoption of adaptation principles in all sectors through a concrete set of measures. Thus, the strategy includes the possibility of developing municipal action plans, helping municipalities to put in place specific initiatives to install preventive policies against extreme events and develop coordinated action

[5] Institut Català d'Energia
[6] Oficina Catalana de Canvi Climàtic

[7] Departament de Governaciò, Administracions Pùbliques i Habitatge

protocols and resources in order to be able to effectively deal with the needs of society in the Tordera basin when they arise.

Implementation of the relevant legislation and the required coordination of the measures included in the Catalan Adaptation Strategy can rely on a high level inter-departmental committee on climate change, created to face the cross-cutting issues on the table.

In fact, lack of institutional coordination preventing an integrated approach is one of the strongest **barriers** to policy optimisation and prevents the complete fulfilment of the opportunities offered by adaptive management to reduce societal vulnerability: different policies may be mutually contradictory, or even negatively affect the goals pursued. This is the case when sectoral development policies seeking to increase the productive capacity of the territory (e.g. through tourism or farming) hinder other policies aiming at improving water bodies' ecological status, such as the implementation of an environmental flow regime. Therefore, adaptation calls for new forms of policy design, promoting an integrated approach with a single overarching common goal: the reduction of societal vulnerability to the impacts of global change.

Furthermore, BeWater participants consider access to **funding** a major barrier for developing adaptive solutions. Especially for the stakeholders operating in agriculture and forestry, the **bureaucratic intricacies** involved in obtaining funding are so complex that many people refrain from applying for subsidies. Tordera participants feel that the administration should provide citizens with better guidance to develop their applications, and also that citizens should take a more **proactive approach**. The joint involvement of many actors would enhance future investments and induce the administration to improve **governance practices**. To complement existing participatory sessions on water management, the creation a Permanent Participation Centre for the basin (PPC-WMO12) would constitute a strong opportunity to tackle these challenges. Participants also considered that improved and consolidated citizen participation would allow a shift away from policies strongly oriented at protecting private interests towards a more inclusive approach, by raising awareness of the magnitude of the risks that such policies entail in the face of global change.

Similarly, policymakers participating in the project stated that global change could be considered an opportunity to improve those practices that “we all know we should improve”, but where change is hampered by political conflict. Therefore, a local, detailed, bottom-up river basin adaptation plan is of great value, and currently there are funding lines in Catalonia that can be spent on specific initiatives like those included in this plan. In this policy context, **the Tordera River Adaptation Plan is a complementary tool** for improving the adaptive capacity of existing management arrangements.

1.3.3 *Main Challenges*

This sub-section presents the main challenges facing the river basin, based on the stakeholder contributions and the narrative developed with them.

Challenge A: Water quantity

The **lack of an adequate environmental flow regime** was identified as the most important factor for the bad ecological status of the water bodies in the basin. Similarly, stakeholders considered anthropogenic pressure on the basin's water as the main challenge in the basin.

The current number of gauging stations is considered inadequate, and **data available insufficient to adequately monitor** present river flows. In many municipalities people still have private wells dating from the 1950s through the 1970s, and it is believed that many of these are not correctly registered, a fact that hampers adequate oversight of extraction rates. Stakeholders considered that the overall functioning of the control and monitoring plan to ensure compliance with the water quality standards outlined in the Water Framework Directive (WFD) is insufficient throughout the basin.

The Tordera basin's **groundwater bodies are officially declared overexploited** [76]. Water extraction from shallow aquifers for irrigated horticulture in the coastal area is causing **saltwater intrusion**, while **bottling industries** located in the upper part of the river extract large quantities of high-quality water from deep wells. According to studies of the Montseny Natural Park[8], the groundwater extraction rate in 2002-2003 was higher by a factor of 20 with respect to 30 years ago; and compared to measurements made in 1988-1989, extraction rates tripled over the last 15 years. These changes to water bodies negatively affect 34% of flora and fauna and 50% of habitats of interest for environmental protection objectives related to the Montseny Biosphere Reserve Conservation Strategy [77]. This trend also applies to other parts of the basin, such as the **wetlands** located in Sils, whose valuable ecosystems are almost entirely dependent on groundwater levels.

Unconventional water production (e.g. desalination and wastewater reuse) is currently one of the main proposals intended to address the lack of water for some uses. According to some stakeholders these projects are crucial for adaptive water management strategies to overcome trade-offs between bulk water cost, water demand and water availability. The Tordera basin has a desalination plant operating since 2002 and expanded in 2007, as well as several water reuse initiatives. Nonetheless, other stakeholders indicate that these solutions also entail significant impacts, such as **increased energy consumption**, **concentration of pollutants** and, paradoxically, **reduction of river flows**, because surface water bodies in many cases strongly depend on wastewater flows, and recycling would reduce the amount of water returned to the stream after use [78].

Water supply is highly dependent on energy consumption. For example, desalination facilities planned to address average water demand in Catalonia will have a capacity of about 70 Hm^3/year, accounting for 0.12% of total energy consumption in the region [79]. Therefore, it is particularly relevant to evaluate the overall suitability of options related to water recycling and desalination where the **trade-off between water availability and energy consumption** is particularly high. Energy efficiency is strongly related to water-saving opportunities (the less water consumed, the less energy consumed) [80].

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[8] Parc natural i Reserva de la Biosfera del Montseny

The Tordera river is connected to an **inter-basin water transfer system** with the aim of achieving higher flexibility of available volumes for supply [81]. The idea is to enhance the opportunities to supplement local resources with those flowing in this regional distribution system, especially in times of drought. Unfortunately, this strategy is building expectations among the citizens in the basin that water availability will not be a problem in the future. The inter-basin water transfer system depends on the flows of other rivers (Ter and Llobregat) also affected by growing demand, lack of implementation of environmental flow regimes, and drought, similar to the situation in the Tordera basin. Bulk water costs, which municipalities have to pay to access this resource, are considerably higher than the cost of local resources, and municipalities do not have a strong bargaining position when they deal with the large corporations managing the inter-basin water transfer system. In a nutshell, all stakeholders viewed **the basin's self-sufficiency for water availability as an important challenge**.

Challenge B: Health of forests and water ecosystems

The Tordera river basin society emphasised the need to **integrate forest management practices as a strategic element of water management in the river basin**. Unattended forests are currently undergoing excessive biomass growth and high tree mortality, making them more vulnerable to wildfires and affecting the quality of the forest ecosystems. As most forests are private, public policies for adaptation need to be geared to encouraging good practices by landowners, rather than formulated as direct interventions. Therefore, the challenge of environmental protection, although it is a government responsibility, is strongly linked to the action of the forestry and agriculture sectors [82].

The **disappearance of traditional animal husbandry** has had an important impact on forest structure, resulting in fewer open spaces and meadows as well as more understory vegetation, which affects **wildfire risk**. Stakeholders from the agricultural sector say that extensive livestock farming cannot be reinstated without proper funding programmes, as current activities **cannot reach economic profitability**. In their opinion, livestock management practices related to underforest management are laborious and lower the already fragile economic viability of livestock operations in the area. Therefore, if this activity is promoted as an option for forest management, it would have to be entirely dependent on subsidies – a finding that gave birth to the phrase *"civil servant sheep"*. Moreover, current subsidies to the agriculture and livestock sectors were said to be leading to undesired effects [83].

Stakeholders envision the overall challenge for the basin in terms of moving past the currently **imbalanced land use mosaic**, combining arable land, forests, areas of natural interest and urban areas, in such a way that it enhances the capacity of the territory to develop and maintain itself.

Montseny Natural Park authorities point out that the exclusive pursuit of economic profitability in forest interventions had led to the **use of non-native or unsuitable species**, the black poplar being a case in point. Such species, introduced by humans

or colonising degraded habitats, endanger the biodiversity of the park (in terms of climate, pests and ecological functions) [84].

Adaptive forest management strategies and maintenance of native forest species is fundamental to ensure healthy forest ecosystems more capable of withstanding stressful global change conditions, as well as to **avoid loss of biodiversity**.

In relation to **water ecosystems**, an incorrect river flow regime, existing pressure and impacts on riparian vegetation, and infrastructure impeding connectivity between habitats are giving some invasive species (mostly fish and riparian vegetation) a prominent role in local ecosystems. **Colonisation of the basin's habitats by invasive species** affects land- and water-related ecosystems in different ways: reducing populations of native species, increasing those of specific pests, reducing water quality (e.g. in case of algal blooms) and affecting water quantity (e.g. eucalyptus trees).

River hydromorphology is significantly modified by infrastructural works traversing the region: the riverbed hosts gas and oil pipelines, a high-speed train track, highways, high-voltage power lines, and water pipelines. Moreover, **gravel extraction** from the riverbed in the past made the bed significantly deeper, affecting flooding dynamics and connection with groundwater. **Sediment mobilisation** – highly dependent on river flow regimes and river morphology – is disrupted, causing **increased erosion of the coastline**, too. Hydromorphological quality is strongly related to the quality of water- and land-related ecosystems, determining water temperature, flow speed, turbidity, and the health of riparian vegetation, inter alia. Therefore, **restoring the functionality of the river space** is a crucial challenge in the basin.

Challenge C: Water quality

Drinking water quality in the basin is very high on the agenda, due to a faecal bacteria pollution episode that made 650 people ill in Santa Maria de Palautordera in 2002 [85]. The water utility reported that pollution was due to uncontrolled urban wastewater discharge by upstream municipalities, and the incident caused great and still-persistent mistrust of tap water quality among the local population.

The installation of **wastewater treatment plants** is considered a challenge in the basin. Many small towns and dwellings, especially in the upper part of the river, have no treatment facilities and discharge their wastewater directly into the river. Although specific treatment development plans are in place, both for industries and towns, the **lack of a solid funding scheme** and sound coordination between public administrations is a major obstacle to increasing the quality of river waters.

Problems related to water quality also affect the **management of infrastructure and treatment facilities**. This is illustrated by the case, reported by stakeholders, of drinking water supply to Tossa de Mar, Lloret de Mar, and Blanes in the 1950s and 1960s, when demand rose due the development of tourism. Tossa de Mar and Lloret de Mar integrated their water supply with wells in the Tordera aquifer, but these wells

contained high levels of iron and manganese, so that additional treatment became necessary. The Costa Brava Consortium (CCB)[9] was formed to handle the cost, and currently provides bulk water to 27 municipalities of the area, under direct assignment by the Catalan Water Agency[10]. Aquifer quality constrains drinking water quality and quantity, so wells positioned close to the coast must have a lower extraction rate than those located further inland, to avoid increasing salinity rates. Municipalities are therefore engaged in **difficult negotiations on the bulk water price** set by the Costa Brava Consortium and by the desalination plant in Blanes (managed by Aigües Ter Llobregat - ATL), as some have greater need than others to integrate their supply with the (expensive) desalinated water [86].

Challenge D: Integrated Water Management

Stakeholders indicated that they do not have sufficient **access to relevant information** on the basin's water management. For example, information on the exact amount of water extracted by bottling industries is not available to citizens, nor even to the Water Agency [87], as this activity is regulated under mining legislation and protected by industrial information rules. Citizens stated that their basin is providing 28% of all mineral water consumed in Spain and that "*more water flows through the highway than through the river"* [88]. This is only one example of why lack of access to transparent and relevant information is considered a major challenge for sound adaptive water management and citizen participation. Society in the Tordera basin experiences **water governance** as insufficiently democratic, demanding better practices and specific deliberative spaces to cope with the basin's challenges.

Moreover, **water use entitlements** are considered to be less than ideally managed; currently assigned water quantities add up to more water than actually flows in the river, **making water scarcity the direct result of management practices**. Entitlements are legislated by Spanish authorities and responsibilities shared with the Catalan Water Agency, but the Catalan administration claims it has limited bargaining power to introduce any changes, given the current jurisprudence on the matter and the fact that any potential agreements would need to be voluntary. On this issue, the main challenge reported is that, in order to reclaim the water entitlements needed to implement an environmental flow regime, the Agency is required to compensate users for loss of earnings until the entitlement expiration date, entailing unaffordable and unjustified costs. This is particularly challenging with regard to **long-term service contracts** awarded to water supply and treatment companies.

The **economics of water** is a major issue, as Catalonia is experiencing significant problems funding proper construction, operation and maintenance of water supply infrastructure. The challenges have to do with the distribution of responsibilities, inconsistencies in bulk water costs, **water pricing design**, and the **management objectives** set for water supply and treatment facilities. Indeed, companies operating

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[9] Consorci Costa Brava
[10] Agència Catalana de l'Aigua

water production and distribution systems need to prioritise economic management criteria to keep the business running, while public administrations need to guarantee a high-quality water supply to all citizens as well as healthy water bodies and related ecosystems. Since direct catchment from water bodies is cheaper than unconventional resources, and since cost recovery is proportional to the volume of water sold, **purely financial business criteria are in open contradiction with the general interest,** which is to protect water bodies and reduce consumption levels.

Beyond this contradiction, the basin has many tourist facilities, including hotels, scattered houses with swimming pools, camping sites, harbours, and so forth, as well as transport infrastructure and supply services. This entire infrastructure is designed to meet **peak demand** in the high season for tourism, but the costs of operating and maintaining this capacity fall on the shoulders of the year-long resident population. This situation is considered unfair by residents, and leads to intense debates on water pricing in the basin, especially in the delta area.

To ensure adaptive management practices, public authorities need to face the major challenge of achieving **better coordination** at all levels. Stakeholders pointed out that many policy objectives are not met due to **contradictory sectoral policies** and **perverse subsidies** [89]. For example, the Department of Agriculture[11] is promoting expansion and consolidation of irrigated agriculture while water authorities need to reduce the volume extracted from Tordera aquifers. Similarly, municipalities would welcome more coordination and better dialogue with the Catalan Water Agency, on matters such as the development of wastewater treatment plants. Lastly, to promote the implementation of important measures, municipalities feel a need for better coordination among themselves on issues related to spatial planning and others.

[11] Departament d’Agricultura, Ramaderia, Pesca i Alimentació.

1.4 Adaptation Actions

The following sections provide a **general overview of the water management options** and suggested bundles of individual options that emerged from the process.

First, the whole set of options is outlined in terms of its main characteristics; next, the information is presented in keeping with the bundling process described in section 2.3, including a basic description of the actions involved, phasing in time, and opportunities for implementation. For more detailed information on the concrete features related to each option, please refer to Part 2 of this plan.

This chapter concludes with some points on **monitoring of the options** and on the eventual implementation process.

1.4.1 *Context*

To address the challenges they had first identified, stakeholders were invited to contribute to the formulation of potential water management options. Their answers led to the identification of 33 water management options (WMOs) for the Tordera river basin, described in detail in Part 2.

Table 2 lists the options and presents a selection of additional information associated with each one. While the options are grouped into **bundles** in the present chapter according to their synergistic interactions and common objectives they contribute to, this table provides an overview of information to individual options. This information can be used by decision makers when determining which single option or options would be most appropriate to achieve their targeted objectives.

More specifically, for each option the table lists one or more of the **challenges** identified for the Tordera basin (see Chapter 3) and provides the option's score from the **multi-criteria analysis** exercise. The stakeholders arrived at the score (ranging from 0 to 100) by assessing each option's impact on the river basin and assigning weights to the relative significance of option features and impacts. A higher score represents a stronger overall performance than that of possible alternatives in view of the criteria that mattered to local stakeholders (see Box 3 for further information about the multi-criteria analysis).

Each option is further characterised by a set of additional implementation-oriented factors, such as its **feasibility, acceptability** and **policy synergies**. These factors help to determine whether there will be barriers to the option's implementation or, conversely, whether there may already be elements in place that facilitate its implementation. The **costs** represent an indicative estimate of the full cost of implementing the water management option and can be used to determine which options fall within a given allocated budget. Finally, the **priority** associated with each option, reported in the section describing the adaptation pathway, is a combination of how an option performs according to stakeholder preferences and implementation-oriented factors evaluated through expert opinion.

The information presented also enables stakeholders to compare the various options and identify individual ones that fulfil desired expectations, such as selecting an option which addresses a specific challenge within certain cost limitations, while meeting an individual criterion such as having high "acceptability".

Out of 33 water management options, there are seven addressing water quantity (Challenge A), ten addressing health of water and forest ecosystems (Challenge B), four addressing water quality (Challenge C) and nine addressing integrated water management (Challenge D). Several options address more than one challenge: two address both water quantity and water quality, and one addresses both water quantity and integrated water management.

The **prioritisation exercise** revealed that the majority of options designed to cope with challenges A and D have high priority. This indicates that the implementation of water management options aiming at improving the **quantitative state of water bodies** as well as **integrated water management strategies** are considered **most urgent** when planning for adaptation in the Tordera river basin.

This assessment may be underpinned by the multi-criteria analysis score, which is particularly high for options involving restoration of an environmental flow regime (WMO29) and the revision of water use entitlements (WMO31).

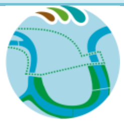
A priori, **most options are considered feasible and acceptable**, even if minor obstacles for implementation need to be overcome. Where serious obstacles are envisioned, these mostly refer to changes in legislation or institutional structures. Low acceptability, where that is the assessment, mostly concerns water management options that would affect private property or entail heated political debate. Confirming the importance of adopting an integrated view of water management, **adaptive forest management** (WMO33) scored highest in the analysis.

Table 2: Overview of the identified water management options for the Tordera river basin. The table illustrates the whole set of options, characterising the estimated feasibility, acceptability and synergies with other policies in terms of low (=0), medium (=1) or high (=2). Also included is the score obtained in the multi-criteria analysis (range: 0 to 100), as well as estimated cost ranges (€ for total estimated costs below 200,000 euro, €€ for costs between 200,000 and 1 M euro, €€€ for costs higher than 1 M euro).

#	WMOI cons	Name of WMO	Challenge	Priority	Feasibility	Accepta bility	Policy synergies	MCA score	Cost range
1		Develop and refurbish facilities to consolidate and extend livestock grazing in the forest.	B	High	2	2	2	59	€€
2		Create specific branding for the commercialisation of extensive livestock products .	B	Low	2	2	2	54	€
3		Expand the Catalan School for Shepherds in the Tordera basin area.	B	High	2	2	2	48	€€
4		Promote rainfed crop production.	A	Medium	1	2	1	45	€€
5		Revise the Extractions Master Plan.	A	High	0	0.5	1	44	€€

6		Establish water use entitlement conditions.	A/D	High	1	0.5	1	49	€
7		Promote knowledge transfer on irrigation with reclaimed water.	A	High	2	2	2	47	€
8		Integrate water-saving solutions in construction protocols.	A	High	1	1.5	2	58	€€
9		Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses.	D	Medium	1	2	2	37	€€
10		Promote water recycling in production processes.	A	High	1	2	2	44	€
11		Create “Water User Associations” (WUA).	D	High	0	0.5	1	61	€€
12		Create a “Permanent Participation Centre”(PPC)	D	High	1	1.5	2	59	€€

13		Develop a water traceability label for agricultural products.	A	Low	0	0.5	1	46	€€
14		Create a Municipal Adaptation Coordination Board (MACB).	D	High	1	2	2	54	€
15		Enhance phytotreatment plants in small municipalities and scattered houses.	B	High	1	2	2	45	€€€
16		Create an “Integrated Plan for the Protection of the Tordera Delta” (IPPTD).	B	High	1	2	2	70	€
17		Foster selective fishing.	B	Low	0	0.5	1	52	€
18		Foster local use of adaptation-to-global-change indicators.	D	High	1	2	2	53	€
19		Raise awareness.	D	High	2	2	2	57	€€

20		Modernise irrigation techniques.	A	High	1	2	2	45	€€€
21		Integrate adaptation principles into water service provider contracts.	D	High	2	1.5	1	40	€
22		Enhance environmental protected areas.	B	Medium	1	2	2	69	€
23		Water provision guarantee as a precondition for urban expansion.	D	High	1	1.5	1	41	€
24		Recover wetlands and their connectivity .	B	Medium	1	1.5	2	64	€€
25		Eliminate toxic substances used in municipal parks and gardening practices.	C	Medium	1	2	2	40	€
26		Create a catchment agreement to reduce diffuse pollution.	C	High	1	0.5	2	46	€€

27		Centralise and facilitate access to relevant data on the basin water bodies' status and uses.	C	High	1	2	2	38	€
28		Protect groundwater recharge areas.	A/C	Medium	1	2	2	53	€
29		Implement an environmental flow regime.	A/C	High	0	1.5	1	69	€€
30		Recover and protect river space.	B	Medium	1	1.5	1	60	€
31		Revise and update water entitlements.	D	High	0	0.5	2	69	€€
32		Develop River custody agreements.	B	High	2	2	2	48	€€
33		Conclude adaptive forest management agreements.	B	High	2	2	2	81	€€

The set of 33 water management options (WMOs) developed by the participants from the Tordera river basin are characterised by a **high degree of complementarity** and strongly inspired by the Water Framework Directive's environmental conservation principles. Participants have a sound understanding of this European legislation thanks to the participation processes required for the development of the current river basin management plan for the Catalan river basin district. Most options, in fact, focus on restoring water quantity and/or quality to bring about an urgent recovery of the ecological status of water bodies. Along the same lines, the participants considered the recovery of hydrogeomorphological quality as crucial for the basin's resilience to global change.

All water-using sectors are addressed, with a special emphasis on local populations, tourism, and agricultural water use. It is worth mentioning that the majority of proposed options aim to strengthen water management practices with an **intersectoral multiplying effect** at a basin-wide scale. For example, a specific plan to apply integrated water management strategies for the delta area is proposed, but given that the lower river section bears the effects of upstream management, this process will affect the whole basin.

Features illustrating the **potential implementation process** of the proposed water management options' have also been characterised. Many options involve action at a **municipal** level (e.g. WMO14), although underpinned by other options aiming for improved coordination with **regional** and **national** authorities (e.g. WMO16).

Most of these actions might be carried out in the **short term** (less than 2 years after the publication of this plan) and would deliver medium to high effectiveness within a short time.

The implementation cost of the water management options proposed generally lies in one of two ranges: either less than 200,000 €, or between 200,000 € and 1 M €. The **cost estimation exercise** should be considered a first **approximation** only, given different biases and lack of information that are impossible to correct at this stage. The relatively low cost estimations are due to the fact that most proposals involve **management solutions** and fostering of behavioural changes, rather than infrastructural approaches to adaptation; the focus is on increasing the flexibility of water use patterns (demand management, e.g. WMO21), and on sound planning (e.g. WMO23) to reduce vulnerability.

Notably, participants did not place any special emphasis on tackling **extreme events**, as flood damage has not been high in recent years and **awareness of this risk is currently quite low**. Nevertheless, different options aim to provide more resilience to drought, probably because of how the last long-lasting drought in 2008 was experienced and the lack of an integrated drought management plan for the basin.

1.4.2 *Bundle Factsheets*

This section presents **specific factsheets** for each of the bundles of water management options developed as described in section 2.3. These factsheets aim to summarise the most relevant information relative to the individual water management

options, as well as the rationale of the relationship between them. Each bundle has a title denoting the actions included, based on the **4 most prioritised water management options**: "Conclude adaptive forest management agreements" (WMO33), "Implementation of an environmental flow regime" (WMO29), "Create a Permanent Participation Centre" (WMO19) and "Create an integrated plan for the protection of the Tordera delta" (WMO16). The factsheets also include points about the implementation process: 1) ideal **timing** (adaptation pathways), and 2) brief indications on **context-related opportunities** that may be enhanced. The bundles should be considered a manner of presenting the set of water management options and may be used by decision makers as suggestions for joint implementation of multiple options, optimising co-benefits and inviting collaboration between different authorities to deliver an integrated approach.

1.4.2.1 Bundle 1: Enhance Adaptive Forest Management

The Tordera river basin society emphasised the need to **integrate forest management practices as a strategic component of water management in the river basin**. Unmanaged forests are currently experiencing excessive biomass growth and high tree mortality, making them more vulnerable to wildfires and affecting the quality of the forest's ecosystems. Healthy forests have a positive impact on local water cycle regulation. Stakeholders envision that the overall challenge for the basin is to overcome the currently imbalanced land use mosaic, combining arable land, forests, areas of natural interest and urban areas, so that it enhances the capacity of the territory to develop and maintain itself.

This bundle includes options aiming at the r**ecovery of extensive livestock grazing in the forest**, combining **infrastructural** actions (WMO1) with more **socioeconomic** options, such as encouraging and supporting new professionals to enter the sector (WMO3) and better focusing of the grazing activities through their inclusion as part of specific agreements (WMO33). Moreover, to consolidate the activity, WMO2 aims at **improving the economic viability** of the sector through better branding of products and by generating commercial opportunities.

WMO33 "Conclude adaptive forest management agreements" was the reference option for the co-benefit exercise, having scored 81 in the multi-criteria analysis results, the highest score among all the options in the Tordera project. High co-benefits from joint implementation are expected between all the options in this bundle. Many actions among those proposed are already being implemented, up to a point, in the Montseny and Montnegre–Corredor natural parks. These should be consolidated and expanded, and the lessons learned should be applied. Indeed, the only barrier to full support for this bundle is the potential for conflict of grazing activities in closed forest areas. This objection may be overcome by enhancing the use of adaptive management agreements between public authorities and forest owners.

Issues Tackled by Options in Bundle 1	Description of WMOs	Type of Action
Disappearance of traditional animal husbandry has an important impact on forest structure, resulting in fewer open spaces and meadows, as well as more understory vegetation, which affects wildfire risk.	**WMO1. Develop and refurbish facilities to consolidate and extend livestock grazing in the forest.**	**INFRASTRUCTURE & AGREEMENT**
	To facilitate livestock management in forested areas, this option includes the building of fences to keep the livestock in the forest, setting up watering and foddering points for livestock, as well as specific agreements on the paths to be used by herders to move about the land. The option focuses on grazing to bring back mountain meadows and lower pastureland, while grazing in closed forests may present more difficulties.	
Bringing back extensive livestock farming is not possible without proper funding programmes, as current activities cannot reach economic profitability. Moreover, livestock management practised taking into account the needs of forest management is labour-intensive and undermines the already fragile economic viability.	**WMO2. Create specific branding for the commercialisation of extensive livestock products**	**ASSOCIATION**
	To contribute to consolidating forest management linked to livestock operations, this option involves the creation of an association of producers and the development of a brand to market their products, to increase added value of products, improve visibility and share processing costs.	
Currently there is an urgent need for generational turnover in the livestock farming sector, but young people interested in taking over herding face multiple obstacles to get into business.	**WMO3. Expand the Catalan School for Shepherds in the Tordera basin area.**	**AGREEMENT**
	This option aims to contribute to consolidating the model developed by the Catalan School for Shepherds[12] to increase interest in this occupation and to ensure generational turnover. The option proposes to identify farming operations willing to collaborate with the school and potential new holdings to operate, and to teach and encourage sustainable shepherding.	
To build resilience to global change and reduce the expected impact, public authorities and the forestry exploitation and agriculture sectors[29] need to closely cooperate.	**WMO33. Conclude adaptive forest management agreements.**	**AGREEMENT**
	To enhance adaptive measures to be implemented, this option proposes to foster pilot cases for specific adaptive forest management agreements between forestland owners and the administration. Agreements can entail a range of actions, depending on specific forest management needs. Actions may include thinning, clearing, eradication of alien species, erosion prevention and other specific interventions, such as facilitating grazing. These agreements should also include riparian vegetation management.	

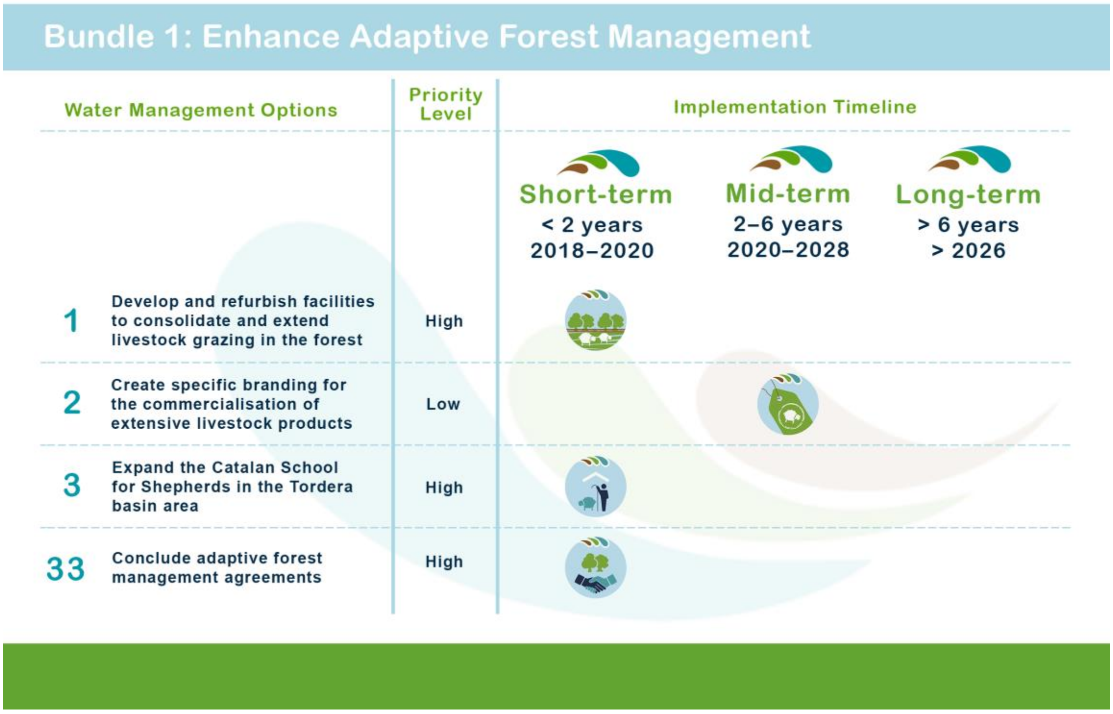
[12] Escola de pastors de Catalunya

ADAPTATION PATHWAY

WMOs 1 (livestock infrastructure), 3 (shepherd school) and 33 (adaptive forest management agreements) are preconditions for the production of extensive livestock products that can then be promoted through WMO2. More specifically, WMO3 should be implemented early, as shepherds need time to become adept enough to participate in the other actions, such as concluding adaptive forest management agreements (WMO33) or branding of products (WMO2).

WMO2 is not considered a priority, as the viability of the grazing initiatives should be first be validated, and only later could a specific marketing initiative be applied in order to tighten the production, commercialisation and consumption model for the whole basin.

WMO33 has a medium time lag between implementation and effectiveness, so the earlier the agreements are in place, the better the results and synergy with new herds and facilities.



IMPLEMENTATION OPPORTUNITIES

Key stakeholders for this bundle, namely the Catalan Office for Climate Change[13], the Barcelona Provincial Council[14], ultimately responsible for national parks, the Department of Agriculture[15] and the Department's county offices, have stated that they are already working towards this approach and agree the bundle includes crucial elements for adaptive forest management. Additionally, the County Councils[16] for Maresme, Vallès Oriental and La Selva counties, forest landowners, and municipalities should be involved, to enhance and sustain the concrete actions the options entail locally.

[13] Oficina Catalana de Canvi Climàtic
[14] Diputació de Barcelona
[15] Departament d'Agricultura, Ramaderia, Pesca I Alimentació
[16] Consells Comarcals

1.4.2.2 Bundle 2: Water Use Rights and Reduction of Consumption Levels

The **lack of an adequate environmental flow regime** and **high water consumption** were identified as the most important factors to be addressed for increasing resilience to global change in the basin. Adequate control of extraction rates is hindered by the presence of a large number of wells that are not properly **registered** and **monitored**, and the fact that water use **entitlements** are not well managed: the quantities assigned are greater than actual flow in the river, so that water scarcity is a direct result of management practices. The Tordera basin groundwater bodies have been officially declared **overexploited**, with multiple ensuing impacts.

The options in bundle 2 tackle these challenges combining options intended to **adjust water use rights to more sustainable extraction rates** (WMO31, WMO29, WMO24, WMO5, WMO6) and **promote water-saving consumption patterns** (WMO7, WMO8, WMO10, WMO20), as well as governance-oriented options that enhance **water accounting and control** (WMO11, WMO13) or improve on the current **legal framework** that affects drivers of water demand (WMO21, WMO23). The aim of this bundle is to foster a coordinated series of actions **reducing anthropogenic pressure on water bodies** and set up more suitable management conditions.

For the co-benefit identification exercise, options 29 (implementation of an environmental flow regime) and 31 (revision and updating of entitlements) were taken as a reference, both having scored 69 in the multi-criteria analysis exercise. High co-benefits are expected from the combination of options in this bundle, as they are all very **complementary and interrelated**. The only exception concerns the combinations of establishing water use entitlement conditions (WMO6) with options involving technological solutions for reutilisation: Irrigation with reclaimed water (WMO7), Adopting water-saving solutions in new constructions (WMO8) and Enhancing recycling in production protocols (WMO10). Low co-benefit ratings are assigned to these combinations, as participants considered their effectiveness to be strongly reduced by the small-scale character as well as uncertainties regarding technical and economic viability.

<table>
<tr><th>Issues Tackled by Options in Bundle 2</th><th>Description of WMOs</th><th>Type of Action</th></tr>
<tr><td rowspan="2">The 2003 edict that declared the alluvial aquifer in the central and lower section of the river Tordera through the 2003 edict to be overexploited also decreed the development of an “Extractions Master Plan” for these water bodies. The existing plan is considered outdated and could be better adjusted to current needs and conditions.</td><td>WMO5. Revise the Extractions Master Plan.</td><td>INFORMATION MANAGEMENT</td></tr>
<tr><td colspan="2">In the context of the present Extractions Master Plan, a specific IT management tool was developed so that an overall water balance of the basin’s uses could be drawn up for individual river sections, with the aim of regulating extraction rates. This option seeks to 1) update and improve the data for this accounting tool, 2) extend its territorial scope, and 3) delegate the use and maintenance of the IT tool to local entities.</td></tr>
<tr><td>Investments in water-saving</td><td>WMO6. Establish water use</td><td>PARTICIPATION &</td></tr>
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<tr><td rowspan="2">technologies don't deliver the expected results due to the rebound effect: saved water is re-invested in production until the entitled volumes are used up, so water savings fail to return to water bodies. When public administration subsidises water-saving practices in order to decrease the pressure on the environment, specific conditions can be introduced in water entitlements to guarantee that savings are put to their intended use.</td><td>entitlement conditions.</td><td>AGREEMENT</td></tr>
<tr><td colspan="2">An adequate normative structure exists, but there is a need to expand, innovate and consolidate the range of available arrangements that can be brought in when new conditions are negotiated. This option seeks to 1) promote a participatory process / open debate targeting municipalities, big water users, and relevant actors with the aim of 2) gathering information about the opportunities to modify/integrate entitlements (existing and new) allowed under the current legal framework and 3) developing specific agreements for the Tordera basin.</td></tr>
<tr><td rowspan="2">Irrigation with reclaimed water is considered a big opportunity to avoid using high-quality water of higher quality for crops, but it is crucial to evaluate the ensuing limitations and opportunities of these solutions in terms of public health concerns; agronomic, infrastructural, managerial, and energy consumption and managerial parameters;, as well as normative issues and coordination between authorities and normative issues.</td><td>WMO7. Promote knowledge transfer on irrigation with reclaimed water.</td><td>STUDY & DISSEMINATION</td></tr>
<tr><td colspan="2">This option promotes carrying out a study to evaluate the effectiveness of plots currently irrigated with reclaimed water in terms of all critical factors, to increase the information available on the limitations and opportunities of such projects for the Tordera basin. A knowledge transfer programme would ensure the dissemination of findings, with the aim of helping to reduce pressure on water bodies in the basin.</td></tr>
<tr><td rowspan="2">Urban water consumption has a significant impact on the basin. Water savings could be maximised in urban and tourism-related buildings, both refurbished and new, reducing current water consumption levels.</td><td>WMO8. Integrate water-saving solutions in construction protocols.</td><td>STUDY & DISSEMINATION</td></tr>
<tr><td colspan="2">This option is intended to 1) promote a basin-specific study aiming at identifying opportunities for water reutilisation in buildings and optimisation of operation and maintenance conditions for these installations; 2) disseminate good practices in the design of grey water management installations in buildings; and (3) use these findings to revise current management patterns of water saving solutions in buildings and local subsidies and permits intended to support this kind of initiatives.</td></tr>
<tr><td rowspan="2">There are different industries in the basin that have a water consumption pattern that could include potentially use closed water recycling systems;, like for example wine production or the chemical industry are examples. Increasing the use of these technologies could help reduce water demand.</td><td>WMO10. Promote water recycling in production processes.</td><td>PILOT & DISSEMINATION</td></tr>
<tr><td colspan="2">This option aims to promote specific pilot cases for individual industries, to serve as benchmarks and examples of best practices and innovative projects involving closed water recycling systems. A programme to push the information obtained to public administration, academia and relevant actors aims to foster increased adoption of these water-saving systems.</td></tr>
<tr><td rowspan="2">New forms of governance are needed so that water extraction can be properly balanced with good quantitative status of water bodies new forms of governance are</td><td>WMO11. Create Water User Associations (WUA).</td><td>ASSOCIATION</td></tr>
<tr><td colspan="2">This option is intended to promote 1) a study to evaluate the barriers and opportunities to setting up a</td></tr>
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<tr><td>needed. The 2003 edict that declared the Tordera groundwater bodies overexploited decreed the creation of a Water User Association, without success.</td><td colspan="2">Water User Association in the Tordera basin; 2) interventions to increase the availability and transparency of information on water extractions in the basin; and 3) a specific deliberative space for people/entities holding a water entitlement to:
• coordinate and agree on sustainable extraction rates,
• manage the IT water management/accounting tool described in WMO5,
• monitor and follow up the measures agreed,
• serve as an interlocutor before the water authority and local entities.</td></tr>
<tr><td rowspan="2">For different reasons, such as land ownership patterns, operating agreements, and difficulties constituting irrigation community organisations, many farmers lack formalised water entitlements. Water use without an entitlement entails significant problems for proper water accounting and extraction management, entailing groundwater overexploitation and causing salt-water intrusion in groundwater bodies of the coastal area.</td><td>WMO13. Develop a water traceability label for agricultural products.</td><td>AGREEMENT</td></tr>
<tr><td colspan="2">To penalise farmers for abstracting water without a valid entitlement, this option proposes the development of a “water traceability label” for those farmers who do have a regular permit, thus allowing consumers to recognise and reward producers contributing to the protection of the basin’s resources.</td></tr>
<tr><td rowspan="2">Different farm plots in the basin use gravity irrigation techniques, entailing high quantities of water diverted from the river. Water use by the agricultural sector could be optimised through different techniques.</td><td>WMO20. Modernise irrigation techniques.</td><td>INFRASTRUCTURE</td></tr>
<tr><td colspan="2">This option proposes to install pressurised irrigation devices or refurbish gravity-fed irrigation systems in conjunction with WMO5 (the basin water accounting tool) and WMO6 (entitlement conditions), to ensure that the investment in optimised irrigation infrastructure actually delivers an environmental benefit.</td></tr>
<tr><td rowspan="2">Currently, water service provider contracts established between public administration and private companies include binding conditions on authorised water sources and allowed quantities. Contract duration is very long. If any change to these contractual conditions is needed, companies would have the right to claim compensation for their loss of earnings. Under the expected global change conditions for Catalonia it is crucial to have increased flexibility in water management and concession operations, to allow the protection of the general interest, which entails preserving strategic water bodies to enhance resilience.</td><td>WMO21. Integrate adaptation criteria into water service provider contracts.</td><td>STUDY & DISSEMINATION</td></tr>
<tr><td colspan="2">This option aims to promote a study on the opportunities to integrate the principles of adaptation to global change into current legal framework regulating the outsourcing of water provision services. The results of this study would then be disseminated through a specific knowledge transfer programme targeting relevant actors, such as municipalities.</td></tr>
<tr><td>Urban expansion entails a significant challenge for local authorities to</td><td>WMO23. Require guaranteed water provision as a</td><td>STUDY &</td></tr>
</table>

<table>
<tr><td rowspan="2">secure an adequate water supply service. Current legislation decrees that water authorities should produce a viability report evaluating water supply and sanitation provisions for new buildings, but its results are not binding. This situation leads to the construction of buildings without a guaranteed water supply, thus increasing new water demand because of fait accompli policies.</td><td>precondition for urban expansion.</td><td>DISSEMINATION</td></tr>
<tr><td colspan="2">This option aims to promote a specific research programme aiming at providing relevant information needed to promote a better understanding of the issue and of the legal tools available to make provision guarantee reports at municipal level binding:
Degree of water supply provision guarantee of new urban planning,
Limitations and opportunities for a better supply guarantee,
Availability of legal tools to reduce pressure on water bodies caused by urban expansion.
The results of the study would then be disseminated with a specific knowledge transfer programme targeting public administration, academia and relevant actors.</td></tr>
<tr><td rowspan="2">In different areas of the basin, wetlands are degraded inter alia because they lack hydrological connectivity to related aquifers. Restoring connectivity is also crucial to maintain suitable habitats for many species.</td><td>WMO24. Recover wetlands and their connectivity.</td><td>PILOT & DISSEMINATION</td></tr>
<tr><td colspan="2">This option aims to promote strategic pilot cases aiming to test different ways of optimising the ecological and hydrological functionality of water bodies by recovering their connectivity as follows: 1) modifying the extraction rates of those water users exploiting the groundwater bodies connected to the wetland area chosen for the pilot; and 2) analysing appropriate indicators for the Tordera basin to evaluate the ecological status of wetlands.

The results of the study would then be disseminated with a specific knowledge transfer programme targeting public administration, academia and relevant actors.</td></tr>
<tr><td rowspan="2">The river Tordera has a torrential flow regime and is characterised by high hydrological variability. Moreover, water demand pressures hinder the implementation of an environmental flow regime consistent with its ecological requirements.</td><td>WMO29. Implement an environmental flow regime.</td><td>INFRASTRUCTURE & AGREEMENT</td></tr>
<tr><td colspan="2">This option aims to promote actions along the river focused on restoring environmental flow regimes, taking into account different possibilities of intervention:
Elimination of direct extractions in the headwaters (farmers, scattered houses, …)
Elimination of in-stream barriers (permeability of the dams at Montclús, Santa Fe and other locations)
Interventions for better efficiency
Flow-limiting and peak-flow control devices in extraction points
Refurbishment of gauging stations
Creation of regulation ponds for irrigation systems
Increased coordination between relevant departments in public administration.
Optimisation of local and regional supply</td></tr>
</table>

	systems • Enforcement of public hydraulic domain legislation	
Given the high number of outdated entitlements, many containing important irregularities, it is urgent to update water extraction rights.	**WMO31. Revise and update water entitlements.**	**INFORMATION MANAGEMENT**
	To help reduce extractions and increase the availability and transparency of information, this option aims to promote the creation of a communication and coordination channel between local entities and the water authority to foster proactive cooperation in the process of updating the water use entitlement register to reflect actual uses. The option also seeks to promote the online publication of the water entitlement register.	

ADAPTATION PATHWAY

WMO31 (Revision and actualisation of water entitlements) should be implemented in parallel and in coordination with WMO6 (Establish water use entitlement conditions), which can be very useful in the revision process negotiation, as well as with WMO5 (Revise the Extractions Master Plan) that sets the new water extraction rates allowed in the basin through the revision of the Plan.

Furthermore, the information resulting from WMO7 (Promote knowledge transfer on irrigation with reclaimed water), WMO8 (Water-saving devices in buildings), WMO10 (Recycling in production processes), and WMO21 (Integrate adaptation principles into water service provider contracts) can be useful input to WMO31, WMO5 and WMO6 and should therefore be implemented prior to or in parallel with these.

WMO20 (Modernise irrigation techniques) is an option that allows adapting to lower water availability rates or a reduction of the entitlement as a result of WMO29 (Implement an environmental flow regime) and WMO31, and is linked to the conditions established by WMO5 and WMO6. Nevertheless, implementing this option takes time, so the sooner it is implemented, the better.

WMO13 (Water traceability label) needs WMO31 to be implemented first, because of the need to clearly identify those who have updated and legalised their entitlements. This option was rated as having a low priority, since stakeholders believe its implementation requires a strong political will.

WMO11 (Creating a Water User Association) is a precondition to WMO5 and should therefore be implemented prior to or in parallel with it, given the need to clearly identify an interlocutor for the extraction rate redesign.

WMO24 (Recover wetlands and their connectivity) includes the modification of extraction rates for water users exploiting groundwater bodies connected to the wetland area chosen for the pilot. Therefore, this option could also benefit from the implementation of WMO5, WMO6 and WMO31.

WMO29 includes many different actions, but surely needs to run in parallel with WMO31, WMO5 and WMO6.

WMO23 (Require guaranteed water provision as a precondition for urban expansion) entails a study and a process that doesn’t directly depend on other options in the bundle, but would enhance reduction of water demand over time.

Bundle 2: Water Use Rights and Reduction of Consumption Levels

	Water Management Options	Priority Level	Implementation Timeline: Short-term < 2 years 2018–2020	Mid-term 2–6 years 2020–2028	Long-term > 6 years > 2026
5	Revise the Extractions Master Plan	High			
6	Establish water use entitlement conditions	High			
7	Promote knowledge transfer on irrigation with reclaimed water	High			
8	Integrate water-saving solutions in construction protocols	High			
10	Promote water recycling in production processes	High			
11	Create “Water User Associations” (WUA)	High			
13	Develop a water traceability label for agricultural products	Low			
20	Modernise irrigation techniques	High			
21	Integrate adaptation principles into water service provider contracts	High			
23	Require guaranteed water provision as a precondition for urban expansion	High			
24	Recover wetlands and their connectivity	High			
29	Implement an environmental flow regime	High			
31	Revise and update water entitlements	High			

IMPLEMENTATION OPPORTUNITIES

The Catalan Water Agency [17]commented that the new river basin management plan takes into account many of the options presented in this bundle and gave specific feedback on their degree of incorporation into official planning. In particular, the implementation of an environmental flow regime (WMO29) is considered a top priority, as well as all the options that support this process, such as the revision of entitlements (WMO31), revision of the Extractions Master Plan (WMO5),

[17] Agència Catalana de l’Aigua

establishment of water use entitlement conditions (WMO6) or the creation of a water user association (WMO11).

For sound implementation, many of this bundle's options require intensive collaboration with other official bodies, such as the Department of Agriculture[18], the Catalan Office for Climate Change[19] and municipalities.

Options involving technological solutions for reutilisation – Irrigation with reclaimed water (WMO7), Adopting water-saving solutions in new constructions (WMO8) and Enhancing recycling in production protocols (WMO10) – would also need to engage with research entities and private companies to overcome viability constraints.

1.4.2.3 Bundle 3: Best Practices and Citizen Engagement

Access to transparent and relevant information – including best-practice approaches – is a major challenge for sound adaptive water management and citizen participation. Society in the Tordera basin considers that water resource management is insufficiently democratic, and holds that better governance and **specific deliberative spaces** facilitate addressing the basin's challenges.

The options in Bundle 3 tackle these challenges in different ways, addressing the need for information to enhance best practices at sectoral level (WMO4, WMO9, WMO15, WMO17, WMO25, WMO27), as well as more specifically to raise awareness on the concrete challenges of the basin (WMO19) or to take action in a coordinated manner (WMO26, WMO32). The option involving the creation of a Permanent Participation Centre (PPC) would create multiple opportunities for citizens and the administration to develop more capabilities and evolve towards better forms of governance allowing people to participate properly in decision making (WMO12).

Two water management options were taken as a reference for this bundle: WMO12, which scored 59 in the multi-criteria analysis, and WMO19, which scored 57. All options in this bundle are expected to deliver high co-benefits if jointly implemented, especially the options promoting awareness raising and citizen participation, which help create a **favourable implementation environment** for most options and produce multiplying effects. For example, to develop a basin-wide agreement to reduce diffuse pollution (WMO26), sound information and active engagement of the basin's stakeholders and society in general is crucial. Therefore, the presence of a permanent centre for participation (WMO12) could benefit the creation of such an agreement. On the other hand, rainfed agriculture has low economic viability and therefore, like organic farming, it needs to increase the added value of products: the catchment agreement seeks to reduce diffuse pollution caused by irrigated (intensive) farming. Switching from irrigated farming to rainfed agriculture, as well as any policies encouraging new farms to choose rainfed production, would strongly benefit from the economic and political support of a basin-wide agreement.

ISSUES TACKLED BY OPTIONS IN BUNDLE 3	Description of WMOs	Type of Action

[18] Departament d'Agriculutra, Ramaderia, pesca i Alimentació
[19] Oficina Catalana de Canvi Climàtic

The expansion and consolidation of irrigated agriculture is putting a lot of pressure on the water bodies of the basin. Rainfed crops are not sufficiently promoted to become a viable alternative.	**WMO4. Promote rainfed crop production.**	**INFORMATION**
	To promote practices aiming at increased economic viability of rainfed crop production and restore a balanced land use mosaic, this option proposes creating specific knowledge transfer programmes in the framework of farm advisory services, including assistance with crop selection and rotation, soil management (structure and fertility), green water management, farm operation design, and marketing of produce.	
The energy supply needed for correct functioning of water management infrastructure (such as water treatment plants, pumping plants and/or extraction facilities) can be hard to provide in small towns and scattered houses. A locally produced renewable energy supply could foster better water management practices.	**WMO9. Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses.**	**PILOT & DISSEMINATION**
	This option aims to promote the development of pilot cases on the use of renewable energy in water treatment plants, water heating installations, pressure pumping and/or extraction pumping in villages and scattered houses. The information obtained would then be disseminated to public administration, academia, water utilities and relevant actors.	
Currently there is a time gap between successive calls for participation for Catalan river basin management plans, planned every 6 years according to the Water Framework Directive implementation calendar. This interlude means that citizens are not engaged in following up implementation of measures, relevant information is not readily available in accessible formats, and communication between the people of the county and public administration is hindered.	**WMO12. Create a “Permanent Participation Centre”.**	**INFORMATION & PARTICIPATION**
	This option wants to promote the constitution of a “Permanent Participation Centre” with the aim of creating better conditions for citizens to participate in the design and revision of water policies. The centre would host a local office of the water authority and include a documentation centre. This would allow the Participation Centre to: 1) disseminate relevant information about the basin, 2) foster local debate and coordinate citizens’ contributions, 3) inform the public about the uptake of those contributions and 4) provide conflict mediation.	
Treatment of wastewater produced by small towns and scattered houses are a significant challenge in the basin.	**WMO15. Promote phytotreatment plants in small municipalities and scattered houses.**	**PILOT & DISSEMINATION**
	Soft treatment plants, such as artificial wetlands, green filters and the like, can be valuable ways of overcoming issues with the design and funding of suitable water treatment plants, but there are few evidence sources to back up the viability of such solutions at present. The information obtained from a pilot implementation would then be disseminated to public administration, academia, water managers and	

<table>
<tr><td></td><td colspan="2">relevant actors.</td></tr>
<tr><td rowspan="2">Rising populations of alien species are a major challenge in the basin. Different sections of the Tordera river are affected by the proliferation of alien fish species.</td><td>WMO17. Foster selective fishing.</td><td>INFORMATION & PARTICIPATION</td></tr>
<tr><td colspan="2">To engage citizens in the protection of the basin’s biodiversity and help reduce the pressure of alien species in the river, this option proposes selective fishing programmes developed by fishing associations, underpinned by the publication of a specific fishing guide.</td></tr>
<tr><td rowspan="2">The basin’s society is not sufficiently engaged and aware of the challenges of the Tordera basin. Awareness-raising programmes are in place, but new, interesting campaigns and programmes could be enhanced.</td><td>WMO19. Raise awareness.</td><td>INFORMATION & PARTICIPATION</td></tr>
<tr><td colspan="2">To offer concrete opportunities for people to be involved in the river’s protection, this option proposes a set of actions, such as designing specific basin-wide programmes for schools and adult education, creating environmental paths, showcasing natural heritage, strengthening volunteer services and promoting initiatives aimed at diversifying peak-season tourism.</td></tr>
<tr><td rowspan="2">In several areas of the basin, municipal park maintenance protocols and gardening activities use water-polluting substances entailing health risks. In particular, the controversial compound glyphosate (classified as “probably carcinogenic in humans” by the WHO) is generally used in municipal playgrounds, causing serious concern among citizens.</td><td>WMO25. Eliminate toxic substances used in municipal parks and gardening practices.</td><td>INFORMATION & AGREEMENT</td></tr>
<tr><td colspan="2">This option involves the development of a guide indicating alternative products and best practices to avoid the use of toxic agrochemicals for gardening purposes. Additionally, the guide would be disseminated to the official bodies or departments in charge of municipal parks and gardens, as well as the general public. To encourage the widest possible adoption of better practices, this option would also promote a commitment signed by the basin’s municipalities to adopt the advice contained in the guide.</td></tr>
<tr><td rowspan="2">Diffuse pollution of water bodies with nutrients as a result of crop fertilisation is a relevant challenge for water quality in the basin, entailing considerable environmental degradation and high drinking water purification costs. Since all sectors do not jointly shoulder the responsibility of increasing water quality, environmental degradation is ongoing and urban users carry most of the economic burden of necessary water treatment.</td><td>WMO26. Create a catchment agreement to reduce diffuse pollution.</td><td>AGREEMENT</td></tr>
<tr><td colspan="2">This option seeks to engage both the agricultural sector and urban water users in restoring water quality through a specific agreement that would enable a move to a lower-impact production pattern and share the cost more equitably.</td></tr>
<tr><td rowspan="2">Relevant data series about the Tordera basin are produced by different entities monitoring the river’s condition, including public authorities, non-governmental organisations and research projects. In many cases, the basin’s stakeholders are not informed</td><td>WMO27. Centralise and facilitate access to relevant data on the basin water bodies’ status and uses.</td><td>INFORMATION</td></tr>
<tr><td colspan="2">This option is intended to promote the creation</td></tr>
</table>

about the nature, scope, updating and publication of these figures, and their publication format makes them hard to search.	of a webpage in which all the relevant data on the Tordera river basin collected by public authorities, non-governmental organisations or research projects is published in an accessible format.	
Public authorities lack the means to establish sufficient monitoring, control and maintenance of river spaces. One way to enhance citizen involvement is to engage local governments in developing specific programmes.	**WMO32. Develop river custody agreements.**	**AGREEMENT**
	To foster the joint involvement of citizens and local governments in the recovery and protection of river space, this option would entail generating the conditions for creating effective river custody agreements and ensuring their continuity. These agreements are direct contracts between local governments and citizen groups who would undertake to restore and protect a specific river section.	

ADAPTATION PATHWAY

WMO4 (Promote rainfed crop production), WMO25 (Transition to non-toxic gardening), WMO26 (Basin agreement on diffuse pollution) and WMO32 (River custody agreements) could be implemented after the first results of citizen participation (WMO12) and raise awareness (WMO19) have generated sufficient information and understanding among stakeholders. WMO12 and WMO19 should therefore be implemented soon.

The centralised webpage with relevant information on the basin (WMO27) should become available in parallel with WMO12 (Create a Permanent Participation Centre), as high co-benefits would arise.

WMO17 (Foster selective fishing) could be implemented anytime. As the current river basin management plan includes reviewing and updating environmental indicators for fish species, the option should perhaps be implemented on the basis of the updated information, making it a medium-term option.

Bundle 3: Best Practices and Citizen Engagement

	Water Management Options	Priority Level	Short-term < 2 years 2018–2020	Mid-term 2–6 years 2020–2028	Long-term > 6 years > 2026
4	Promote rainfed crop production	Medium		●	
9	Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses	Medium		●	
12	Create a Permanent Participation Centre (PPC)	High	●		
15	Promote phytotreatment plants in small municipalities and scattered houses	High		●	
17	Foster selective fishing	Low			●
19	Raise awareness	High	●		
25	Eliminate toxic substances used in municipal parks and gardening practices	Medium		●	
26	Create a catchment agreement to reduce diffuse pollution	High		●	
27	Centralise and facilitate access to relevant data on the basin water bodies' status and uses	High	●		
32	Develop river custody agreements	High		●	

IMPLEMENTATION OPPORTUNITIES

This bundle is composed of options involving very specific and diverse stakeholders. Indeed, the participatory character of these options, as well as the intended knowledge transfer, requires a diversity of actors involved in the implementation process. For example, the Catalan Water Agency is willing to share all of its information and feed it into a new website as proposed in WMO27, "Centralise and facilitate access to relevant data on the basin water bodies' status and uses". Nevertheless, unless local governments, research institutes and non-governmental organisations actively provide the data, this option cannot succeed.

Other options involve piloting, which requires the engagement of several different local actors. For example, for WMO15 "Promote phytotreatment plants in small municipalities and scattered houses", the Catalan Water Agency, the Montseny park authorities[20], the Montseny local council, the park administration offices at Can

[20] Diputació de Barcelona – Xarxa de parcs Naturals

Casades and Can Lleonard, Santa Fe Hotel, and Restaurant Avet Blau would all need to actively collaborate.

In terms of awareness raising, environmental NGOs and citizen organisations have a crucial role and would pursue all actions proposed.

The proposal to create a Permanent Participation Centre (PPC) (WMO12) for the Tordera basin is also backed by almost all other public authorities that see the benefit of increasing the quality of participatory processes and the usefulness of deliberative spaces. For example, municipalities feel that the PPC would create the opportunity for better water planning and management at the local level, and would also improve their communication channels both with the Agency and with their citizens.

1.4.2.4 Bundle 4: Adaptation and Environmental Protection

To support adaptive management practices, public authorities need to face the major challenge of achieving **better coordination at all levels**. For example, municipalities would welcome more coordination and better dialogue with the Water Agency on matters such as the development of wastewater treatment plants.

In addition, on the assumption that increasing environmental quality is crucial for building resilience, specific options should be implemented to **enhance adaptive capacity** in the basin.

The options grouped in bundle 4 tackle these issues in different ways, providing tools for **local adaptation policy implementation** (WMO14, WMO18) and fostering the needed integration of perspectives and knowledge through **citizen participation** (WMO16, WMO22). Other options in this bundle promote **concrete interventions** to avoid increasing the basin's vulnerability (WMO24, WMO28, WMO29, WMO30).

WMO16 "Create an Integrated Plan for the Protection of the Tordera Delta", scoring 70 in the multi-criteria analysis, and WMO22 "Enhance environmental protected areas", scoring 69, were made central to this bundle. High scores indicate that participants value the **delta area** highly and understand that its degradation would increase their vulnerability to the effects of global change. If jointly implemented, high co-benefits are expected between all the options of this bundle. The creation of a **municipal adaptation board** (WMO14) would especially provide consistent mutual harmonisation and support among the basin's municipalities to enable a sound implementation of adaptation options, such as the recovery of the river space or the protection of groundwater recharge areas.

Issues Tackled by Options in Bundle 4	Description of WMOs	Type of Action
Lack of resources hinders planning, funding, implementation and effectiveness monitoring of policies that seek adaptation to global change at the municipal level.	**WMO14. Create a Municipal Adaptation Coordination Board (MACB).**	**COORDINATION**
	To promote cooperation between municipalities that seek to implement municipal adaptation plans and/or adaptation measures, this option proposes the creation of a permanent adaptation board.	

<table>
<tr><td rowspan="2">The Tordera delta area is particularly sensitive to the impact of global change and is affected by multiple upstream pressures. Fragmentation of powers among public administration bodies and the different roles of a variety of stakeholders make it difficult to manage the delta in an integrated manner.</td><td>WMO16. Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD).</td><td>PARTICIPATION</td></tr>
<tr><td colspan="2">To protect the whole delta area in an integrated manner, this option proposes fostering a specific process to draw up an Integrated Protection Plan. The proposal involves a set of actions to restore the sediment dynamics of dunes and beaches, constrain land uses, decrease water extraction, increase wastewater treatment and enhance biodiversity protection.</td></tr>
<tr><td rowspan="2">Global change is a complex challenge that is not currently taken sufficiently into account when building infrastructure and developing spatial interventions. General indicators have been developed to evaluate the effects of global change, but are not integrated in local decision making processes. As a result, the impacts of global change are less accounted for in local policy design and implementation.</td><td>WMO18. Foster local use of adaptation-to-global-change indicators.</td><td>STUDY, PILOT & DISSEMINATION</td></tr>
<tr><td colspan="2">This option seeks to commission a study to evaluate opportunities to adapt existing indicators to the specific reality of the Tordera basin and identify opportunities to integrate the use of the adapted indicators in local decision-making processes on development. Furthermore, this option aims at designing pilot cases exemplifying the application of these indicators in a local analysis of vulnerability to global change.

A specific knowledge transfer programme would disseminate the information obtained to public administration, academia and relevant actors.</td></tr>
<tr><td rowspan="2">The Tordera basin is characterised by its particularly rich natural habitats, but spatial development and attendant infrastructure have fragmented strategic areas for many species, reducing their mobility.</td><td>WMO22. Enhance environmental protected areas.</td><td>PARTICIPATION</td></tr>
<tr><td colspan="2">This option aims to promote a participatory process with relevant actors with the aim of updating current maps of protected areas and integrating strategic ecological corridors to connect terrestrial ecosystems. Results obtained from the participatory process would then be fed into the establishment of appropriate forms of environmental protection in the identified areas (both new and pre-existing).</td></tr>
<tr><td rowspan="2">In different areas of the basin, wetlands are degraded, inter alia, because of missing hydrological connectivity to associated aquifers. Restoring connectivity is also crucial to maintain suitable habitats for many species.</td><td>WMO24. Recovery of wetlands and their connectivity.</td><td>PILOT & DISSEMINATION</td></tr>
<tr><td colspan="2">This option aims to promote strategic pilot cases to test different ways of optimising ecologic and hydrologic functionality of water bodies by recovering their connectivity as follows: 1) reducing the extraction rates of water users exploiting the groundwater bodies connected to the wetland area chosen for the pilot project (in bundle 2); and 2) analysing appropriate indicators to evaluate the ecologic status of wetlands in the Tordera basin (bundle 4).

The results of the study would then be disseminated</td></tr>
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<tr><td></td><td colspan="2">through a specific knowledge transfer programme targeting public administration, academia and relevant actors.</td></tr>
<tr><td rowspan="2">Current legislation provides specific protection of catchment areas around drinking water wells, but there are many specific areas in the basin where rainwater seeps through the subsoil and recharges aquifers. Often these areas are not taken into account in zone planning, so infrastructural works, industrial areas, car parks, fuel stations, and so forth are located in these sensitive areas.</td><td>WMO28. Protect groundwater recharge areas.</td><td>INFORMATION & COORDINATION</td></tr>
<tr><td colspan="2">This option aims to integrate municipal zoning protocols with special protection measures, based on current groundwater cartography, and aiming to avert the degradation of strategic recharge areas in the territory.</td></tr>
<tr><td rowspan="2">The river Tordera has a torrential flow regime and is characterised by high hydrological variability. Moreover, pressures due to water demand hinder the implementation of an environmental flow regime consistent with its ecological requirements.</td><td>WMO29. Implement an environmental flow regime.</td><td>INFRASTRUCTURE & AGREEMENT</td></tr>
<tr><td colspan="2">This option aims to promote actions along the river focused on recovering an environmental flow regime, taking into account different possibilities of intervention:
Elimination of direct extraction pumping in the headwaters (by farmers, owners of scattered houses, and so forth)
Elimination of in-stream barriers (permeability at Montclús, Santa Fe and other dams)
Interventions for better efficiency
Placement of flow-limiting and peak-flow control devices in extraction points
Refurbishment of gauging stations
Creation of regulation ponds for irrigation systems
Increased coordination between relevant departments in public government bodies
Optimisation of local and regional water supply systems
Enforcement of public hydraulic domain regulation</td></tr>
<tr><td rowspan="2">The presence of a large number of infrastructural works in the river entails the need to protect and restore river spaces in a way consistent with the strategic environmental and hydraulic functions the river performs.</td><td>WMO30. Recover and protect river space.</td><td>LEGAL</td></tr>
<tr><td colspan="2">This option aims to promote the protection of particular areas with a high strategic value, such as:
the river section called “La Ferreria”
most important floodplains in the central and lower parts of the basin
the headwaters
The option also involves declaring some river sections with good environmental status as “river reserves”.</td></tr>
</table>

ADAPTATION PATHWAY

The creation of an adaptation board (WMO14) and the participation process for the development of a Protection Plan for the Tordera Delta region (WMO16) should be

implemented within a short time span, as they facilitate and enhance options 15, 16, 18, 22, 24, 29, 28, 30. Also, WMO29 (Establishing environmental flow regimes) is a long process that would help ameliorate certain relevant environmental problems, so it should also be implemented soon.

Bundle 4: Adaptation and Environmental Protection

	Water Management Options	Priority Level	Short-term < 2 years 2018–2020	Mid-term 2–6 years 2020–2028	Long-term > 6 years > 2026
14	Create a Municipal Adaptation Coordination Board (MACB)	High	●		
16	Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)	High	●		
18	Foster local use of adaptation-to-global-change indicators	Medium		●	
22	Enhance environmental protected areas	Medium		●	
24	Recover wetlands and their connectivity	Medium		●	
28	Protect groundwater recharge areas	Medium		●	
29	Implement an environmental flow regime	High	●		
30	Recover and protect river space	Medium		●	

IMPLEMENTATION OPPORTUNITIES

Several opportunities in this bundle were seen as viable: WMO16 “Create an Integrated Plan for the Protection of the Tordera Delta” calls for a coordinated effort by the Catalan Climate Change Office[21], the Catalan Polytechnic University[22], Centre for Advanced Studies of Blanes[23], the General Directorate for Coastal and Marine Sustainability in Spain’s Ministry for Agriculture and the Environment[24], the Catalan Water Agency[25], the Catalan Department of Agriculture[26], citizen platforms (e.g. Preservem el Litoral), municipalities and non-governmental organisations. The Tordera delta is in a strategic location where many interests converge; therefore,

[21] Oficina Catalana de Canvi Climàtic
[22] Universitat Politèchnica de Catalunya
[23] Centre d’Estudis Avançats de Blanes
[24] Dirección General de Sostenibilidad de la Costa y del Mar
[25] Agència Catalana de l’Aigua
[26] Departament d’Agricultura, Ramaderia, Pesca i Alimentació

focused solutions developed through sound participation boost the willingness of many actors to pursue the option.

1.4.3 *Monitoring*

Adaptive management assigns a strategic and **central role** to monitoring. Plans have to be adjusted to future conditions as they unfold, taking account of **uncertainty** over future developments, and the adaptation plan has to be constantly **updated** with new information from monitoring, **evaluation** and lessons learned. This section therefore outlines the main elements that should be taken into account when monitoring the outcomes and impact of proposed adaptation options.

Getting the indicators right

Monitoring the environmental outcomes of implementing a particular water management option in a specific place and time is **fraught with difficulties**, as the water system is normally impossible to isolate from the numerous **external drivers and pressures** that affect it concurrent with the implemented option. For instance, it is generally very hard to directly measure the impact of an option that saves on water taken from the river, as natural water availability in a system will depend on manifold factors such as recent weather, evolving land use, the behaviour of other users and so on. The same applies to measures that have other goals, such as water quality. In view of the **extreme complexity** and the **multiple causal chains** impinging on single parameters, environmental programmes usually resort to monitoring the degree of implementation of a given measure. In effect, they rely on scientific consensus about whether a measure delivers the desired effect on a certain parameter and about the expected range of this effect.

In addition to monitoring measure implementation as described, adaptive management often also monitors the overall system (the river basin, in this context), to track its development over time and to allow for reactions to unforeseen trends and developments.

Different strategies for monitoring and evaluation are currently in place, including the monitoring and control protocols regarding the implementation of the river basin management plan or indicators signalling the vulnerability of an area to the impacts of climate change; it is not easy to provide a **comprehensive view** of all monitoring results. Given that adaptation takes place at multiple scales, a complete picture of the adaptation progress can only be obtained and the impact of the options implemented be established if information can be strategically combined [90]. Therefore, local use of adaptation-to-global-change indicators (such as those proposed in WMO18) in coordination with national indicators of a comparable nature is crucial to obtain an overall, aggregated picture without losing sight of the context-specific nature of adaptation. For instance, actions aiming to reduce water consumption at end-user level are often not sufficiently monitored and no information is available on actual water savings obtained by those actions at basin level.

Governance plays a crucial role in the way that adaptation policies and monitoring practices are developed, coordinated and implemented. This is illustrated in the development of a composite indicator of adaptation to climate change in Catalonia

[91], based on an original shortlist of 84 indicators that were screened based on available quantitative and qualitative data from multiple sources. This was a first exercise that revealed **knowledge gaps** and **usability challenges**, which may be overcome through stakeholder engagement in the further development of the composite indicator. Citizen science projects [92] may be an interesting example of how to include the general public in the process of data gathering and providing input to monitoring processes.

In order to help improve the current monitoring setup in the Tordera basin, some options proposed in this plan are intended to improve current monitoring practices (e.g. through the presence and operation of the gauging stations included in WMO29) or **availability of scientific knowledge** (e.g. indicators related to the ecological status of wetlands included in WMO24). The latter is particularly relevant, as difficulties establishing the status of water bodies (e.g. as transitional or heavily modified water bodies) hinder chances of implementing a monitoring protocol. In addition, groundwater control is of particular importance in the Tordera basin and the revision of current Extractions Master Plan would lead to more and better sampling points (WMO5).

Monitoring of the implementation of the Tordera River Basin Adaptation Plan

Indicators for monitoring can assume various forms, each of which contributes to a comprehensive overview of implementation, whether of individual options or of whole bundles. Types of monitoring indicators include [93]

- *financial input indicators* that are used to monitor progress in terms of the annual payment of the funds available for any operation,
- *output indicators* that measure activities directly carried out within options (e.g. number of training sessions organised).

It is not possible to designate any single responsible authority to follow up and coordinate the implementation of options included in the Tordera River Basin Adaptation Plan. Hence, evaluation and monitoring of the entire set of options, given the multisectoral character of the plan, requires the **commitment of a combination of responsible bodies**. In fact, when developing the water management options for this plan, a review of existing management plans focusing on the river basin was undertaken together with a comparison among them (see Part 2).

These existing plans, such as the River Basin Management Plans developed in compliance with the European Water Framework Directive, have a **monitoring and evaluation network** in place in which the monitoring and evaluation of the present report’s water management options can be integrated. For example, the outcome and impact evaluation of all the options in this plan that address the Catalan Water Agency could be incorporated in the monitoring and control plan [54] in force.

Potential monitoring synergies exist; for example, with regard to option WMO28 “Protect groundwater recharge areas” and WMO23 ”Create a catchment agreement to reduce diffuse pollution”. In the first case, a whole set of indicators established by the Groundwater Directive (2006/118/EC) are already in place to evaluate the quantitative and qualitative state of the basin’s aquifers. For the latter, the same indicators and monitoring protocols established by the Nitrate directive (91/271/EEC)

may be used, helping to monitor progress in reducing the presence of pollutants as well as the level of risk related to drinking water quality standards in the area.

However, some water management options are **unique** to this river basin adaptation plan and therefore do not have specific links to existing monitoring strategies. For some of these options, opportunities exist to implement them within specific projects, such as those eligible under the LIFE programme, which includes a budget for monitoring and evaluation activities and requires output monitoring of all projects. An external financing scheme could be used to fund the following options: “Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD) “(WMO16) and “Enhance soft wastewater treatment plants in small municipalities and scattered houses” (WMO15). More specifically, WMO16, which involves a participatory process to develop the delta plan, may include indicators related to the level of interest local population showed in the planning process or the actions included in the plan. On the other hand, WMO15 involves pilot wastewater treatment facilities, where the direct impact of the action on outflow quality, as well as on the river’s nutrient load, may indicate the effectiveness of the action.

To monitor the implementation process and impact of actions directed at ecological conservation of forests, different **references are available**. For example, the quality of the Montseny conservation strategy is developed in a way consistent with **national quality standards** [94] including a sound register of all actions undertaken and the means to track points of improvement. This information is made available for all internal communication between technical departments, and constitutes a solid basis for public participation, where the implementation of the conservation plan is periodically evaluated together with all relevant stakeholders and local society.

Measures related to adaptive forest management should be closely coordinated with **wildfire risk management**. Currently this is considered part of the prevention policies, whereas the present monitoring of the environmental quality of forested areas is more focused on post-wildfire ecosystem recovery. Therefore, specific monitoring of process, outcome and impact is particularly relevant for concluding adaptive forest management agreements (WMO31) and may be developed on a case-by-case basis.

As for options related to agriculture, such as for example the modernisation of irrigation techniques (WMO20), such measures are generally monitored to establish whether funding eligibility requirements are met and target stakeholders are addressed. Monitoring of the **specific targeted objectives** is project based and established in accordance with the standards set by the funder.

1.5 Recommendations for implementation

The Tordera River Basin Adaptation Plan has outlined the participatory approach that was followed to develop a set of targeted water management options and, subsequently, bundles of these options. The outlined (bundles of) options serve to address the main challenges that were identified by the basin's stakeholders. This chapter provides guidance and recommendations for decision makers, individuals and entities that are in a position to implement either whole bundles of synergistic water management options or individual options. The information provided throughout the plan is thus intended to serve as a **tool to help to guide policymakers and decision makers** in selecting appropriate options or sets of options to implement within the basin to address the basin's specific needs.

Implementation of all options within a given bundle

The bundles presented in Chapter 4 are sets of options, which have been grouped together on the basis of their expected ability to **collectively address the challenges** identified within the Tordera river basin and react to additional local needs (i.e. Create a Permanent Participation Centre.) Implementation of an entire bundle ensures a numerous synergies between the options and the pursuit of one or more common objectives. Two water management options that are strongly aligned may have **reduced implementation or maintenance costs** if they are implemented together. Other combinations may lead to an **increased impact** addressing an existing challenge.

The bundle factsheets in Chapter 4 provide a wealth of information on how the water management options interact, to support decision-making processes. For example, there are indications of the objectives that could be reached by choosing to implement a given bundle, the costs involved, the ideal phasing of the options in time, etc. If an entire bundle is to be implemented, the **'adaptation pathway'** provides further information about which options are critical to implement before other options in the bundle. For example, in bundle 1 "Enhancing adaptive forest management", WMO2, which aims to create a specific branding and sales strategy for livestock products, necessarily requires WMO1 (livestock infrastructure), WMO3 (shepherds school) and WMO33 (Conclude adaptive forest management agreements) to be implemented, in order to consolidate the viability of grazing before tightening production, commercialisation, and the consumption model of its products at basin level.

Implementation of individual water management options

The existence of very **specific objectives**, resource or capacity limitations, or other considerations may make the implementation of an entire bundle unfeasible. In this case, implementing just one or more individual options will not necessarily have a negative impact on their effectiveness. While all of the water management options presented are suitable for implementation in the river basin, the decision to implement individual options on their own requires a check that the option does not rely on any other water management option. Information on the relationship between the options is outlined in the bundle factsheets in section 4.2 and should be checked before reaching conclusions on this matter.

Here, a particular focus should be given to **high-priority water management options**, which have been identified based on the wishes and needs of the stakeholders engaged in the process and taking into account **implementation-oriented factors** such as the multi-criteria analysis, performance with regards to the challenges, feasibility, acceptability and policy synergies. As such, these options are strongly aligned with community interests and are foreseen to offer large potential in addressing the targeted challenges identified within the basin (see Table 2). In order to assess the best implementation timing, the adaptation pathways as presented in section 4.2 should be consulted.

Following these criteria, **the following water management options are recommended within the river basin:**

- **The implementation of an environmental flow regime** (WMO29) is considered by all participants by far the most important action needed in the Tordera basin. This option, which addresses the challenge of water quantity, would indeed provide an answer to the current depletion of water bodies, allowing a certain amount of water to be kept in the river for maintaining ecosystem functionality. Its implementation would trigger a whole set of improvements of different kinds, such as restored hydrological connectivity between water bodies, correct sediment dynamics, and enhanced water quality.
- **Creating a Permanent Participation Centre** (PPC) (WMO12) is considered crucial to improve integrated water management in the Tordera basin. Some measures, like the revision of current exploitation rates of water bodies, are not being implemented because of a lack of appropriate procedures to take local socioeconomic drivers into account in decision making and technical planning.
- **Conclude adaptive forest management agreements** (WMO33), which scored 81 in the multi-criteria analysis (the highest score of the whole Tordera set of water management options), tackles the challenge of improving current forest management in the basin. Up to a point, many actions included in this option have already been implemented in the Montseny and Montnegre–Corredor natural parks: they include thinning, clearing, eradication of alien species, preventing erosion, and other specific interventions such as facilitating grazing. Nevertheless, these measures should be consolidated and expanded, making use of lessons learned.
- **The creation of an Integrated Plan for the Protection of the Tordera Delta (IPPTD)** (WMO16) is considered an important process to achieve better resilience to global change in the basin by improving the health of water- and forest-related ecosystems. An integrated planning process would also enhance the effectiveness of actions taken by combining sectoral approaches and assure the engagement of all stakeholders in its design and development.

In order to assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial. Therefore, there should be serious consideration of the suggestions made in section 4.3 regarding the alignment of

existing monitoring plans with the requirements of the water management options specified in this plan. This includes finding synergies with existing monitoring schemes regarding the **identification of suitable indicators** for measuring the output.

Policy recommendations supporting adaptation in the Tordera river basin

Moreover, implementing the Tordera River Basin Adaptation Plan or at least some of its key elements requires a **strong political will**, as the transition to more resilient societies requires that deeply entrenched accommodations be shaken up and **socioeconomic inertia** be overcome. Overall policy recommendations to facilitate this transition are presented in this section, which aims to address leverage points that could foster the integration of adaptive principles in current normative, legal and political practices.

Policy recommendation 1: Integrated policy development.

Adaptation management has to rely on a **broad and integrated view** of the interactions between factors affecting the local water cycle, aiming for stronger coordination in policy design and development. For example, it is important to better coordinate forest management practices with water management strategies, so that the local interactions of forested areas with the dynamics of the local water cycle can be better understood and so that findings can be fed into basin-wide water accounting. Given that forested land in the basin is mostly privately owned, specific agreements such as the proposed adaptive forest management agreements (WMO33) may be a tool to overcome the limitations of public intervention in these areas and to implement focused action.

Policy recommendation 2: Improving governance and regulatory frameworks

Public authorities and the local population need certain conditions in order to fulfil their social responsibility to reduce the basin's vulnerability to global change. On the one hand, **improving governance practices for integrated water management** is fundamental to build a proactive society, ready to adapt its activities to a changing environment as well as participate in adaptive water management design. Therefore, Tordera stakeholders said that the creation of a Permanent Participation Centre (PPC) (WMO12) would allow capacity building and raise awareness (WMO19), improve the quality of and access to information (WMO27), encourage conflict resolution practices and improve communication with the Catalan Water Agency. In the same line, **specific deliberative spaces** need to be created, such as the Water User Associations (WMO11) proposed by the Tordera stakeholders to promote sustainable extraction rates from the basin's groundwater, or the creation of a Municipal Adaptation Coordination Board (MACB) (WMO14) to potentiate and coordinate municipal adaptation initiatives.

On the other hand, some crucial **changes in normative settings are essential**. For example, to reinstate an environmental flow regime (WMO29), new ruling is needed on extraction entitlements, rules that match every single user's water consumption patterns with the overall protection of river flows in order to increase resilience for all uses. These changes also need to address water service provider companies, which need to operate under new contractual conditions, ruled by adaptive management principles and under the full control of public authorities (WMO21). It is worth

mentioning that the difficulties related to private companies managing water supply services are behind the current trend that has numerous municipalities returning this task to a system of direct public control.

Policy recommendation 3: Attuning socioeconomic development with environmental conservation

Workshop participants stressed that local water management needs to be aligned with the carrying capacity of the territory, ensuring **self-sufficiency of the water supply** for local uses by recovering a balanced land-use mosaic and better managing the basin's role in the overarching regional water distribution system management.

Increased protection of the ecological status of **local water sources** is a crucial step towards building resilience, so several water management options proposed in this plan are focused on restoring wetlands and the connectivity between water bodies (WMO24), enhancing protected areas (WMO22), river space restoration (WMO30) and protection of groundwater recharge areas (WMO28). Despite the wealth of the Tordera basin's richness of environmental conservation sites, these cannot be adequately protected without seeking to attune local socioeconomic activities. Tackling this major challenge will be the goal of one of the most ambitious proposals included in this plan: the creation of a specific plan for the Integrated Protection of the Tordera Delta (IPPTD) (WMO16).

Policy recommendation 4: Experience-based adaptive learning

Probably the most important policy recommendation needed to underpin an adaptive management plan for a river basin is the chance to gather lessons learned and acquire experience-based knowledge supporting this transformational process. **Mainstreaming adaptation monitoring systems into sectoral monitoring, reporting and evaluation practices** would strongly enhance the consistency and congruence of adaptation policies with the socioeconomic development of the territory. Tailor-made indicators, formulated in such a way that the requirements are operational and the information can actually be taken up in policy making processes [95] should result from increased science–policy collaboration.

PART 2 – Water Management Options

1.6 Detailed description of the water management options

WMO 1: Develop and refurbish facilities to consolidate and extend livestock grazing in the forest

Overall description of the WMO

Short explanation	The lack of active forest management entails an increase of the density of plant cover and undergrowth, increasing in this way total forest biomass. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health. Grazing activities are expected to contribute to a reduction of biomass in forests. In order to facilitate livestock management in the forest, this option includes the building of fences to host the livestock in the forest, beverage and foddering points for livestock, as well as specific agreements on pathways to be used by shepherds to move in the territory.
Addressed challenges	(B) Health of forests and water ecosystems. In particular: restore land use mosaic, reduce biomass.
Target locations and water uses	Location: River as a whole. In particular, natural park areas, like Montseny or Montnegre–Corredor, as well as the area around Arbúcies and la Selva Region would be target locations. Water uses: Agriculture, Forestry. Reduction of biomass would have combined benefits on forests and water ecosystems.
Benefits	Enhance extensive agriculture, increase forest health, reduced wildfire risk, create employment, and consolidate engagement of local actors.
Potential negative impacts	When livestock production needs to satisfy forest management objectives, the farm's economic profitability is reduced. Therefore, integrating production practices enhancing forest management into herd management may increase structural dependence of subventions.
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacle
Robustness	Yes.
Flexibility	Yes. Pasture areas can be re-designed in accordance to forest conditions, as well as the infrastructure proposed is removable and flexible to different use patterns.
Costs	Total cost estimate: 133,459 € The cost estimation is based on the following assumptions: • A study will be conducted to identify areas where interventions/grazing would be optimal to obtain the desired effects. This requires 6 person-months of a technician; • 300 ha of forest will be fenced to host livestock (about 200 km of fence); 80 beverage and foddering points will be established; • The initial agreement for will require an investment of 6 person-months of a technician; • The animation of the programme will require 3 person-

	month of a technician. Investment made by shepherds (livestock and time as well as maintaining the infrastructures) is not considered since returns on this activity are supposed to compensate for the costs. Therefore, only supporting costs (mandatory to make the sustainable grazing activity economically possible) are considered.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - General Forestry Policy Plan (Pla General de Política Forestal 2014-2024) - Montseny Biosphere Reserve Conservation Plan (Pla de conservació del Parc Natural i Reserva de la Biosfera del Montseny) - Livestock development Plan (Pla de recuperació del sector oví i cabrum) - Rural Development Program for Catalonia (Programa de Desenvolupament Rural 2014-2020) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) Different policy lines at Catalonian level contemplate this option and mainly address funding of new herds and infrastructure; EU programmes or private funds could also enhance initiatives. Barriers to the implementation are related to propriety rights and definition of the area of pasturage. Private funds have promoted this kind of measure in the past, but consistency and timeline of the programme often did not allow follow-up and consolidation of the herds.
Suggested stakeholder involvement	Main stakeholders are Natural Park Authorities or forestland owner associations who would need to impulse the initiative. Barcelona and Girona County Council, as well as the Agriculture Department should provide funding and political support. Municipalities have also a crucial role, providing authorisations for pasturage and transit, as well as fostering the visibility of the project.
Acceptance	High. Some doubts were raised during second workshop on an over-estimation of the effectiveness of the measure at basin scale. Stakeholders consider the option regards grazing to recover mountain meadows and lower pastureland, while grazing in closed forests may present more difficulties. Generally speaking, public administration is willing to fund this kind of measure and has already included similar proposals in strategic policy lines, Municipalities would need means to be provided in order to collaborate; forest owners and farm associations would collaborate only if clear agreements and favourable economic conditions are in place.
Preconditions for success	Identification of farmers and forest landowners willing to take up the proposal and establish an activity or modify their herd design. Improve local commercialisation strategies to enhance added value.
Preconditions for success	Identification of farmers and forest landowners willing to take up the proposal and establish an activity or modify their herd

	design. Improve local commercialisation strategies to enhance added value.
Concrete examples where applied	• Montseny, Solana de Matagalls pasturage [96] • Montnegre–Corredor, Vall de Fuirosos [97]

WMO 2: Create specific branding for the commercialisation of extensive livestock products

Overall description of the WMO

Short explanation	The lack of active forest management entails an increase of the density of plant cover and undergrowth, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health. In order to contribute consolidating forest management related livestock farms, this option proposes to create an association of producers and develop a brand for the commercialisation of their products, with the aim to increase added value of products, improve visibility and share costs for product transformation.
Addressed challenges	(B) Health of forests and water ecosystems. In particular: sustain extensive livestock farming.
Target locations and water uses	Location: River as a whole. Water uses: Local population, Agriculture, Forestry. In particular, natural park and all other touristic areas in the basin would be target locations.
Benefits	Enhance creation of added value needed for the economic viability of livestock management in function of forest management objectives. Raising awareness and local development.
Potential negative impacts	When livestock production needs to satisfy forest management objectives, the farm’s economic profitability is reduced. Therefore, branding products would help associations of extensive livestock producers to enhance added value.
Timeline of implementation	Mid term (2 - 6 years’ time)
Feasibility	No major obstacle
Robustness	Yes.
Flexibility	Yes. Branding can be re-designed in accordance to value chain and product visibility needs.
Costs	Total cost estimate: 539,454 € The cost estimation is based on the following assumptions: • A specific association would be constituted to manage and promote the brand. Current cost estimation could be increased by additional administrative costs, up to a maximum of 15 000 €. • Running costs include administrative costs, management and branding as well as communication tasks. Cost estimation of commercial actions could also be increased due to local market constrains, but was currently not possible to evaluate with more precision.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - General Forestry Policy Plan (Pla General de Política Forestal 2014-2024)

	- Montseny Biosphere Reserve Conservation Plan (Pla de Conservació del Parc Natural i Reserva de la Biosfera del Montseny) - Livestock development Plan (Pla de recuperació del sector oví i cabrum) associations of producers and diversification - Proximity selling Decree of Catalan Government (Decret 24/2013, de 8 de gener - DOGC núm. 6290 - 10/01/2013) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) - “Innovation in the agro-food sector” program of Agriculture Department of Catalonia - Catalan Adaptation Strategy (Estrategia d’adaptació al canvi climàtic) The General Forestry Policy Plan, the Livestock Development Plan, the Rural Development Programme and the Catalan Adaptation Strategy developed by Catalan Government all include specific funding oriented at increasing added value of products obtained by extensive livestock grazing. More specifically for the Tordera basin includes concrete dispositions to generate commercialisation opportunities of products obtained in the park’s area. Moreover, a favourable legal framework and economic incentives for commercialisation of these kind of products are designed by the Proximity Markets Decree of Catalan Government and the “Innovation in the agro-food sector” programme of Agriculture Department of Catalonia.
Suggested stakeholder involvement	Main stakeholders are Agro-cooperatives and Natural Park Authorities who would need to impulse the initiative and establish the production conditions for the label. Barcelona and Girona County Council, as well as the Agriculture Department should provide funding and political support. Municipalities should enhance promotion of products.
Acceptance	High. In order to establish the label, coordination between authorities and producers is needed for water entitlement cross check. The Agriculture Department would need to avoid any overlapping with other labels, production protocols and certificates. Park Authorities would need to include lessons learned from negative experiences on previous similar initiatives but are still willing to foster this kind of initiatives.
Preconditions for success	Identification of value chains rooted in consumption patterns of the local area.
Concrete examples where applied	• Guide to local food products, Ripollés [98] • Montnegre–Corredor, Asaja KM0 online shop [99] • Promoting local products after wildfire [100] • Montseny park Rural commercialisation project [101]

WMO 3: Expand the Catalan School for Shepherds in the Tordera basin area.

Overall description of the WMO

Short explanation	The lack of active forest management entails an increase of the density of plant cover and undergrowth, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health. Currently there is an urgent need for generational turnover in the livestock farming sector, therefore this option aims to contribute consolidating the model developed by the Catalan School for Shepherds as to increase interest for the profession to ensure generational turnover. The option proposes to identify farms willing to collaborate with the school and potential new farms to be exploited; teach and encourage sustainable shepherds' activities.
Addressed challenges	(B) Health of forests and water ecosystems. In particular: tackle generational turnover of extensive livestock farming.
Target locations and water uses	Location: River as a whole. Water uses: Local population, Agriculture, Forestry. In particular, natural park and other forested areas in the basin would be target locations.
Benefits	Enhance generational turnover in the livestock-farming sector, sustain herd management practices functional to adaptive forest management practices.
Potential negative impacts	Cultural barriers for new shepherds to be accepted in local community and lack of consolidation of new herds given economical and agronomical constraints.
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacle
Robustness	Yes.
Flexibility	Yes; new herds can adapt to new conditions of the forest and of the market.
Costs	Total cost estimate: 160,791 € The cost estimation is based on the following assumptions: • One-year programme by a manager specialised in the sector to create the conditions to extend the number of livestock farmers collaborating with the Catalan school of shepherds project in the Tordera basin area. • A specialised manager for 3 PM/year dedicates specific follow-up to enhance and consolidate the programme. Communication tasks are not included, given that the network of partners of the shepherds' school would provide these.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Montseny Biosphere Reserve Conservation Plan (Pla de Conservació del Parc Natural i Reserva de la Biosfera del Montseny)

	- Livestock development Plan (Pla de recuperació del sector oví i cabrum) associations of producers and diversification - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) The Catalan School for Shepherds is a Project based on private and public funding. The extension of the initiative is contemplated by the Livestock Development Plan and the Rural Development Programme promoted by Catalan Government. For the Tordera headwater area, opportunities are contemplated by the Montseny Biosphere Reserve Conservation Plan, which aims to enhance economic and social development inside the park perimeter. EU funding and synergies with European Network for Rural Development [102] offer also possibilities for implementation.
Suggested stakeholder involvement	Main stakeholders are Catalan shepherd school and park authorities, providing permits, design and promotion of the school agreements with landowners and farmers; Barcelona and Girona County Council, as well as the Agriculture Department should provide funding and political support. Municipalities should enhance welcoming of new population.
Acceptance	High. Generally speaking all actors would support the measure, obstacles to the implementation would include the limited number of herds where the program could be established and socio-cultural reluctance to the establishment of new people in the area.
Preconditions for success	Farms willing to collaborate.
Concrete examples where applied	• La Gaiata Association project “Ramats al bosc”[103] • Projecte Gripia [104] • Montseny Park Rural commercialisation project [86]

WMO 4: Promote rainfed crop production

Overall description of the WMO

Short explanation	The expansion and consolidation of irrigated agriculture is a strong pressure for the water bodies of the basin. Rainfed crops are not sufficiently promoted to become a viable alternative. In order to promote practices aiming at increased economic viability of rainfed crop production, this option proposes to create specific knowledge transfer programmes in the framework of Farm Advisory Services, including assistance with crop selection and rotation, soil management (structure and fertility), green water management, exploitation design and commercialisation of products.
Addressed challenges	(A) Increase water quantity. In particular, reduce agricultural water consumption.
Target locations and water uses	Location: River as a whole. Water uses: Agriculture, water management.
Benefits	Increase agro-biodiversity, diversify agriculture production and reduce pressures on water resources.
Potential negative impacts	None
Timeline of implementation	Mid term (2 - 6 years' time)
Feasibility	Minor obstacles: related to the integration of new policies into the existing Farm Advisory Service programme.
Robustness	Yes;
Flexibility	Yes; rainfed crops can be adapted to new conditions, because not subject to high investment.
Costs	Total cost estimate: 303,366 € The cost estimation is based on the following assumptions: • Integration with specialised professional advise service by integrating existing Farmers Advisory Service, provided under the Common Agriculture Policy implementation standards, with a half time contract at manager level. • Combination of communication tools and actions for knowledge transfer to farmers on how to increase economic viability of rainfed crops in the basin. Cost estimation includes a publication to disseminate the knowledge acquired to other basins in Catalonia.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Montseny Biosphere Reserve Conservation Plan (Pla de Conservació del Parc Natural i Reserva de la Biosfera del Montseny) - Rural Development Programme for Catalonia

	(Programa de Desenvolupament Rural 2014-2020) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) These policy lines promote the recovery of rainfed agriculture related habitats, agrarian diversification and subsidies with farmers to adopt more resilient agriculture practices. Sensible also to different EU funds.
Suggested stakeholder involvement	County Agriculture Department Vallès Oriental, Maresme and La Selva would support increasing economic opportunities and production diversification. Farmer Associations would have the role to take up the advice and collaborate to knowledge sharing.
Acceptance	High. Advisory service has high acceptance for all stakeholders, but in order to foster the actual adoption of rainfed practices socio/political/cultural problems need to be addressed. Rainfed agriculture is more sensible to drought but has lower input requirements; these characteristics are not favourable for agro-industry, but more interesting for extensive/traditional agriculture orientated farms.
Preconditions for success	Collaboration with the existing FAS [105], like those existing for irrigation [106]
Concrete examples where applied	Berglund, M.; Dworak, T. (2010): Integrating water issues in Farm advisory services - A Handbook of ideas for administrations.[107]

WMO 5: Revise the Extractions Master Plan.

Overall description of the WMO

Short explanation	The declaration of overexploitation of the alluvial aquifer in the central and lower section of the River Tordera through the 2003 edict[108], decreed developing an "Extractions Master Plan" (EMP) for these water bodies POE, DOGC 11/2/2003). In the context of this master plan a specific IT management tool was developed that allows establishing an overall water account of the basin's uses in accordance to specific river sections, with the aim to regulate extraction rates. This option wants to promote: • Updating of the management tool: increase the quality and scope of data included, increase the level of detail and gather relevant information that can be made available for local entities. • Amplifying the territorial scope where the tool is used, like for example the Arbúcies and Santa Coloma streams, with the aim to extend the Extractions Master Plan to the whole basin. • Delegation for the use and maintenance of the IT tool to local entities.
Addressed challenges	(A) Increase water quantity. In particular: promote stricter framework for groundwater extractions.
Target locations and water uses	Location: Current EMP concerns only the lower part of the River, but this option proposes to extend it to the River as a whole. The option targets specifically groundwater users and would integrate current water management;
Benefits	Increase health of water ecosystems, strongly related to biodiversity, hydro geomorphology, water quality and salt intrusion; it also benefits accounting for water uses and empowerment of local actors for water allocation conflict solving.
Potential negative impacts	Potentially, limitations on groundwater extractions may increase the pressure on other water bodies and water transfer demand.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Serious obstacles: constitution of WUA conditions the delegation of the accounting tool, extension of the EMP will affect vested interests and data availability is not always guaranteed..
Robustness	Yes.
Flexibility	Yes; the EMP could be revoked and reviewed in any moment.
Costs	Total cost estimate: 482,846 € The cost estimation is based on the assumption that the actual revision process of this master plan would be at the expense of Water Authority in its normal functions, while BeWater would

	complement and consolidate actions towards increased water accounting, through: • Coordination for data gathering with local entities with the help of a specialised technician to set up a common platform. • In order to expand the area managed under the conditions of the master plan, juridical advice is needed to set up and develop the negotiations with municipalities from the Arbúcies and la Selva region. • Enable the Water User Association - WMO11 – to be in charge to use, maintain and update the water accounting tool provided by the Extractions Master Plan.
Synergies and conflicts with policy objectives	This option is in conflict with almost all sector plans, as water demand for economic activities would have fewer possibilities to expand to allow water tables to improve. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) Catalan Water Agency indicates they are contemplating new management conditions to coordinate ground and surface water bodies in the area, revising the current restrictions imposed by the current EMP.
Suggested stakeholder involvement	Catalan Water Agency, the exploitation board and local entities. Catalan Water Agency needs to promote and fund the action, while the exploitation board engages all water users of the regulated water body. Engagement of local entities is also crucial, especially if the scope of the Plan is amplified.
Acceptance	Low. If adequately managed the extraction plan would increase water provision guarantee of current users and all actors agree on the necessity for revision, but acceptance will be affected by the manner in which the measure is executed. Willingness of local stakeholders to comply with new dispositions is conditioned by favourable socio-political environment.
Preconditions for success	The constitution of a WUA (WMO11), awareness rising on the need to regulate extractions.
Concrete examples where applied	2003 Lower Tordera aquifer overexploitation edict

WMO 6: Establish water entitlement conditions

Overall description of the WMO

Short explanation	Investments in water-saving technologies don’t deliver the

	expected results due to the rebound effect: saved water is re-invested in production until the entitled volumes are used up, therefore savings don't return to water bodies. When public administration awards subsidies to foster water-saving practices and decrease the pressure on the environment, specific conditions can be introduced in the entitlement in order to guarantee effective savings. For example: adopting flow limiting devices, adopting complementary environmental protection measures, realising technological improvements, installing piezometers, increasing the time lag of the entitlement validity in exchange of a reduction of volumes entitled, etc… An adequate normative structure exists, but there is the need to amplify, innovate and consolidate the available options that can be used when new conditions are negotiated. This option wants to promote a participatory process / open debate targeting municipalities, big water users and relevant actors with the aim to: • Disseminate information about the opportunities to modify/integrate entitlements (existing and new) contemplated in current legal framework; • Gather experiences from citizens, administration and academia on the effectiveness of the different conditionalities currently already adopted; • Design new specific proposals for the Tordera basin.
Addressed challenges	(A/D) Increase water quantity/ IWM. In particular: generate opportunities to reduce water extraction
Target locations and water uses	Location: River as a whole. The option targets all water uses with an entitlement and integrates current water management practices.
Benefits	Strong increase in health of water ecosystems, strongly related to more biodiversity and better hydro geomorphology. Preserving local water bodies from over extraction would also reduce salt intrusion and bulk water cost caused by treatment.
Potential negative impacts	Potentially, limitations on water extractions may increase the pressure on water transfer demand.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles: vested water uses would be affected, but no loss of water productivity.
Robustness	Yes.
Flexibility	Yes; the conditions can be re-negotiated and adapted.
Costs	Total cost estimate: 57,762 € The cost estimation is based on the following assumptions: • Material and information production for the participatory process developed by the Catalan Water Agency with professional facilitators. • Specialised professional advice (part-time) to structure received information and design concrete proposals for the basin

	• Special communication programme to disseminate the results and the lessons learned of the process itself to transfer knowledge to other Catalonian and Spanish basins.
Synergies and conflicts with policy objectives	This option is in conflict with almost all sector plans, as water demand for economic activities would have to take into consideration provision limitations and environmental flow regimes. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) Recently approved management plan clearly supports the measure, as it contemplates new negotiation processes and exploring conditions to be put in place.
Suggested stakeholder involvement	Catalan Water Agency and local entities. Catalan Water Agency would promote and fund the action with the aim to increase available regulation tools, increase awareness and conditions for implementation. Conditions of implementation would be co-designed with the people owning an entitlement.
Acceptance	Low, revisions of water entitlement conditions are politically conflictive because of vested interests. Nevertheless, the Catalan Water Agency contemplates the measure as part of the revision of entitlement process (WMO31).
Preconditions for success	The willingness of the Catalan Water Agency to proceed.
Concrete examples where applied	A negotiation process to introduce conditions in existing water use entitlements was established during the first RBMP (2009-2015) [109]

WMO 7: Promote knowledge transfer on irrigation with reclaimed water.

Overall description of the WMO

Short explanation	Irrigation with reclaimed water is considered a big opportunity to avoid using water of higher quality for crops, but it is crucial to evaluate limitations and opportunities of these solutions in terms of public health concerns, agronomic, infrastructural, energy consumption and managerial parameters, as well as coordination between authorities and normative issues. This option aims to promote: • The elaboration of a study to evaluate the effectiveness of currently existing irrigation with reclaimed water aiming to achieve a reduction of pressure on water bodies in the basin, including an evaluation of the entailed energy consumption, in order to increase the information available on the limitations and opportunities of such projects for the Tordera Basin. • Realise a knowledge transfer programme on the use of regenerated water for irrigation targeting public administration, academia and relevant actors.
Addressed challenges	(A) Increase water quantity. In particular: reduce the impact of agriculture water use.
Target locations and water uses	Location: River as a whole. The option targets irrigated agriculture and gardens (built-up land). Water uses: agriculture and water management.
Benefits	Better scoping of water reuse opportunities.
Potential negative impacts	Increase in water treatment (energy consumption), concentration of pollutants and reduction of wastewater feeding river flows.
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacle.
Robustness	Yes.
Flexibility	Yes; the knowledge can enhance better adaptation strategies.
Costs	Total cost estimate: 139,634 € The cost estimation is based on the following assumptions: • Full PhD programme student during three years in order to elaborate the information object of a knowledge transfer programme • Development of a knowledge transfer programme based on 10 field visits for around 20 people and a publication to report the experience and disseminate the lessons learned.
Synergies and conflicts with policy objectives	No conflict in principle with any policy or programme, but health legislation does not favour reutilisation for certain water uses. Synergies with

	- Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) - Spanish decree on water reutilisation (R.D. 1620/2007) [110] All policies mentioned enhance water reutilisation, and current RBMP has a special programme dedicated to this subject, while the decree establishes constraints.
Suggested stakeholder involvement	Catalan Water Agency (Agència Catalana de l'Aigua), Agriculture Department (Departament d'Agriculutra, Ramaderia, Pesca I Alimentació), Agrarian Research Institute (Institut de Recerca i Technologia Agroalimentàries), Health Department (Departament de Salut), Health Agency (Agencia Catalana de Seguritat Ambiental) and Water utility company (Consorci Costa Brava).
Acceptance	High. Actors agree with the concept of the option, but economic, technical and normative feasibility are tricky, reducing the amount of cases where water reuse can be implemented.
Preconditions for success	Availability of Consorci Costa Brava and/or other actors implementing reutilisation systems to provide data for the study.
Concrete examples where applied	• Consorci Costa Brava are very much involved in pilot cases in their service area [111], (partially in our basin). • Reutilisation projects enhanced by the Water Agency [112] • Reutilisation projects enhanced by Agrarian Research Institute [113] • DEMOWARE project [114]

WMO 8: Integrate water saving solutions in construction protocols.

Overall description of the WMO

Short explanation	Urban water consumption has a significant impact on the basin. Water savings could be maximised in urban and touristic buildings, both if refurbished or new constructions, reducing current water consumption levels.
	This option wants to promote:
	• A basin-specific study aiming at:
	  ○ Identifying opportunities for water reutilisation in buildings,
	  ○ Identifying opportunities and barriers to optimise operation and maintenance conditions for installations,
	  ○ Minimise energy consumption for water reutilisation installations.
	• Dissemination of good practices in the design of grey water management installations in buildings.
	• Revision of management patterns and local norms orientated to support this kind of initiatives.

Addressed challenges	(A) Increase water quantity. In particular: optimise water use in buildings.
Target locations and water uses	Location: River as a whole. The option targets specifically built-up land and all related water users.
Benefits	Higher water use efficiency, increased information on how to optimise water use savings.
Potential negative impacts	Costs may override benefits.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to the coordination between urban planning and water supply provision, as well as between Municipalities and real estate construction promoters.
Robustness	Yes; once installed, cost of investment obliges to maintain the system as long as possible even if conditions change.
Flexibility	No, this is a grey measure, not easy to adapt to new conditions.
Costs	Total cost estimate: 323,345 € The cost estimation is based on the following assumptions: • Preparation of material for dissemination re-editing existing material from the Barcelona Council (Diputació) • Elaboration of a diagnostic study specific for the Tordera by engineer full time • Foster take-up by municipalities through the work of a full time coordinator, moving around the basin to establish pertinent agreements.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió

	del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) - Spanish decree on water reutilisation (R.D. 1620/2007) The Catalan River Basin Management Plan and the Catalan Adaptation Strategy promote the establishment of new construction protocols enhancing water savings. Furthermore, the Spanish decree on water reutilisation (R.D. 1620/2007) establishes conditions for water reutilisation, also for domestic use.
Suggested stakeholder involvement	Barcelona Council (Diputació) -network of towns and villages for sustainability- and Municipalities to promote the options and construction companies to provide data and adopt the conclusions. Catalan Water Agency is willing to collaborate with local entities to foster this option. Barcelona Council's Network of Towns and Villages for Sustainability is promoting this kind of interventions and has relevant experience that can enhance the implementation of the measure at Municipal level. Target stakeholders are municipalities where these kinds of measures have not been applied.
Acceptance	High. New buildings allow best conditions for the implementation of the measure, while refurbishing old buildings is often not viable. This measure is already included in strategic policy lines, but limited funding available. For increased application, Municipalities would need support and information. Stakeholders suggested this measure should be combined with increased rainwater harvesting devices.
Preconditions for success	Availability of engaged actors to participate in the study.
Concrete examples where applied	Today 46 Municipalities in Catalunya have adopted this type of ordinance: • Prototype for municipal protocols for this approved by Catalan government [115] • Presentation by environmental department of Barcelona Council [116] • Report on water protection guidelines for Tordera by the ctalan Water Agency [117] • Study dated 2010 on the state of art of the adoption of municipal ordinances for water saving [118] • Sant Cugat Municipality experience [119]

WMO 9: Promote renewable energy to power water management infrastructure in small urbanisations and scattered houses.

Overall description of the WMO

Short explanation	Disposing of the necessary energy supply for correct functioning of water management infrastructure, like water treatment plants, impulsion and/or extraction can be problematic in small urbanisations and scattered houses. In

	these cases, locally produced renewable energy supply could enhance better water management practices. This option aims to promote: • Pilot cases on the use of renewable energy in water treatment plants, water heating, impulsion and/or pumping in small towns and scattered houses. • Dissemination of the information obtained targeting public administration, academia, water utilities and relevant actors.
Addressed challenges	(D) Integrated water management. In particular tackling the relation water-energy.
Target locations and water uses	Location: River as a whole. The option targets water management sector, especially with regards to small municipalities.
Benefits	Possibility for small towns and municipalities to install water treatment currently unviable because of the lack of energy supply. Increase health of water ecosystems, biodiversity, and water quality due to the improved wastewater treatment.
Potential negative impacts	Renewable energy installation technical constraints and maintenance.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to renewable energy installation technical constraints and maintenance.
Robustness	Yes;
Flexibility	Yes, renewables would be adapted to treatment needs.
Costs	Total cost estimate: 329,258 € The cost estimation is based on the following assumptions: • Two pilot cases of renewable energy installation to power soft depuration plants proposed in measure 15, developed and designed by a researcher during 3 years. • Development of a knowledge transfer programme and publication on lessons learned after the first 3 years of pilot running. • Maintenance of the pilot cases is accounted for in the description of option 15.
Synergies and conflicts with policy objectives	May present normative and legal conflicts with current energy legislation which does not allow self-provisioning. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) - National Adaptation Strategy for Spain [120] - Catalan Renewable Energy Strategy [121] - Energy and climate change Plan for Catalonia (Pla d'Energìa i Canvi Climàtic de Catalunya 2012-2020) [122]

	All mentioned policies actively sustain renewable energy use, including water management devises.
Suggested stakeholder involvement	Catalan Water Agency (Agència Catalana de l'Aigua), Catalan institute for energy (Institut Català d'Energia), water service operators and municipalities.
Acceptance	Catalan Water Agency supports the measure and is available to work in collaboration with key actors for the implementation. Nevertheless, in their opinion, in order to obtain a significant impact, the measure should be combined with water savings (reducing energy consumption for distribution) and should include solutions to reduce the energy consumption for water heating.
Preconditions for success	Economic and technical feasibility.
Concrete examples where applied	• Acuamed [123] • Case studies of energy and water management in the region (Tordera Aquifer) [124]: • Study on renewable energy for desalting plants [125] • Study for renewable energy for purification processes [126] • Study for renewable energy for electrolysis process [127]

WMO 10: Promote water recycling in production processes

Overall description of the WMO

Short explanation	There are different industries in the basin that have a water consumption pattern that could include closed water recycling systems, like for example wine production or chemical industry. This option aims to promote: • Concrete pilot cases for industries as a reference for best practices and innovation projects on closed water recycling systems. • Dissemination of the information obtained targeting public administration, academia and relevant actors.
Addressed challenges	(A) Increase water quantity. In particular: optimise current water use.
Target locations and water uses	Location: River as a whole. The option targets agriculture, industry and energy water use sectors, as pilots could be enhanced in different production sectors.
Benefits	Reduce pressure on water bodies and reduction of external water demand.
Potential negative impacts	Increased investments costs.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to initial investment.
Robustness	Yes; once installed, cost of investment obliges to maintain the system as long as possible even if conditions change.
Flexibility	No, this is a grey measure, not easy to adapt to new conditions.
Costs	Total cost estimate: 406,539 € The cost estimation is based on the following assumptions: • Full PhD programme student during three years in order to elaborate the information and engage industries in the initiative. • Development of a publication reporting lessons learned and dissemination of findings to target audience.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) The Catalan River Basin Management Plan and the Catalan Adaptation Strategy promote water saving technologies to be adopted by industrial processes. These projects could also benefit from funding obtained through the Eco-innovation programme of the European Commission [128].
Acceptance	High There is no significant reason a priori for anyone to reject the option if proper funding is provided.
Suggested	Catalan Water Agency or Consorci Costa Brava, together with the industrial partner should design the pilot; County Council (in

stakeholder involvement	accordance to the area where the pilot is located) may give support and facilitate funding. The Catalan Water Agency would promote the option in a collaborative framework. Water technology companies and industries willing to do a pilot would design and develop the measure. Target actors for knowledge transfer programme would receive the results of the study.
Preconditions for success	Economic and technical feasibility, water tariffs limiting the use or limited water use permits.
Concrete examples where applied	- SELWA project [129]

WMO 11: Create Water User Associations (WUA)

Overall description of the WMO

<table>
<tr><td>Short explanation</td><td>Groundwater bodies in the Tordera Basin are overexploited, given that the level of extractions is superior to the recharge rate. Even if recent figures indicate a positive trend, new forms of governance are needed in order to allow generating a balance between extractions and good quantitative status of the water bodies. The creation of a Water User Association was promoted in the past, decreed by the 2003 edict of overexploitation, without success.
This option wants to promote:
Elaborate a study to evaluate the barriers and opportunities to build a WUA in the Tordera basin, including:
Literature review on the role of WUA in adaptive management,
Analysis of the history of WUA in Tordera engaging relevant actors,
Formulation of proposals to promote a WUA in the Tordera basin.
Interventions to increase the availability and transparency of information on the extractions in the basin.
Promotion of a specific deliberative space and decision making of people/entities that have an entitlement (WUA) in order to:
Coordinate and agree on sustainable extraction rates,
Manage the IT water management/accounting tool described in option number 5,
Monitor and follow-up the measures agreed,
Behave as an interlocutor between the water authority and local entities.</td></tr>
<tr><td>Addressed challenges</td><td>(D) Integrated water management. In particular: water governance.</td></tr>
<tr><td>Target locations and water uses</td><td>Location: River as a whole. The option targets all water users of a certain water body.</td></tr>
<tr><td>Benefits</td><td>The water user association allows solving structural problems related to specific socioeconomic dynamics. In this case, a WUA would enhance reduced extraction rates and enhance water accounting.</td></tr>
<tr><td>Potential negative impacts</td><td>The WUA is an association of entitlement beholders only. Impossibility to include citizens who do not have an entitlement in this association may potentially consolidate decisions based on the defence of vested interests of the entitlement holders and pervert the objectives of the WUA.</td></tr>
<tr><td>Timeline of implementation</td><td>Short (under 2 years’ time)</td></tr>
<tr><td>Feasibility</td><td>Major obstacles, affected by political constraints and implementation of WMO5.</td></tr>
</table>

Robustness	Yes.
Flexibility	Yes, the WUA may enhance flexibility in decision taking in case an increased adaptation effort is required.
Costs	Total cost estimate: 693,073 € The cost estimation is based on the following assumptions: • Researcher dedication during two years to elaborate the diagnostic study. • A permanent staff at manager level to run and coordinate the WUA. • Promotion of the WUA with 4 annual meetings.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) - National Irrigation Plan of the Ministry of Agriculture (Ministerio Agricultura Pesca y Alimentación) [130] The Catalan River Basin Management Plan and the Catalan Adaptation Strategy promote Creation of citizen associations to enhance better water governance and adaptation. Spanish water law (TRL art. 81) establishes the protocol for the creation of WUAs. The RBMP specifically indicates the options as a priority for this management cycle.
Suggested stakeholder involvement	The Catalan Water Agency would promote the option and actors owning a water use entitlement would need to participate.
Acceptance	Low. General acceptance in society is high, but in practice different water users refuse the option because of the potential modifications of their entitlement. Catalan Water Agency has taken up the measure in the current RBMP and will promote the measure and try to overcome the political barriers.
Preconditions for success	Legitimacy of the WUA, clear conditions and process of decision taking.
Concrete examples where applied	- Llobregat Delta WUA [131] - Reporting on the creation of a WUA in the Tordera River [132] - International experience of EU funded projects on WUA [133]

WMO 12: Create a Permanent Participation Centre (PPC)

Overall description of the WMO

Short explanation	Currently there is a gap between calls for participation established by the WFD implementation calendar for Catalan RBMPs, planned every 6 years. This disconnection implies citizens are not engaged in following up the implementation of measures, don't have access to relevant information in accessible formats and communication is hindered between the territory and public administration. This option wants to promote: • The constitution of a "Permanent Participation Centre" with the objective to enhance better conditions for citizens to participate in the design and revision of water policies. • Create a documentation centre allowing: o To promote dissemination of relevant information for the basin, o To promote local debate and coordinate citizen's contributions, o Inform about the uptake of those contributions, o Foster conflict mediation.
Addressed challenges	(D) Integrated water management. In particular: enhance the quality of water governance.
Target locations and water uses	Location: River as a whole. The option targets all water use sectors, and all land uses.
Benefits	Increased water governance quality allows solving structural problems related to specific socioeconomic dynamics.
Potential negative impacts	Longer periods needed for adopting policies.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to the legitimisation of the space and effective participation of the Tordera society.
Robustness	Yes.
Flexibility	Yes, the PPC may enhance better response to changing environment.
Costs	Total cost estimate: 700,428 € The cost estimation is based on the following assumptions: • Creation of local office where a documentation centre is created and correspondent activities can be developed. • Specialised professional at manager level to implement and maintain the activities developed at the documentation centre.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya)

	- Catalan Adaptation Strategy (Estratègia d'adaptació al Canvi climatic) - Catalonian transparency law (Llei de transparencia, acceso a la información pública y buen gobierno) - Europe for Citizens Programme [134] All these policies actively promote the creation of deliberative spaces and participation processes.
Suggested stakeholder involvement	ACA and local entities.
Acceptance	High. Catalan Water Agency implements compulsory participation processes as transposed from the WFD, but accepts there is a need for consolidating these practices. (Option taken up by Agency). Minor barriers are related to funding and political legitimation, while for the Tordera society acceptance is related to time and attention needed for capacitation & participation.
Preconditions for success	Legitimacy of the PPC, take up of the issues resulting the debate into policy and management.
Concrete examples where applied	- Proposal to institute "Basin Councils" for permanent participation for the first RBM planning cycle [135] - Catalan Water Agency participation processes [136] - Catalan Adaptation Strategy participation process [137]

WMO 13: Develop a water traceability label for agricultural products

Overall description of the WMO

Short explanation	For different reasons, like land ownership patterns, exploitation agreements and difficulties constituting irrigation community organisations, many farmers lack formalised water entitlements. Water use without entitlement entails significant problems for proper water accounting and extraction management, entailing groundwater overexploitation and provoking salt-water intrusion in groundwater bodies of the coastal area. In order to penalise farmers for abstracting water without a valid entitlement, this option proposes to develop a “water traceability label” for those farmers who do have regular permission, thus allowing consumers to recognise and reward producers contributing to the protection of the basin’s resources.
Addressed challenges	(A) Increase water quantity. In particular: enhance water accounting.
Target locations and water uses	Location: River as a whole. The option targets specially agriculture water sector and irrigated land use.
Benefits	The label would help better awareness rising about the importance of water accounting and avoid illegal wells currently causing overexploitation of groundwater.
Potential negative impacts	Difficulty to control and free riding of some producers.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Serious obstacles, related to the process of water entitlement regularisation and transparency of information.
Robustness	Yes.
Flexibility	Yes, the label may enhance more resilience for agriculture water supply.
Costs	Total cost estimate: 397,530 € The cost estimation is based on the following assumptions: • Creation of the label and pertinent communication tools • Full time technician engaged to manage and promote the label for commercialisation strategy development. Current cost estimation may be increased by added costs related to the establishment of the water traceability protocols, where close collaboration and information sharing needs to be put in place. These elements were not possible to estimate at this stage.
Synergies and conflicts with	No conflicts with any current policy or programme. Synergies with

policy objectives	- Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) - Catalan Adaptation Strategy (Estrategia d'adaptació al canvi climàtic) All mentioned policies entail measures related to enhancing water accounting in agriculture, increasing control and reducing the impacts of overexploitation.
Acceptance	Low, as it would affect those producers who have no regular entitlement and enhance the revision of entitlements of the existing ones, which may entail a reduction of current extraction rates.
Suggested stakeholder involvement	Catalan Water Agency (Agència Catalana de l'Aigua), County Agriculture Departments (Oficines comarcals del Departament d'Agricultura), farmer cooperatives. Catalan Water Agency is highly interested in supporting the measure. County Agriculture Department Vallès Oriental, Maresme and La Selva should support increased water accounting and product value, but have limited motivation to burden their affiliates with water law enforcement. Farmer Associations are reluctant due to the high number of infringements and administrative burden.
Preconditions for success	Political will to tackle illegal well problems in the lower part of the basin.
Concrete examples where applied	- Traceability norms in EU (Regulation 178/2002) [138]

WMO 14: Create a Municipal Adaptation Coordination Board (MACB)

Overall description of the WMO

Short explanation	Lack of resources hinder planning, funding, implementation and monitoring the effectiveness of adaptation to global change policies at municipal level. In order to foster collaboration between municipalities enhancing the implementation of municipal adaptation plans and/or adaptation measures, this option proposes the creation of a permanent adaptation board.
Addressed challenges	(D) Integrated water management: increase solidity of adaptation measures.
Target locations and water uses	Location: River as a whole. The option targets all water use sectors, and all land uses.
Benefits	The board would help better coordination, funding and implementation of adaptation measures, as well as the development of municipal adaptation plans promoted by Catalan office for Climate Change.
Potential negative impacts	Extra burden on administration and human resources.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to the workload municipalities can handle.
Robustness	Yes.
Flexibility	Yes, the board may enhance adaptation measures to be implemented.
Costs	Total cost estimate: 142,949 € The cost estimation is based on the following assumptions: • In order to promote the participation of municipalities to the board, a kick off conference is organised. • For the duration of the WMO, 4 meetings per year and specific communication material and actions put in place. Cost estimation does not include any funding for the development of the activities the board may decide to implement as currently this is not possible to estimate.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climatic) Policies mentioned actively support supra-municipal networks and coordination

Suggested stakeholder involvement	Barcelona Council (Diputació) - network of towns and villages for sustainability (Xarxa de Municipis i Pobles per la Sostenibilitat), Municipalities and Catalan Office for Climate Change (Oficina Catalana de Canvi Climàtic).
Acceptance	High. Municipalities are interested to reduce implementation costs of adaptation measures; increase coordination and political recognition. The Catalan Office for Climate Change already has subsidy lines to develop municipal adaptation plans and Barcelona Council also could provide an adequate framework for implementation.
Preconditions for success	Willingness of a sufficient number of municipalities to take part of the board.
Concrete examples where applied	- Example from Bages region of municipalities associated to face wastewater treatment [139]. - EU initiative of Majors coordination for adaptation [140] - Catalan declaration for Municipalities for adaptation [141]

WMO 15: Promote phytotreatment plants in small municipalities and scattered houses.

Overall description of the WMO

Short explanation	Treatment of wastewater produced by small towns and scattered houses are a significant challenge in the basin. Soft treatment plants like artificial wetlands, green filters and similar, can be a valuable option to overcome design and funding problems of adequate water treatment plants, but currently there are few references underpinning the viability of such solutions. This option aims to promote: • Pilot cases in small municipalities (< 2000 inh.) and scattered houses in order to improve data availability on different examples of phytotreatment. • A specific knowledge transfer programme to disseminate information obtained targeting public administration, academia and relevant actors identified by a specific dissemination strategy.
Addressed challenges	(C) Increase water quality. In particular: enhance low-tech solutions in order to overcome problems related to wastewater treatment.
Target locations and water uses	Location: River as a whole. The option targets local population, tourism and water management sector, all built-up land use.
Benefits	Allows water sanitation where currently no facility is provided; low-tech investment required; low energy and maintenance costs.
Potential negative impacts	None.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to the process of adaptation to new practices.
Robustness	Yes, the pilots are designed under certain conditions and are difficult to change in a short time lag.
Flexibility	Yes. Modularity of treatments plots can be introduced.
Costs	Total cost estimate: 1,300,589 € The cost estimation is based on the following assumptions: • Three pilot cases, established in the upper part of the basin • 6 years of pilot design and development with support of a researcher and a technician with full time dedication. • The elaboration of a publication indicating lessons learned and dissemination to enhance the application of soft depuration in similar conditions.

	This cost estimation des not include the cost of property of land where soft depuration plants would be installed, as in the current assumption these are already owned by municipalities.
Synergies and conflicts with policy objectives	No conflict with any policy or programme Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'adaptació al Canvi climatic) - Montseny Biosphere Reserve Conservation Plan (Pla de conservació del Parc Natural i Reserva de la Biosfera del Montseny) All policies mentioned support water depuration and low energy input solutions. EU funding, like Life+ programme could fund the pilots too.
Suggested stakeholder involvement	Catalan Water Agency (Agència Catalana de l'Aigua), Montseny park authorities, Montseny Municipality, Can Casades and can Leonard (park administration offices), Santa Fe Hotel, Restaurant Avet Blau
Acceptance	High. Coordination effort with municipalities and water users is needed, as well as information management to overcome the uncertainty about soft depuration plant technology. Catalan Water Agency has taken up the proposal.
Preconditions for success	Possibility to integrate the proposal into Municipal water management roadmap, as these may be subject to constraints.
Concrete examples where applied	- Phytotreatment in Catalonia [142] - A review of cases around Europe [143]

WMO 16: Create an integrated plan for the protection of the Tordera Delta (IPPTD)

Overall description of the WMO

Short explanation	The Tordera Delta area is a particularly sensitive area to the impact of global change and receives multiple impacts from upstream pressures. Fragmentation of public administration competences and the role of a variety of stakeholders generate difficulties for managing the area in an integrated manner. In order to protect the whole delta area in an integrated manner, this option proposes to enhance a specific process of elaboration of an Integrated Protection Plan. The proposal involves a set of actions to recover sediment dynamics of dunes and beaches, constrain land uses, decrease water extractions, increase depuration and enhance biodiversity protection.
Addressed challenges	(B) Health of forests and water ecosystems
Target locations and water uses	Location: lower part. The option targets all water uses and all land use sectors.
Benefits	Creates the conditions to design and implement a strong and focused set of measures for this particular territory.
Potential negative impacts	If no actions take place after the participation process has delivered results, political reluctance will increase.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to the trust in the process.
Robustness	Yes.
Flexibility	Yes, citizen participation process can include changes due to climate change.
Costs	Total cost estimate: 160,187 € The cost estimation is based on the following assumptions: • Cost estimation focuses on the development of a 3-year participation process, with professional facilitation. • Specialised technician is hired to design the process and develop the necessary information, as well as a manager to coordinate and promote the process, both with part-time dedication. • One-year communication programme to disseminate results. Cost estimation does not contemplate a fund to implement the actions resulting the participation process, which was not possible to envision today.
Synergies and conflicts with policy objectives	May induce conflicts with sectoral planning, given eventual land and water use restrictions. Synergies with

	- Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climatic) - Catalan coastal law (Llei del Litoral[144] - Territorial Plan for Catalonia (Pla territorial General de Catalunya) - System of environmental protection in Catalonia (System of Natural Protection Areas in Catalonia) All policies mentioned would contribute funding and developing the option. The Catalan River Basin Management Plan includes a Plan for the coordinated exploitation of Surface and groundwater in the Tordera delta region and takes up the Spanish coastal adaptation strategy. So does the Catalan Adaptation Strategy, while the Catalan coastal law supports Integrated strategies for coastal protection. It might be that also under the Territorial Plan for Catalonia and the System of environmental protection in Catalonia funding could be made available.
Suggested stakeholder involvement	Catalan Office for Climate Change (Oficina Catalana de Canvi Climàtic), Catalan Polytechnic University (Universitat Politèchnica de Catalunya), Centre for Advanced Studies of Blanes (Centre d'Estudis Avançats de Blanes), Coastal Department of the Ministry for agriculture and environment (Dirección General de Sostenibilidad de la Costa y del Mar), Catalan Water Agency (Agència Catalana de l'Aigua), Agriculture Department of Catalan Government (Departament d'Agricultura, Ramaderia, Pesca I Alimentació), Citizen platforms (Preservem el Litoral), municipalities and NGOS.
Acceptance	High. Catalan office for climate change and Water Agency already indicated they would collaborate promoting the initiative. Nevertheless, given social mistrust to administration and eventual impact on private interests, it may require some effort to get everybody on board.
Preconditions for success	Legitimation of the participatory process.
Concrete examples where applied	- Integrated Plan for the Protection of the Ebro Delta [145]

WMO 17: Foster selective fishing

Overall description of the WMO

Short explanation	The increase of alien species populations are a major challenge in the basin. In the Tordera river different sections are affected by the development of alien fish species. In order to engage citizens in the protection of the basin's biodiversity and help reducing the pressure of alien species in the river, this option proposes fostering selective fishing programmes entailed by fisher associations.
Addressed challenges	(B) Health of forests and water ecosystems. In particular: invasive species.
Target locations and water uses	Location: River as a whole. Water uses: local population, tourism and Agriculture.
Benefits	Increase in biodiversity.
Potential negative impacts	More difficult control on fishing practices in protected areas where today any fishing is banned.
Timeline of implementation	Long (> 6 years' time)
Feasibility	Major obstacles, related to the prohibition to fish in some areas, even if alien species.
Robustness	No.
Flexibility	Yes. Guide can be updated anytime.
Costs	Total cost estimate: 33,594 € The cost estimation is based on the following assumptions: • The elaboration of a specific fishing guide for the Tordera basin. • Dissemination of the publication and awareness rising amongst target audience of the key messages.
Synergies and conflicts with policy objectives	Conflicts with - Montseny Biosphere Reserve Conservation Plan (Pla de conservació del Parc Natural i Reserva de la Biosfera del Montseny) where currently no fishing is allowed. Synergies with - Continental fishing law (Llei 22/2009, de 23 de desembre) [146] providing funding for raising awareness.
Acceptance	low. Strong doubts were raised during second workshop on an over-estimation of the effectiveness of the measure.
Suggested stakeholder involvement	Fishing association of the Basin, Natural Park Authorities and Agriculture Department of Catalan government, Inter-departmental coordination entity on continental fish health (Comissió per a la Conservació de les Espècies Aqüícoles).
Preconditions for success	Capacitation of fishers to execute the good practices and increased control.

Concrete examples where applied	- Publication by fishing association AEMS –rìos con vida [147] - book García de Jalón, Diego y Schmidt, Guido (coords.): “Manual práctico para la gestión sostenible de la pesca fluvial”. AEMS. Madrid. 1995. Sthis reports includes administrative, biological and economical management issues and consitutes an important refernce in Spain.

WMO 18: Foster local use of adaptation-to-global-change indicators

Overall description of the WMO

Short explanation	Global change is a complex challenge and currently is not sufficiently taken into account when building infrastructure and developing interventions in the territory. General indicators have been developed to evaluate the effects of global change, but these are not integrated into local decision making processes, entailing reduced accounting for these impacts in local policy design and implementation. This option wants to promote: • A study to evaluate the opportunities to adapt existing indicators to the specific reality of the Tordera Basin and identify opportunities to integrate its use in local development decision-making processes. • Design pilot cases on the application of these indicators in a local vulnerability to global change analysis. • A specific knowledge transfer programme to disseminate information obtained targeting public administration, academia and relevant actors.
Addressed challenges	(D) Integrated water management. In particular: better design and monitoring of adaptation measures.
Target locations and water uses	Location: River as a whole. It targets all water use sectors and land uses.
Benefits	Increased consideration of adaptation challenges in all local policy implementation processes would benefit the whole basin dynamics and would enhance raising awareness at different levels on the need to adapt to global change, inclusive the administration.
Potential negative impacts	Using indicators may induce extra workload for municipalities.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles related to the incorporation in normal policy implementation procedures of the indicators & capacity building of administrative personnel.
Robustness	Yes.
Flexibility	Yes. Indicators can be updated anytime.
Costs	Total cost estimate: 177,749 € The cost estimation is based on the following assumptions: • Researcher developing during the first year a diagnostic study • A three-year PhD programme dedicated to design and development of the pilot cases • Elaboration of a publication and dissemination of the lessons learned. • Promotion of the uptake of findings at municipal level, 1 PM of specialise technician of the Catalan office for

	climate change.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Montseny Biosphere Reserve Conservation Plan (Pla de conservació del Parc Natural i Reserva de la Biosfera del Montseny) - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) The Catalan River Basin Management Plan, the Catalan Adaptation Strategy and Montseny Biosphere Reserve Conservation Plan Rural Development Programme remark the importance of the availability of sound indicators.
Suggested stakeholder involvement	Catalan Climate Change Office (Oficina Catalana de Canvi Climàtic) to prepare the indicators for local use, Local entities and municipalities to implement the indicators in relevant evaluations.
Acceptance	High. Catalan Office for Climate Change is willing to foster the option; nevertheless coordination efforts and workload for municipalities should be addressed.
Preconditions for success	Clear information and capacity building of local entities to adopt the indicators.
Concrete examples where applied	Catalan global change indicator [148] Mayors Adapt [149]

WMO 19: Raise awareness

Overall description of the WMO

Short explanation	The basin's society is not sufficiently engaged and aware about the challenges of the Tordera River. Awareness rising programmes are in place, but new, interesting campaigns and programmes could be enhanced. In order to offer concrete opportunities for people to be involved in the river's protection, this option proposes a set of actions, such as: design specific programmes at basin scale for schools and adult education, create environmental pathways, fostering natural heritage, strengthen voluntary services and promote initiatives aiming at diversifying seasonal tourism.
Addressed challenges	(D) Integrated water management. Awareness rising can enhance a broad spectrum of improvements of management conditions.
Target locations and water uses	Location: River as a whole. It targets all water use sectors and land uses.
Benefits	Increased consideration of adaptation challenges in all local policy implementation processes would benefit all FCM factors and would raise awareness at different levels on the need to adapt to global change, inclusive the administration.
Potential negative impacts	None
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacles.
Robustness	Yes.
Flexibility	Yes. The more awareness raising, the more resilience.
Costs	Total cost estimate: 298,103 € The cost estimation is based on the following assumptions: • Compilation of existing data to feed in different awareness raising programmes • Specialised communication work, including the development of pertinent material • Elaboration of an APP by 6Pm technician work • Development of educational pathways along the river areas • Development of a specific programme "Foster your river" employing full time technician • Increased coordination between existing volunteer programmes employing full time technician • A conference on adaptation seasonal opportunities for tourism sector 6PM of a technician to foster the uptake of the proposal that arise and a dissemination programme to enhance results to be implemented.
Synergies and	No conflicts with any current policy or programme.

conflicts with policy objectives	Synergies with - Montseny Biosphere Reserve Conservation Plan (Pla de conservació del Parc Natural i Reserva de la Biosfera del Montseny) - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) All policies actively promote awareness rising and knowledge transfer.
Acceptance	High. All key stakeholders would be willing to implement the option if adequate funding is available.
Suggested stakeholder involvement	Touristic, education, volunteer and environmental organisations, municipalities.
Preconditions for success	Clear information to disseminate, people's willingness to participate.
Concrete examples where applied	- Network of green schools [150] - Environmental NGOs [151] - Knowledge transfer [152] - Monitoring environmental state [153]

WMO 20: Modernisation of irrigation technologies

Overall description of the WMO

Short explanation	In order to optimise water use by agriculture sector, this option proposes to install pressurised irrigation devices or refurbish gravity irrigation systems in accordance with option 5 on the basin water accounting tool and option 6 on entitlement conditions.
Addressed challenges	(A) Increase water quantity. In particular: reduce pressure of agriculture water use on water bodies.
Target locations and water uses	Location: River as a whole. Target water use sector agriculture and irrigated land uses.
Benefits	Reduction of water derived for irrigation.
Potential negative impacts	Increased efficiency implies a reduction of water returning to water bodies. These irrigation returns and other leaks of the distribution system are currently maintaining associated ecosystems. Therefore this measure should be implemented in combination with WMO5, 6 and 31, dealing with reduction of abstractions and revision of entitlements.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to the constitution of the user association required by Spanish law.
Robustness	Yes; once installed, cost of investment obliges to maintain the system as long as possible, even if conditions change.
Flexibility	No, this is a grey measure, not easy to adapt to new conditions.
Costs	Total cost estimate: 1,772,667 € The cost estimation is based on the following assumptions: • 25% of current irrigation area potentially to be modernised (156 Ha) • Investment and running cost estimated taking as a reference existing subventions to the sector in Catalonia.
Synergies and conflicts with policy objectives	Potential conflicts may be significant depending on the technology chosen, I.e. pressurised irrigation, which increases energy consumption, and intensification of agronomic models would contradict environmental objectives. In the case of refurbished gravity irrigation systems, diffuse pollution would be the main factor of conflictive objectives. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020)

	All these policies support and fund modernisation and contemplate enhancing optimisation of agriculture water use.
Suggested stakeholder involvement	The and Catalan Agriculture Department would promote the design and funding of the measure, the Catalan Water Agency would ensure that water savings return to the river, while irrigation associations would manage the infrastructure.
Acceptance	High. Modernisation is the main petition of current farmers in the area.
Preconditions for success	Creation of a farmer association and funding.
Concrete examples where applied	- Traditionally modernisation is the main measure used for reducing environmental impact of irrigation in Spain - Report on problems related to irrigation and modernisation in Spain [154] - Report on conditionality linked to FEADER funds for irrigation (Regulation 1305/2013) [155]

WMO 21: Integrate adaptation principles into water service provider contracts

Overall description of the WMO

Short explanation	Currently water service provider contracts established between public administration and private companies include binding conditions on sources entitled, quantities allowed to extract and have very long duration. In case any variation is needed on these contractual conditions, companies would have the right to claim refunding equal to lost benefits. Under the foreseen global change conditions for Catalonia it is crucial to have the needed water management and exploitation regime flexibility to allow the protection of general interest: preservation of strategic water bodies for enhancing resilience. This option aims to promote: • A study on the opportunities to integrate adaptation to global change principles into current juridical framework regulating externalisation of water provision services. • Dissemination of the results of the study with a specific knowledge transfer programme targeting relevant actors.
Addressed challenges	(D) Integrated water management. In particular: increase of flexibility in water management.
Target locations and water uses	Location: River as a whole. It targets bulk water providers and other water service contracts.
Benefits	Public administration would recover opportunities and funds for adaptive management it does not have today.
Potential negative impacts	Increase business risk for service provider companies.
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacles referring to the study, which would help to overcome serious obstacles related to the economic implications of the application of its conclusions.
Robustness	Yes.
Flexibility	Yes.
Costs	Total cost estimate: 154,200 € The cost estimation is based on the following assumptions: • Three-year full time research programme • Publication and dissemination of results to target audience at the end of the research programme.
Synergies and conflicts with policy objectives	Conflict with current water service contract protocols, like currently the case for the biggest bulk water service provider in Catalonia [156] Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) The Catalan River Basin Management Plan promoted the

	reformulation of bulk water supply contracts and supporting the redaction of Master plans by municipalities. The Catalan Adaptation Strategy supports the adoption of adaptation principles in all sectors, while the National adaptation Plan supports increasing knowledge on adaptation. Furthermore, economic problems related to municipal adoption of the new contractual conditions could be sustained by European climate adaptation platform (Climate-ADAPT), EU-Cities Adapt or Mayors Adapt programmes.
Suggested stakeholder involvement	Government of Catalonia would set the proper framework for the results of the study to be disseminated; municipalities and water utilities would give input data and adopt the new legal conditions.
Acceptance	High. The study proposed would be very useful to overcome the reluctance of water service provider's and administration to assume the economical, political and technical burden of making the contracts more adaptive.
Preconditions for success	Political will to prioritise adaptation to global change in water management.
Concrete examples where applied	- Barcelona Metropolitan area is revising service contracts [157]

WMO 22: Enhance environmental protected areas

Overall description of the WMO

Short explanation	The Tordera basin is characterised by special habitat richness, but territorial development and related infrastructures have fragmented strategic areas for many species, reducing their mobility. This option wants to promote: • A participatory process with relevant actors with the aim to revise the current cartography of protected areas and integrate strategic ecologic corridors to connect terrestrial ecosystems. • Gather results obtained from the participatory process and establish adequate forms of environmental protection in the identified areas (new and existing).
Addressed challenges	(B) Health of forests and water ecosystems. In particular: enhance protected habitats and their connectivity.
Target locations and water uses	Location: basin as a whole. Targets all water use sectors and all land uses located in the areas where new protection forms would be put in place..
Benefits	Increase in biodiversity and functionality of the local water cycle.
Potential negative impacts	High opportunity costs.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles related to the opportunity costs of protected areas and with the difficulties of monitoring and control of the compliance of established protection norms.
Robustness	Yes.
Flexibility	Yes. Increased protection enhances resilience.
Costs	Total cost estimate: 86,333 € The cost estimation is based on the following assumptions: • One-year participation process with professional facilitation and design by half time employed technician • Design and maintenance of the process by manager half time employed • Elaboration of communication material and dissemination activities • Uptake of produced information fostered by employing a technician full time
Synergies and conflicts with policy objectives	Conflict with urban planning may occur. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) System of environmental protection in Catalonia (Sistema

	d'Espais Naturals protegits de Catalunya) All these policies promote the consolidation and protection of environmentally strategic areas, and their connectivity as well as participatory approaches.
Suggested stakeholder involvement	Department of Territory and sustainability (Departament de Territori I Sostenibilitat), Natural park authorities, municipalities and NGOs, as well as general public.
Acceptance	High. Only affected economic interests would require compensation.
Preconditions for success	Implementation of a sound monitoring and control planning and funds.
Concrete examples where applied	- Different cartographies are available in order to evaluate the habitat connectivity [158] - Plan for the recovery of river connectivity [159]

WMO 23: Require guaranteed water provision as a precondition for urban expansion

Overall description of the WMO

Short explanation	Urban expansion entails a significant challenge for local authorities to warrant adequate water supply service. Current legislation decrees that water authorities should elaborate a viability report evaluating the water supply and sanitation provision for new buildings, but its results are not binding. This condition causes the construction of buildings without water supply guarantee, boosting new water demand based on fait accompli policies. This option aims to promote: • A specific programme targeting municipalities evaluating: • The level of water supply provision guarantee of new urban planning, • Limitations and opportunities for a better supply guarantee, • Availability of legal tools to reduce pressure on water bodies by urban expansion. • Dissemination of the results of the study with a specific knowledge transfer programme targeting public administration, academia and relevant actors.
Addressed challenges	(D) Integrated water management. In particular the relation between water provision and urban expansion.
Target locations and water uses	Location: basin as a whole. Targets local population, tourism and water management use sectors and built-up land uses.
Benefits	Increase water supply guarantee for residents.
Potential negative impacts	Increased political pressure on the Catalan Water Agency to authorise water uses.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles related to the availability of information and collaboration of stakeholders to the study.
Robustness	Yes.
Flexibility	Yes. The new procedure would create more room for adaptive management.
Costs	Total cost estimate: 111,429 € The cost estimation is based on the following assumptions: • One year full time researcher programme to design proposals • One year juridical advice from water agency staff dedicated to the programme • Elaboration of a publication and dissemination of results to target audience
Synergies and	Conflict with urban planning may occur.

conflicts with policy objectives	Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) Both policies actively promote demand management and support municipal water management master plans, promote studies to enhance adaptation and reduce water demand.
Suggested stakeholder involvement	Catalan Water Agency and municipalities would collaborate to contribute to the study and eventually adopt its conclusions.
Acceptance	High, the debates on water as a limiting factor for urban expansion is urgent and politically mature. The Water Agency indicates initiatives in this sense are being promoted in Municipal water provision master plans.
Preconditions for success	Political willingness.
Concrete examples where applied	- Link to current reporting characteristics of the "Informes de planeamiento urbanístico" [160] - Juridical guide for municipalities on water and urban planning [161] - Analysis on territory and water [162]

WMO 24: Recover wetlands and their connectivity

Overall description of the WMO

Short explanation	In different areas of the basin wetlands are degraded – inter alia – because of lacking hydrologic connectivity to related aquifers. Its recovery is also crucial to maintain adequate habitats for many species.
	
	This option aims to promote:
	• Strategic pilot cases aiming to
	  ○ Test different ways to optimise ecologic and hydrologic functionality of water bodies recovering their connectivity.
	  ○ Analyse appropriate indicators for the Tordera basin to evaluate the ecologic status of wetlands.
	• Dissemination of the results of the study with a specific knowledge transfer programme targeting public administration, academia and relevant actors.

Addressed challenges	(B) Health of forests and water ecosystems. In particular: recover water bodies' functionality.
Target locations and water uses	Location: basin as a whole. Targets local forest and water management use sectors.
Benefits	Increased health of water ecosystems and resilience.
Potential negative impacts	Some entitlements may be affected, but will likely receive compensation.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles related to the process agreements for the pilot.
Robustness	Yes. The option can maintain its effectiveness under different climatic and socioeconomic development scenarios.
Flexibility	Yes. Recovery depends on solid decisions affecting groundwater extractions, but the option is a pilot and can be adapted.
Costs	Total cost estimate: 577,703 € The cost estimation is based on the following assumptions: • Development of 3 pilot cases, employing a full time technician and researcher for a 6-year period for design and implementation. • Three-year lasting dissemination programme.
Synergies and conflicts with policy objectives	Conflict with vested interest based on water extractions of all sector policies. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic)

	- System of environmental protection in Catalonia All policies mentioned actively support recovery of river connectivity. The System of natural protection areas in Catalonia, a combination of plans and programmes, also enhance measures aiming at nature and resource conservation. The pilots could benefit also from FEADER programme [163] , Life programme [164] or The Interreg MED Programme 2014-2020 [165]
Suggested stakeholder involvement	Catalan Water Agency would promote the pilot cases. Other relevant actors are specifically pilot-related.
Acceptance	High. Water Agency would support the pilot proposals; funds should be related to R+D projects, as no specific budget for new pilots in current RBMP.
Preconditions for success	To reach an agreement between stakeholders engaged in the pilots.
Concrete examples where applied	- Estanys de Sils recovery [166] - L'illa de la Tordera recovery [167]

WMO 25: Eliminate toxic substances used in municipal parks and gardening practices

Overall description of the WMO

Short explanation	In different areas of the basin, municipal park and gardening maintenance protocols use water-polluting substances entailing health risks. In particular, the highly toxic component glyphosate is generally used in municipal playgrounds, provoking serious citizen concerns. This option aims to: • Develop a guide indicating alternative products and best practices that allow avoiding the use of agro-toxic substances for gardening purposes. • Disseminate the guide to public administration in charge of municipal parks and gardens, as well as general public. • Foster a commitment signed by the basin's municipalities to adopt the advice contained in the guide.
Addressed challenges	(C) Increase water quality. In particular: prevent pollution caused by pesticides.
Target locations and water uses	Location: basin as a whole. Targets local agriculture, forest use sectors and all land use sectors, focusing at municipal level.
Benefits	Pollution prevention.
Potential negative impacts	None.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to the transition to new products and practices.
Robustness	Yes.
Flexibility	Yes. Practices can be adapted.
Costs	Total cost estimate: 104,727 € The cost estimation is based on the following assumptions: • One year research full time programme for the development of a guide to substitute currently used agro-toxic substances • 3 PM technician to enhance municipalities to change management practices with new products. • Elaboration of a publication and a specific dissemination programme
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya)

	- Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) All policies mentioned support measures oriented at the prevention of diffuse pollution.
Suggested stakeholder involvement	Municipalities, the Department of Territory and sustainability, Agriculture Department and "som lo que sembrem" citizen platform.
Acceptance	High. Municipalities, the Department of Territory and sustainability (Departament de Territori i Sostenibilitat)and Agriculture Department would impulse the initiative, and specific measures against diffuse pollution are also contemplated in the current RBMP. The citizen platform "som lo que sembrem" is a key stakeholder for knowledge sharing.
Preconditions for success	Municipal willingness to collaborate.
Concrete examples where applied	- "Som Lo Que Sembrem" campaign: Sant Celoni and Sant maria de Palautordera already eliminated the use of this toxic product from their municipal gardening practices [168].

WMO 26: Create a catchment agreement to reduce diffuse pollution

Overall description of the WMO

Short explanation	Diffuse pollution of water bodies with nutrients caused by crop fertilisation is a relevant challenge for water quality in the basin entailing an important environmental degradation and high drinkwater purification costs. The lack of co-responsibility between sectors to increase water quality implies continuous environmental degradation and urban users carrying most of the economic burden for needed water treatments. This option aims to engage both the agriculture sector and urban water users in recovering water quality through a specific agreement that would allow changing to a lower impact production pattern.
Addressed challenges	(C) Increase water quality. In particular: preventing diffuse pollution.
Target locations and water uses	Location: basin as a whole. Targets agriculture and local population water use sectors.
Benefits	Pollution prevention.
Potential negative impacts	Increased costs for drinkwater users.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to the transition to new practices and coordination.
Robustness	Yes.
Flexibility	Yes. Agreement can be adapted.
Costs	Total cost estimate: 410,031 € The cost estimation is based on the following assumptions: • During the first year of implementation, the agreement protocol is designed employing for the duration of one year a full time researcher and a technician from agriculture department and one for water agency who would operate in collaboration. • 2 person-month of specific juridical advice for the negotiation process. • Maintenance of the agreement employing a full time technician. • Dissemination programme to inform society about the process. • Revision of the process and agreement at 6 year from first implementation.
Synergies and conflicts with policy objectives	Conflict with Rural Development Programme for Catalonia (Programa de Desenvolupament Rural 2014-2020) aiming to increase agriculture intensification. Synergies with

	- Catalan River Basin Management Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Priority substances [169] These policies do not directly contemplate this specific kind of measure, but would have funds for such an initiative.
Suggested stakeholder involvement	Catalan Water Agency, Agriculture Department and Agrarian Research Institute (Institut de Recerca i Technologia Agroalimentàries) should lead the measure's design and implementation Farmer associations and Municipalities are the key stakeholders for implementation.
Acceptance	Low. Urban water users are not keen on assuming the responsibility to contribute to the production patterns of farms, as they consider they already receive many subsidies. Farmers are willing if good economic conditions could be met.
Preconditions for success	Implementation of a sound monitoring and control
Concrete examples where applied	• First success story in NY water catchment, later disseminated practice in Latin America [170] • Governance of Water-Related Conflicts in Agriculture (2003). Floor Brouwer,Ingo Heinz,Thomas Zabel (Eds,) on German cases [171]

WMO 27: Centralise and facilitate access to relevant data on the basin water bodies' status and uses.

Overall description of the WMO

Short explanation	Different relevant data series exist about the Tordera basin elaborated by different entities monitoring the river's conditions, like public authorities, NGOs or research projects. BeWater project detected that the basin's actors often are not informed about the nature, scope, update and publication access of these figures, and consultancy is hindered by publication format. This options aims to promote the creation of a webpage were all relevant information concerning the Tordera River basin produced by public authorities, NGOs or research projects is published in an accessible format.
Addressed challenges	(C) Increase water quality. In particular: comprehensive information to evaluate ecological state of the river and related water bodies, inclusive data on water quantity.
Target locations and water uses	Location: basin as a whole. Targets local population water use sector.
Benefits	Awareness and better focus of citizen's initiatives and claims, optimisation of new data produced.
Potential negative impacts	None
Timeline of implementation	Short (under 2 years' time)
Feasibility	Minor obstacles, related to access, authorship and formats.
Robustness	Yes.
Flexibility	Yes. Website and data can be adapted.
Costs	Total cost estimate: 197,260 € The cost estimation is based on the following assumptions: • Full time employed technician in order to gather existing information and formulate this in accordance with website and dissemination necessities. • 2 person-month technician dedicated to maintain the webpage for the rest the duration of the programme.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Catalonian transparency law (Llei de transparencia, acceso a la información pública y buen gobierno) All policies mentioned strongly support enhancing knowledge on adaptation and access to information is supported by the

	implementation process of the new “transparency law”.
Suggested stakeholder involvement	Catalan Water Agency and local entities, as well as research institutes or NGOs for input data.
Acceptance	High. The Water Agency indicates information is available and is willing to provide data for the website, with the objective to stimulate more proactive engagement of local entities in monitoring tasks.
Preconditions for success	Willingness to share information by all actors
Concrete examples where applied	Not available.

WMO 28: Protect groundwater recharge areas.

Overall description of the WMO

Short explanation	Current legislation provides specific protection of catchment areas around drinking water wells, but in the basin there are different specific areas where rainwater infiltrates in the subsoil and recharges aquifers. Often these areas are not taken into account in zone planning, positioning infrastructure, industrial areas, parking, fuel stations, etc. in these sensible areas. This options aims to integrate Municipal zone planning protocols with special protection measures, based on existing groundwater cartography, and aiming to avoid the degradation of strategic recharge areas in the territory.
Addressed challenges	(A/C) Increase water quantity/ quality. In particular: integrate territorial planning and water management.
Target locations and water uses	Location: basin as a whole. Targets local population, tourism, agriculture, energy and water management use sectors.
Benefits	Increased health of water ecosystems and increased water availability to face droughts.
Potential negative impacts	Inappropriate vested uses are revealed, but not always possible to eliminate.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to land propriety and overlapping territorial development programmes.
Robustness	Yes, protection zones, once established are quite robust to socioeconomic changes.
Flexibility	Yes.
Costs	Total cost estimate: 68,638€ The cost estimation is based on the following assumptions: • Specific communication programme to enhance administrative and normative coordination. • A fund to provide resources for the implementation of protection zones. Organisation of a conference to evaluate if the programme has been successful.
Synergies and conflicts with policy objectives	Conflicts with urban planning and Rural Development Plans may occur. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Territorial Plan for Catalonia (Pla Territorial General de Catalunya)

	Policies mentioned foster groundwater protection.
Suggested stakeholder involvement	Catalan Water Agency has competences to protect recharge areas and is willing to increase the protected areas. Municipalities would need to integrate this initiative in to local policy development.
Acceptance	High. Municipalities would be interested in protecting groundwater in zonal planning. Water Agency would not expand the protection further than drinkwater – related aquifers, but welcomes initiatives in that sense.
Preconditions for success	Availability of all information.
Concrete examples where applied	Not available

WMO 29: Implement an environmental flow regime.

Overall description of the WMO

Short explanation	The River Tordera has a torrential flow regime and is characterised by high hydrological variability. Moreover water demand pressures hinder the implementation of an environmental flow regime in coherence with its ecological necessities. This option aims to promote actions along the river focused on recovering flows, taking into account different possibilities of intervention: • Elimination of direct catchments in the high river section (farmers, scattered houses, …) • Elimination of in-stream barriers (Montclùs, Santa Fe and other dam permeability) • Interventions for better catchment efficiency • Flow limiting and peak-flow control devices in catchment points • Refurbishment of gauging stations • Creation of regulation ponds for irrigation systems • Increased coordination between relevant departments from public administration. • Calibration between local and regional supply systems • Enforcement of public hydraulic domain regulation
Addressed challenges	(A/C) Increase water quantity/ quality. In particular: multiple challenges related to the lack of water flow.
Target locations and water uses	Location: basin as a whole, but specially the upper part. Targets all water use sectors except forests, and irrigated agriculture and built-up areas.
Benefits	The benefits of this option entail the recovery of most river functionalities and indirectly tackle all challenges.
Potential negative impacts	Less water available for antropogenic uses.
Timeline of implementation	Short (under 2 years' time)
Feasibility	Major obstacles, related to water entitlements, but new legislation can help enforcement.
Robustness	Yes, environmental flow regimes, once established are quite robust to socioeconomic changes.
Flexibility	Yes.
Costs	Total cost estimate: 474,688 € The cost estimation is based on the following assumptions: • Implementation of combined measures for environmental flow regime restoration as planned in the RBMP currently in place, including compensation costs for hydropower plants and other users as well as a

	negotiation process on water title adjustments needed. • Better water efficiency at catchment level through technological adaptation • Monitoring and control of implementation by 1 person-month technician for the whole period.
Synergies and conflicts with policy objectives	Conflicts with sector planning, claiming to consolidate and increase water uses. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Hydraulic Domain Regulation (Reglamento de Publico Dominio Hidràulico) [172] All mentioned policies actively promote the recovery of environmental flow regimes in accordance to EU standards.
Suggested stakeholder involvement	Catalan Water Agency is currently promoting the measure, but will need collaboration form almost all other departments of Catalan Government and all water users.
Acceptance	High. All stakeholders identify in this action the trigger for solving most environmental problems and reducing vulnerability. People holding an entitlement, on the contrary, often don't support the measure, but when proper negotiation is in place, agreements can be made.
Preconditions for success	Political willingness.
Concrete examples where applied	Unfortunately no examples of proper implementation of environmental flow regimes exist in Catalonia.

WMO 30: Recover and protect river space

Overall description of the WMO

Short explanation	The presence of a high quantity of infrastructures in the basin implies the necessity to protect and recover river spaces in coherence with its strategic ecologic and hydraulic functionality in the territory.
	
	This option aims to promote:
	• The protection of concrete areas with high strategic value, like for example:
	  ○ The river section called "La Ferreria"
	  ○ Most important flooding zones in the central and lower sections of the basin
	  ○ Headwaters
	• The creation of river sections declared as "River Reserve" for those sections in good environmental state.

Addressed challenges	(B) Health of Forests and water ecosystems. In particular: restore proper river functionality to face floods and sediment flows.
Target locations and water uses	Location: central section of the river. Targets local population, tourism, agriculture, energy and water management sectors, and all land use sectors except forests.
Benefits	The benefits of this option entail positive effects on sediment flows, flood risk, biodiversity and connectivity.
Potential negative impacts	None.
Timeline of implementation	Medium (2-6 yrs)
Feasibility	Minor obstacles, related to constructions in the riverbed and zonal planning.
Robustness	Yes, once river space has been recovered, these are quite robust to socioeconomic changes.
Flexibility	Yes.
Costs	Total cost estimate: 172,047 € The cost estimation is based on the following assumptions: • Two technicians and one engineer half time employed to identify areas with high strategic value. • Fund for restoration and protection of identified areas. • Identification and establishment of a specific "river Reserve" in upstream sections of the basin employing 6 person-months researcher programme and a full time technician during one year for the formalisation and implementation of reserve protocols. • Maintenance of the River Reserve employing 1 person-month technician during whole period of the programme. • Organisation of a conference to evaluate and

	disseminate results of the actions. • Publication of a brochure on the experience.
Synergies and conflicts with policy objectives	Conflict with zonal planning policies, especially transport and industrial development. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Flood risk plan (Pla de gestió de risc d'inundacions)[173] - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - System of environmental protection in Catalonia (Sistema d'Espais Naturals protegits de Catalunya) All policies mentioned include measures for river space recovery.
Suggested stakeholder involvement	Department of Territory and sustainability would be responsible for enhancing special protection area and river reserves, implementing the measure in collaboration with Catalan Water Agency and municipalities.
Acceptance	High. Catalan Water Agency (Agència Catalana de l'Aigua) is planning to revise current protected areas, but it is an inter-departmental issue calling for a coordination effort.
Preconditions for success	Political willingness and vested interests.
Concrete examples where applied	- All different river space protection forms contemplated today in Catalonia [174] - Spanish river reserves [175]

WMO 31: Revise and update water entitlements

Overall description of the WMO

Short explanation	In order to tackle the high number of outdated entitlements, many containing important irregularities, this option aims to support the updating process of entitlements promoted by the water authority. In order to enhance the reduction of extractions and increase the availability and transparency of information, this option aims to promote: • The creation of a communication and coordination channel between local entities and the water authority in order to foster a proactive collaboration of municipalities and local entities updating the water use entitlement register in accordance with actual uses. • Online publication of water entitlement register.
Addressed challenges	(D) Integrated water management. In particular: reduction of mismatch between water consumption and water entitlements.
Target locations and water uses	Location: River as a whole. Targets local population, tourism, agriculture, energy and water management sectors, and all irrigated and built up land use sectors.
Benefits	The benefits of this option entail very strong positive effects on all factors of the river basin dynamics, except agriculture land use and flooding damage.
Potential negative impacts	None
Timeline of implementation	Short (under 2 years' time)
Feasibility	Serious obstacles, related to the compensations for lost benefits requested by water entitlement beholders.
Robustness	Yes, once entitlements revision process is done, these will be quite robust to socioeconomic changes.
Flexibility	No.
Costs	Total cost estimate: 103,433 € The cost estimation is based on the following assumptions: • Coordination between local entities and the water authority through the organisation of 4 meetings with around 50 participants, during 2 years and including working material. • Fund to enhance actions to revise and reformulate concrete entitlements. • Creation of an online access of the Tordera water entitlement register.
Synergies and conflicts with policy objectives	Conflicts with sector policies aiming for development entailing water demand growth. Synergies with

	- Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - Spanish water law (Texto refundido de la Ley de Aguas Art. 65.1.C TRLA) The Catalan River Basin Management Plan and the Catalan Adaptation Strategy actively promote water entitlements to be updated. Furthermore, the ALBERCA programme of Spanish Ministry (Real Decreto 670/2013, de 6 de septiembre)[176] is the tool enabling revising entitlements at national level.
Acceptance	Low, because most people don't want to change current water entitlement characteristics, often allowing free riding, as old entitlements are generous and accounting for real use is very rough. Nevertheless, Catalan Water Agency plans to impulse a specific programme for Catalonia.
Suggested stakeholder involvement	Catalan Water Agency is currently promoting the measure, but will need collaboration form almost all other departments of Catalan Government and all water users.
Preconditions for success	Political willingness.
Concrete examples where applied	- ALBERCA programme of Spanish Ministry.

WMO 32: Develop river custody agreements

Overall description of the WMO

Short explanation	In order to foster citizens and local entities to collaborate recovering and protecting river space, this option proposes generating the conditions for creating and providing continuity to effective River Custody Agreements. These agreements are direct contracts between local entities and citizens to commit to the protection and restoration of a concrete river section.
Addressed challenges	(D) Integrated water management. In particular: engage local population in river management.
Target locations and water uses	Location: River as a whole. Targets all water management sectors, and all land use sectors.
Benefits	The benefits of this option are localised restoration of river conditions and engagement of local population.
Potential negative impacts	None
Timeline of implementation	Medium (2-6 yrs)
Feasibility	No major obstacles.
Robustness	Yes.
Flexibility	Yes, custody agreements can be re-formulated or adjusted any time.
Costs	Total cost estimate: 374,268 € The cost estimation is based on the following assumptions: • Full technician employed to manage funding opportunities and custody projects in the basin. • Funding by RBMP to implement and maintain the custody programmes for 6 years.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) Both policies mentioned support River Custody programmes. Local experiences developing similar actions to those proposed in the WMO were funded by private initiatives.
Acceptance	High. All stakeholders support stimulating more proactive engagement of local entities in maintenance tasks
Suggested stakeholder involvement	ACA, municipalities and all water users.
Preconditions for success	Political willingness
Concrete	- River custody projects in Catalunya.[177]

examples where applied	- River Ter [178] - River custody projects [179]

WMO 33: Conclude adaptive forest management agreements

Overall description of the WMO

Short explanation	The lack of active forest management entails an increase of the density of plant cover and undergrowth, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to improve the health of forests, while also reducing evapotranspiration and wildfire risk. In order to enhance adaptive measures to be implemented, this option proposes to foster pilot cases for specific adaptive forest management agreements between forestland owners and the administration. Agreements can entail a range of actions, in accordance to the concrete forest management needs.
Addressed challenges	(B) Health of forest and water ecosystems. In particular: increase forest management.
Target locations and water uses	Location: River as a whole. Targets all water management sectors, except industry and energy sectors, and grass and forestland use sectors.
Benefits	Focused, precise and flexible forest management practices. This measure had highest scores in the MCA analysis.
Potential negative impacts	None
Timeline of implementation	Short (under 2 years' time)
Feasibility	No major obstacles.
Robustness	Yes.
Flexibility	Yes, Adaptive forest agreements can be re-formulated or adjusted any time.
Costs	Total cost estimate: 300,948 € The cost estimation is based on the following assumptions: • Amplification of agreement patterns already available by a three-year PhD programme. • Negotiation and agreements established employing a full time technician. • Fund to establish specific actions included in the agreements. • Organisation of a conference on results obtained and presentation of monitoring data.
Synergies and conflicts with policy objectives	No conflicts with any current policy or programme. Synergies with - Catalan River Basin Management Plan (Pla de Gestió del Districte de Conques Fluvials de Catalunya) - Catalan Adaptation Strategy (Estratègia d'Adaptació al Canvi Climàtic) - General Forestry Policy Plan (Pla General de Política Forestal 2014-2024) - Montseny Biosphere Reserve Conservation Plan (Pla

	de conservació del Parc Natural i Reserva de la Biosfera del Montseny) All the policies mentioned actively support adaptive agreements. Could be funded also by private initiatives.
Suggested stakeholder involvement	Natural park entities, landowners and Agriculture Department of Catalan Government (Departament d'Agricultura, Ramaderia, Pesca I Alimentació).
Acceptance	High. All stakeholders agree the option would contribute to better forest management, reduced wildfire risk and obtain forest-related products.
Preconditions for success	Clear contractual conditions and engagement process.
Concrete examples where applied	- "Stove Plan" of Catalan government [180]

Annex 1. Awareness campaign activities

Activity	Title & organisation	Date	Place
Local networking			
	"Walking through the River Tordera, rising awareness of the basin's main challenges". Activity organised by the NGO Coordinadora per la Salvaguarda del Montseny	25/05/2014	Central section of the Tordera Basin
	Awareness Campaign posters distribution in preparation for the participatory process to involve society in BeWater.	on 28/05/2014 and between 11/2014 - 12/2014	Tordera River Basin
Awareness Campaign media			
	Video from the first BeWater stakeholder workshop in la Tordera	03/12/2014	CREAF Web page, BeWater web page, facebook and twitter
	Radio interview in RNE programme "Vida Verda", under the title :"Challenges of Global change in the River Tordera "	21/12/2014	Spanish National Radio
	BeWater project and the Tordera case included in a TV programme dedicated to CREAF's research related to Global Change	27/01/2015	Lab24 programme, Spanish National TV
	Interview on BeWater and adaptation challenges in Tordera	14/04/2016	Radio Tordera, Local broadcast; available on BeWater web page
Awareness campaign sessions			
	Exhibitions with interactive session	12/2014 - 02/2015	Municipal social centre, Hostalric
		02/2015 - 03/2015	Casa Capell, Mataró
		03/2015 - 04/2015	Rectoria Vella, Sant Celoni
		16/05/2015 - 12/06/2015	Can Casades, Montseny Natural park
		17/06/2015 -	La Quadra St M. De

		15/07/2015	Palautordera
		15/07/2015 - 22/09/2015	Can Moragues, Riudarenes
		22/09/2015 to 24/10/2015	Can Ramìs, Sant Celoni
		03/03/2016 - 12/0472016	Municipal library Tordera
Conferences	Public conference for local society: Presentation of BeWater project	12/12/2014	Hostalric
	Some keys to understand Climate Change Adaptation. Science in School Week	19/11/2014	Sant Pere de Vilamajor
	“Water quality in the Tordera Basin”	08/07/2015	La Quadra_ StM.de Palautordera Municipality St M de Palautordera
	5 seminars “Adaptation to Global Change”, capacity building with high school teachers	Between 11/2015 - 05/2016.	Can Balasc, Barcelona

Annex 2. List of acronyms

ATL	Aigües Ter Llobregat
CCB	Consorci Costa Brava
EMP	Extractions Master Plan
FAS	Farm Advisory Service
FCM	Fuzzy Cognitive Map
IPPTD	Integrated Plan for the Protection of the Tordera Delta
IT	Information Technology
MACB	Municipal Adaptation Coordination Board
MCA	Multi Criteria Analysis
MSFD	Marine Strategy Framework Directive
PM	Person Month
PPC	Permanent Participation Centre
RBAP	River Basin Adaptation Plan
RBMP	River Basin Management Plan
RDP	Rural Development Plan
STIR	Stakeholder Integrated Research
WFD	Water Framework Directive
WMO	Water Management Options
WUA	Water user associations

English – Spanish translations

- Agrarian Research Institute – Institut de Recerca i Technologies Agroalimentàries
- Catalan Adaptation Strategy - Estratègia d'Adaptació al Canvi Climàtic
- Catalan Climate Change Office - Oficina Catalana de Canvi Climàtic
- Catalan Coastal Law – Llei del Litoral
- Catalan Department of Agriculture Departament d'Agricultura, Ramaderia, Pesca i Alimentació
- Catalan Energy and Climate Change Plan – Pla d'Energia i Canvi Climàtic
- Catalan Energy Institute – Institut Català d'Energia
- Catalan institute for energy - Institut Català d'Energia
- Catalan Polytechnic University - Universitat Politèchnica de Catalunya
- Catalan River Basin Management Plan - Pla de Gestió del Districte de Conques Fluvials de Catalunya
- Catalan Transparency Law – Llei de transparencia, acceso a la información pública y buen gobierno
- Catalan Water Management Plan– Pla de Gestó del Disticte Fluvial de conques Internes de Catalunya
- Catalana Water Agency - Agència Catalana de l'Aigua
- Centre for Advanced Studies of Blanes - Centre d'Estudis Avançats de Blanes
- Climate change law – Llei Catalana de Canvi Climàtic

- Extractions Master Plan – Pla d'Ordenació d' Extraccions
- Flood risk management plan – Pla de gestió de risc d'inundacions
- General Directorate for Coastal and Marine Sustainability in Spain's Ministry for Agriculture and the Environment - Dirección General de Sostenibilidad de la Costa y del Mar del Ministerio de Agricultura, Alimentación y Medioambiente
- General Forestry Policy Plan – Pla General de Política Forestal
- Hydraulic Domain Regulation - Reglamento de Publico Dominio Hidràulico
- Internal River Basin District - Disticte Fluvial de conques Internes de Catalunya
- Livestock Development Plan – Pla de recuperació del sector ovi i cabrum
- Monitoring and control programme – Programa de seguiment i control
- Montseny Biosphere Reserve Conservation Plan – Pla de Conservació del Parc Natural i Reserva de la Biosfera del Montseny
- National Adaptation Plan – Pla nacional d'Adaptació al Canvi climàtic
- Rural Development Plan - Programa de Desenvolupament Rural
- Spanish water law – Texto Refundido de la Ley de Aguas
- System of Natural Protection Areas in Catalonia - Sistema d'Espais Naturals protegits de Catalunya
- Territorial Plan for Catalonia – Pla Territorial General de Catalunya

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Preface

Climate change projections for the Mediterranean region estimate an increase in water scarcity and drought episodes, as well as more frequent floods and other extreme weather events . There is a high likelihood that these events will evoke substantial socio-economic losses and negative environmental impacts if no action is taken to support territories' adaptation efforts. Furthermore, changes in population and land use, such as urban expansion or the abandonment or intensification of agriculture, also affect the response of territories to these events. In this context, sustainable water management strategies are urgently needed as they will enhance the resilience of socio-ecological systems, referring both to society and the environment.

Current water management practices focus on the river basin level as the natural geographical and hydrological unit. Resilient water management strategies focusing on the river basin can respond to pressures within this unit in an appropriate way, while trying to minimize disruptions to the socio-ecological systems.

'Making Society an Active Participant in Water Adaptation to Global Change' (BeWater) is an EU-funded project which responds to the above challenges by promoting dialogue and collaboration between science and society for sustainable water management and adaptation to the impacts of global change. The BeWater project, taking place from 2013 to 2017, focuses on the design of adaptive water management approaches at a river basin scale in the Mediterranean region. More specifically, the project aimed to develop a river basin adaptation plan for each of four pilot case studies, namely for the Tordera (Spain), Pedieos (Cyprus), Rmel (Tunisia) and Vipava (Slovenia) River Basins. These basins are representative of various Mediterranean conditions with regards to climate, topography, environment, socio-economic and political conditions, land use and water demands.

The adaptation plans were developed in a collaborative process according to a common methodology developed within BeWater, and utilising existing information on the local dynamics of global change. Over the course of the three and a half-year project, the subsequent plan and the plans of the other three pilot cases were co-produced by experts and stakeholders in the respective river basins as well as with scientists and experts from within the BeWater consortium, with guidance from the project's advisory board.

The four river basin adaptation plans (RBAPs) aim at fostering adaptation to global change within the four basins, and serve as a reference for other basins within the Mediterranean region and beyond, that wish to increase their resilience and undertake such a participatory development process. To facilitate the transferability potential, the BeWater project is also producing a handbook presenting lessons learned from throughout the development process.

The present plan is a document designed by the Slovene partners and stakeholders. It outlines the adaptation action for the Vipava river basin.

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Executive Summary

Within the BeWater project (funded by the European Union through the 7th Framework Programme), a River Basin Adaptation Plan was developed for the Vipava river basin to integrate global changes in river basin management. The plan is a guiding document for stakeholders in water use sectors and affiliated policy areas acting in the river basin. The specific aim of this river basin adaptation plan is to increase the resilience of the social and ecological system of the Vipava river basin and to facilitate a proactive response to emerging global changes and related challenges. Therefore, the objective of the adaptation plan is the delineation of water management options that aim to implement sustainable water management in the Vipava river basin for the period until 2030.

In the Vipava river basin, citizens have little awareness of the challenges that they and the environment are facing due to global changes. To start the awareness raising process, stakeholders from the Vipava river basin determined appropriate strategies for management of the Vipava river basin guided by local and international experts. The plan is thus the result of a bottom-up approach in which researchers interacted with stakeholders to identify how pressures from climate change, land use, and elsewhere could be tackled best. During the development process 114 stakeholders provided concrete input regarding the process of formulating and evaluating water management options, as well as identification of adaptation strategies in several stages of a participatory process that included (a) three professionally facilitated workshops, (b) follow-up interviews, (c) individual and group sessions, and (d) an additional open consultation.

Based on stakeholder knowledge and scientific information, three water-related challenges and 20 water management options that would tackle these challenges and support the adaptation process were identified. The majority of options (16) were identified to cope with the challenge of water availability during droughts in the growing season (challenge A), followed by 13 options coping with the appropriate water quality (challenge C). Half of the options (ten out of 20) were identified to address the challenge of reducing flood risks (challenge B); however several options are addressing more than one challenge. To maximise the synergistic benefits among the individual options and to increase their effectiveness, seven different complementary sector-based bundles of options were defined. Within the bundles, stakeholders indicated also the optimal timing for implementing the options over the short, medium and long-term.

According to stakeholders' preferences, implementation-oriented factors such as multi-criteria analysis, the implementation of options regarding the challenges, feasibility, acceptability, and policy synergies, five water management options were assigned the highest priority for the implementation process: a) *Establishment of an inter-municipal expert working group*, b) *An awareness campaign for the local public*, c) *Construction of water reservoirs*, d) *An awareness campaign for water management experts*, and e) *Improving the financing system for water infrastructure*. These options should therefore be highlighted when considering adaptation actions in the Vipava river basin. The majority of recommended options represent a soft approach to adaptation, which achieved the highest preference of stakeholders, having low implementation and operational costs and the best outcome for all three identified challenges of the Vipava river basin. Although the option *Construction of water reservoirs* has the best evaluation outcome for the two identified challenges of the Vipava river basin, the option is a technical solution (grey approach to adaptation) with high implementation costs. As such it is also involved with low feasibility or even conflicts with the objectives of Water Framework Directive.

To assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial.

Hence the alignment of existing monitoring plans with the objective to monitor the implementation of water management options should be considered.

Povzetek

V okviru projekta BeWater (ki ga financira Evropska unija v okviru 7. okvirnega programa) je bil razvit načrt prilagajanja porečja reke Vipave z namenom vključitve globalnih sprememb pri upravljanju porečij. Načrt je ključni dokument namenjen zainteresiranim deležnikom na strani uporabnikov vode in povezanih področij politike, ki delujejo v porečju reke Vipave. Poseben cilj tega načrta je povečanje prilagodljivosti socialnega in ekološkega sistema porečja reke Vipave ter omogočanje proaktivnega odziva na nastajajoče globalne spremembe in s tem povezane izzive. Med drugim je cilj načrta prilagajanja predstavitev možnosti upravljanja voda, ki so namenjene izvajanju trajnostnega upravljanja voda v porečju reke Vipave za obdobje do leta 2030.

V porečju reke Vipave se prebivalci premalo zavedajo izzivov globalnih sprememb, s katerimi se soočajo tako oni sami kot njihovo okolje. Da bi pospešili proces ozaveščanja, so zainteresirani lokalni deležniki s pomočjo domačih in tujih strokovnjakov določili ustrezne strategije za upravljanje porečja reke Vipave. Načrt prilagajanja je torej rezultat pristopa od spodaj navzgor, v katerem so raziskovalci sodelovali z zainteresiranimi deležniki, da bi skupaj ugotovili, kako bi na najboljši način reševali pritiske zaradi podnebnih sprememb, rabe zemljišč in ostalih dejavnikov. Tekom postopka je skupno 114 deležnikov podalo konkretne prispevke k procesu oblikovanja in vrednotenja možnosti upravljanja voda, kot tudi k opredelitvi strategij prilagajanja na različne načine in v več korakih, vključno z: (a) tremi strokovno vodenimi delavnicami, (b) naknadnimi intervjuji, (c) individualnimi in skupinskimi sestanki ter (d) dodatnim javnim posvetom.

Temelječ na poznavanju problematike s strani zainteresiranih deležnikov ter znanstvenih dognanj so bili prepoznani trije glavni izzivi in 20 možnosti upravljanja voda, ki bi reševale te izzive in podpirale proces prilagajanja. Večina možnosti (16) je bilo prepoznanih na področju spopadanja z izzivom razpoložljivosti vode med sušnimi obdobji v rastni dobi (izziv A), ki mu sledi 13 možnosti spopadanja z ustrezno kakovostjo vode (izziv C). Polovica možnosti (10 od 20) je bilo opredeljenih na področju zmanjševanja poplavne ogroženosti (izziv B). Vsekakor pa več možnosti obravnava več kot en izziv. Z namenom povečanja skupnih koristi posameznih možnosti upravljanja in povečanja njihove učinkovitosti, je bilo opredeljenih sedem različnih sektorskih svežnjev. V okviru teh svežnjev so zainteresirani deležniki nakazali tudi optimalni časovni okvir za izvedbo posameznih možnosti v kratkoročnem, srednjeročnem in dolgoročnem časovnem obdobju.

Glede na večjo naklonjenost deležnikov in dejavnikov glede uvajanja možnosti kot so npr. analiza več meril, učinek možnosti na prepoznane izzive, izvedljivost, sprejemljivost in sinergije politik, je bilo petim možnosti upravljanja voda dodeljena najvišja prioriteta pri samem postopku uvedbe in sicer: a) *Oblikovanje medobčinske strokovne delovne skupine za porečje reke Vipave*, b) *Kampanja ozaveščanja lokalne javnosti*, c) *Izgradnja vodnih zadrževalnikov*, d) *Kampanja ozaveščanja o trajnostnem upravljanju voda, namenjena strokovnjakom s področja upravljanja površinskih voda* in e) *Izboljšanje sistema financiranja vodne infrastrukture*. Posledično je potrebno poudariti te možnosti pri obravnavi ukrepov prilagajanja v porečju reke Vipave. Večina priporočenih možnosti predstavlja mehak pristop k prilagajanju, katerim so zainteresirani deležniki dali najvišjo prioriteto, povzročajo nizke stroške uvedbe in obratovanja in imajo najboljši izid za vse tri prepoznane izzive porečja reke Vipave. Čeprav je možnost gradnje vodnih zadrževalnikov dosegla najboljši ocenjeni rezultat za dva ugotovljena izziva, pa ta možnost predstavlja tehnično rešitev (sivi pristop k prilagajanju) z visokimi stroški izvedbe. Kot taka, je tudi slabše izvedljiva ali celo v nasprotju s cilji okvirne Vodne direktive.

Za zagotovitev uspešnega izvajanja posameznih možnosti upravljanja voda ali svežnjev možnosti, je ključnega pomena razvoj in izvedba načrta spremljanja ter vključitev smiselnih kazalnikov. Zato je treba razmisliti o uskladitvi obstoječih načrtov spremljanja s ciljem spremljanja izvajanja možnosti upravljanja voda.

Glossary of key terms

- **Acceptability (as criteria for water management options) -** an option is considered as acceptable if there is not significant reason a priori for actors in the basin to reject the option, e.g. because of its design [1]
- **Adaptation pathway -** portrays a sequence of actions and their implementation prioritisation over the short, medium and long-term, with regards to achieving a set of pre-specified objectives under uncertain changing conditions [2]
- **Adaptive management -** an approach to reduce ecological uncertainty and increase resilience by emphasising that management regimes should be regularly adjusted to changes in the ecological system being managed and to managers' evolving understanding of this system
- **Bottom-up approach -** entails the participation of local actors in decision-making about the selection of the priorities and actions to be pursued in their local area; the approach can interact and be combined with top-down approaches from national and/or regional authorities in order to achieve better overall results [3]
- **Challenge -** something that by its nature or character serves as a call to a special effort; the RBAP focuses on the challenges related to the impacts of global change in the river basin - now and in the years to come
- **Climate change -** any long-term change in climate over time, whether due to natural processes or as a result of human activity [4]
- **Climate change adaptation -** appropriate action to prevent or minimise the damage that climate change impacts can cause, or taking advantage of opportunities that may arise due to climate change [5]
- **Climate change scenario -** the difference between a climate scenario (i.e. a plausible and often simplified representation of the future climate) and the current climate [6]
- **Co-benefits (as criteria for water management options) –** options are considered to have co-benefits when their combined implementation amplifies the total impact-related benefits, as compared to the benefits which would arise from implementing each option individually
- **Environmental flow regime** - describes the amount of water that is needed by the river ecosystem to sustain its natural functioning
- **Extreme weather event** - an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. rainfall over a season) [7]
- **Feasibility (as criteria for water management options) -** an option is considered as feasible if physical, technical, regulatory or organizational obstacles are not existing or can be easily overcome during option's implementation [1]
- **Flexibility (as criteria for water management options) -** an option is considered flexible when it can be adjusted/ complemented or reversed when it turns out to be inadequate or inappropriate in practice [1]
- **Fuzzy cognitive map -** a tool to graphically represent the knowledge about or the perception of a given system; can be converted into simple mathematical models to run simulations and calculate outcomes of possible scenarios to facilitate the discussion and exploration of complex issues [8]
- **Global change** - changes in the global environment that may alter the capacity of the Earth to sustain life, encompassing climate change as well as other critical drivers of environmental change that may interact with climate change, such as land use change, population trends, the alteration of the water cycle and changes in ecosystem functionality [9]

- **Good status (of a water body)** – a term to describe a condition under which water bodies have the biological and chemical characteristics expected under sustainable conditions [10]
- **Governance -** the way rules, norms and actions are produced, sustained, regulated and held accountable; it refers to the processes of interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions [11]
- **Green measures -** ecosystem-based approaches that are using green infrastructure to address three identified challenges. Four options in the RBAP fit in green measures category
- **Grey measures –** measures related to the tehnological and engeniring solutions that include improvements in water availability, water quality or flood risk reduction. Seven options in Vipava River Basin Adaptation Plan fit in grey measures category
- **(Invasive) alien species –** plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health [12]
- **Impact assessment –** a method to identify the environmental, social and economic impacts of an action or project prior to decision-making
- **Implementation barrier or opportunity -** elements deriving from the implementation context influencing the foreseen or ideal development of an action
- **Integrated River Basin Management -** Integrated river basin management (IRBM) is the process of coordinating conservation, management and development of water, land and related resources across sectors within a given river basin, in order to maximise the economic and social benefits derived from water resources in an equitable manner while preserving and, where necessary, restoring freshwater ecosystems
- **Karst -** a special type of landscape formed by the dissolution of soluble rocks, including limestone, dolomite and gypsum; it is characterised by underground drainage systems with sinkholes and caves; Karst regions contain aquifers that are capable of providing large supplies of water [13]; subterranean drainage may limit surface water with few to no rivers or lakes
- **Knowledge transfer –** the process of engaging with researchers, decision-makers or the community and decision-makers to generate, acquire, apply and make accessible the knowledge necessary to successfully develop and enhance evidence-based initiatives which enhance human, material, social and/or environmental wellbeing [14]
- **Meander -** a bend in a watercourse or river formed by erosion on the outer banks due to the flow of moving water and resulting in a winding watercourse; when a meander gets cut off from the main stream, an oxbow lake forms
- **Multi-criteria analysis -** a tool for supporting complex decision-making situations with multiple and often conflicting objectives (e.g. economic, ecological and social) that stakeholder groups and/or decision-makers value differently [15]
- **Mutual learning -** a learning process experienced and shared by different actors developed through direct interactions; the process is conducive to adaptive water management and includes the exchange of information on technical features of river basin management, scientific findings, as well as political aspects, so as to arrive at a shared understanding of issues and possible solutions
- **Oxbow lake -** a crescent shaped body of water lying alongside a winding river; formed when a wide meander from the main stem of a river is cut off [16]
- **Participatory co-creation -** an approach which integrates all stakeholders in the entire design process of an action, i.e. problem definition, solution generation, evaluation of proposed solutions during development, and implementation of solutions, to help ensure the result meets user needs and increase acceptability
- **Policy framework -** a broad set of laws, regulations, or processes that structure political, social, cultural or economic activities in a society; these policies form an interacting web and

therewith impact the functioning of exiting policies as well as new policy developments and policy amendments [17]

- **Pressure -** anthropogenic factors inducing environmental change (impacts), including for example the release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities [18]
- **Resilience -** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change [19]
- **River basin -** the area of land from which all surface water runs off through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta; it is a natural geographical and hydrological unit that is used e.g. by the European legislation to manage a single drainage area [20]
- **River Basin Adaptation Plan -** management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.
- **River Basin Management Plan -** document including the objectives for a given river basin district and the programme of actions required to meet these objectives; the aim is to protect, improve and sustainably use the water environment; these plans are a requirement of the European Water Framework Directive
- **River Basin District** - the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters [21]
- **Robustness (as criteria for water management options) -** an option is considered robust to uncertainties if it can maintain its effectiveness under different climatic and socio-economic development scenarios [1]
- **Sediment management -** organized and coordinated actions to reduce the impact of human activities or natural changes on the quantity and quality conditions of solid material that is or can be transported by or deposited from the river's water [22]
- **Shelterbelts -** a row of trees planted across the direction of wind to deflect and reduce wind speed without causing turbulence; generally, provide protection from desiccating winds to the extent of 5 to 10 times their height on windward side and up to 30 times on leeward side, thus reducing evaporation losses and wind erosion [23]
- **Socio-ecological system –** consists of 'a bio-geophysical' unit and its associated social actors and institutions; delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context [24]
- **Soft measures –** measures related to governance changes and are including policy approaches, raising awareness, monitoring systems and other "soft" approaches. Nine water management options in the river basin adaptation plan fit in green measures category
- **Stakeholder** - any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome; the term is usually reserved for well-organised and active groups and organisations, thus making a distinction from the general public
- **Water management option –** activity developed within the scope of the BeWater project which aims to impact the interactions between water uses and the water body; can be characterised as nature-based approaches (enhancing natural regulation of ecosystem functionality), soft approaches (acting on management or policy norms and regulations) or technical approaches (developed through engineering)
- **Water scarcity –** a lack of sufficient available or safe water resources to meet water needs within a region; this can involve water stress, water shortage or deficits, and water crisis as a

result of climate change, increased pollution, or increased human demand and overuse of water [25]

- **Watershed -** the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater; this area is typically smaller than a river basin, meaning that several watersheds may comprise a single river basin [26]

List of acronyms

ARSO	Agencija Republike Slovenije za okolje (Slovenian Environmental Agency)
CAP	Common Agricultural Policy
CS	Case Study
DRSV	Direkcija Republike Slovenije za vode (Slovenian Water Agency)
EIA	Environmental Impact Assessment supported by Environmental Protection Act (Official Gazette of RS, no. 39/06 - consolidated text, 49/06 - ZMetD 66/06 - dec. U.S. 33/07 - ZPNačrt, 57/08 - ZFO-1A, 70/08, 108/09, 108/09 - ZPNačrt-A, 48/12, 57/12, 92/13 and 56/15) and with Decree on the activities (interventions) for which an environmental impact assessment is mandatory (Official Gazette of RS, no. 51/41)
FCM	Fuzzy Cognitive Map
FFP	Fisheries and Farming Management Plan
FRMP	Flood Risk Management Plan 2015-2021 (FRMP) and Programme of Measures (in preparation)
GeoZS	Geological Survey of Slovenia, Ljubljana
HQ	The higherst discharge observed – extreme; an example of HQ 50 - the flood extent is given for return period of 50 years, extreme weather event
IzVRS	Inštitut za vode Republike Slovenije (Instutute for Water of the Republic of Slovenia)
MCA	Multi-criteria Analysis
MKGP	Ministrstvo za kmetijstvo, gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food)
MOP	Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning)
PMFIWRS	Programme for the Management of Fish in Inland Waters of the Republic of Slovenia
RB	River Basin
RBAP	River Basin Adaptation Plan
RBMP	River Basin Management Plan for period 2015 - 2021 (slo: “NUV II” implementation of the WFD) – in preparation
RDP	Rural Development Programme
SEA	Strategic Environmental Assessment also known as comprehensive environmental impact assessment supported by Environmental Protection Act (Official Gazette of RS, no. 39/06 - consolidated text, 49/06 - ZMetD 66/06 - dec. U.S. 33/07 - ZPNačrt, 57/08 - ZFO-1A, 70/08, 108/09, 108/09 - ZPNačrt-A, 48/12, 57/12, 92/13 and 56/15) and with Decree laying down the content of environmental report and on detailed procedure for the assessment of the effects on certain plans and programmes on the environment (Official Gazette of RS, no. 73/05)

WFD	Water Framework Directive; Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy
WMO	Water Management Option
WWTP	Wastewater Treatment Plant

PART 1

2.1 Introduction

2.1.1 Introduction

The Vipava river basin is a part of the Soča river basin and belongs to the Adriatic sea basin district. The climate of the Vipava river basin is a sub-Mediterranean type, with mild winters and hot summers. The Vipava river basin is constantly influenced by a warm and humid southwestern wind and by the cold and gusty northeastern bora wind, especially in the cold half of the year. According to the trends in the discharges for the Vipava river basin, a decrease in low and mean annual discharge has been observed [27]. Climate change projections show an increase in average annual temperatures and decrease in precipitation. Hence, an additional decrease in low and mean discharges are expected with high probability.

The Vipava river basin as well as other river basins in Slovenia are managed at the national level with the River Basin Management Plan (2009 - 2015) [28] and its Program of Measures in force [29], according to the Water Framework Directive [21]. Nevertheless, the Program of Measures is addressing adaptation to climate change at too general and declarative level so as to support the development of concrete water management strategies and actions. These strategies and actions are needed to increase the resilience of the socio-ecological system of river basins.

Beside the River Basin Management Plan, there are also other sectoral strategic plans related to water management, like for example the flood risk management plan, Natura 2000 Management Programme, and other sectoral documents in agriculture and forestry. As such, these plans should be harmonized with the River Basin Management Plan. Therefore, in the process of developing the Vipava river basin adaptation plan, existing water related sectoral strategic plans must be considered in order to help all the river basin authorities and other relevant actors develop adaptive and harmonized strategies, plans and actions.

To maximise the effectiveness of these sectoral strategies, regional and local characteristics must be considered and local communities must be engaged in developing these strategies. Profund participatory approaches are often missing in policy making (e.g. for designing river basin management plans). Furthermore, many institutions act behind closed doors, making it impossible for the local society (e.g. via NGOs) to participate and discuss already in the early phases of planning and designing of measures.

To begin the integration of global change in the river basin's management at the local level, innovative bottom-up approaches have been tested. By promoting an iterative dialogue and mutually educational collaboration processes between science and society, the process of river basin adaptation plan (RBAP) development is moving away from expert-dominated adaptation planning towards a process that will support the co-design of adaptation responses by stakeholders and scientists. The specific aim of this river basin adaptation plan is to increase the resilience of social and ecological systems linked to the Vipava river basin and to allow a proactive response to emerging global changes and related challenges. There are many initiatives across the world that have started to integrate global change in water management planning at multiple levels. Nevertheless few attempts have been made to integrate global change in river basin management as proposed by the present document.

Text box 1: Definition of RBAP

The BeWater River Basin Adaptation Plan (RBAP) is a management plan containing a series of basin-specific options for increasing the resilience of the basin's water resources as well as societal resilience in the face of global change. It includes an analysis of the options' implementation over time and presents a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.

2.1.2 Objectives and vision

Future climate change projections for the Euro-Mediterranean region estimate an increase in water scarcity and droughts, causing substantial socio-economic losses and environmental impacts. Foreseen global change and recognized existing conflicts among water-related objectives (e.g. improving flood/erosion risk protection, optimizing water use, improving ecological status) are a challenge for developing an integrated and sustainable water management.

The vision for the river basin adaptation plan is to strenghten the resilience of the river basin against the impacts of global changes and to better manage conflicts between sectors. In accordance with the so-called Integrated River Basin Management [30], a long-term inter-sectoral cooperation at the river basin level must be established. Such cooperation can provide a framework for harmonized and feasible strategic planning not only at the national level but also regional and local levels. Long-term inter-sectoral cooperation on adaptation should also:

- assure participation of all river basin authorities and other relevant actors on the basis of equal inter-sectoral partnership;
- assure good knowledge of the socio-ecological systems in and around the basin, especially through iterative dialogue and mutual learning processes between scientific disciplines and society;
- develop all relevant documents (e.g. policies, strategies, projects) in an integrated manner;
- incorporate communities and stakeholder participation into the planning and management processes;
- improve awareness and shared responsibility;
- establish a system to assess whether or not the river basin is being managed sustainably.

In order to make adaptation strategies credible, informed and achievable, they need to be developed in close and continuous consultation with a diversity of stakeholders, sectors and policy areas in the river basin. Within such a long-term cooperation framework, global change impacts can be managed in a more efficient and sustainable way together with prioritizing concrete adaptation actions that can give inter-sectoral synergic benefits.

According to the statement above, the main objectives for the Vipava River Basin Adaptation Plan are:

- to raise public awareness on the importance of sustainable water management, considering the expected impacts of global change at the river basin scale;
- to promote the importance of the involvement of the local stakeholders from various disciplines and levels of practical involvement;

- to identify current water uses, related problems, and potential solutions through the involvement of the communities within the Vipava river basin;
- to prepare, analyse and assess adaptation options which can increase the capacity of the Vipava river basin to adapt to the impacts of global change and other pressures on water resources;
- to support sustainable water management in the long-term by providing recommendations for strengthening the resilience of the river basin's society to global change and improving governance for adaptation.

To address these objectives, the Vipava River Basin Adaptation Plan was developed through an iterative process of mutual learning, participatory techniques, and a bottom-up approach to ensure that stakeholders play an active role in developing appropriate strategies for the management of the Vipava river basin. During this process a total number of 114 stakeholders participated in workshops, consultations, and interviews to express their interest in and views on managing water-related challenges in the Vipava river basin. The participatory workshops led to the identification of three water-related challenges and 20 water management options that would tackle these challenges and support the adaptation process.

2.1.3 Overview of content

Following the introductory section, chapter 2.2 presents details on current and possible future state development of the main socio-ecological systems (land, climate and water, biodiversity, and people) in the Vipava river basin and the context for policy context. The main challenges identified throughout the participatory approach are included in this chapter. Chapter 2.3 provides a short overview of the methods used to identify, formulate and evaluate water management options with a graphical component, a list of water management options and a more detailed description of the river basin adaptation plan planning process with information on the stakeholder engagement process. Chapter 2.4 presents the adaptation actions prepared for the Vipava river basin in a form of seven sector specific bundles together with monitoring and evaluation. Chapter 2.5 concludes with the recommendations for policy/decision makers on priority water management options. Part 2 of the river basin adaptation plan includes a detailed description of the 20 Water Management Options. Engagement and dissemination activities taking place in the Vipava river basin are presented in Annexes I and II.

2.2 Vipava River Basin

After a short introduction to the Vipava river basin, this chapter provides an overview of the current state and expected future state of Vipava's land use and industry activity, climate and water, people, and water uses. The expected future state or so called dynamics are presented mainly for the climate of the Vipava river basin and for resulting water availability. This chapter also includes an overview of the main flood areas in the Vipava river basin that were identified in the transposition of the Floods Directive [31] into Slovenian legislation. In addition, relevant legislation and policies are listed and described. This chapter concludes with an overview of the main challenges identified for tackling global change in the Vipava river basin.

2.2.1 Current status and dynamics

2.2.1.1 Geography and geology

The Vipava river basin is located in south-west Slovenia covering an area of 589 km2. The upper part of the Vipava river basin includes the Vipava River spring and the catchment area of its main tributaries Močilnik, Bela, Hubelj, and Lokavšček. The lower part of the Vipava river basin starts where the Branica River flows into the Vipava River and it includes the Vipava River and the catchment area of its main tributaries Lijak, Vrtojbica, and Branica (see Figure 1). Just after the Vrtojbica River flows into the Vipava River (near the town Miren), the Italian state border forms a virtual boundary around the Vipava river basin. Soon after the state border the Vipava River flows into the Soča River.

Geologically, the Vipava Valley is composed of tertiary and quaternary alluvial sediments where the soil is quite fertile. The mountain range that envelops the valley in the north is a massive Mesozoic limestone accretion, covered by a thin and unstable layer of flysch. For this reason, landslides are common on the steep slopes during heavy rainfall events. The elevated but much lower plateau to the south is largely of more or less pure limestone from the Mesozoic era [32]. Both limestone plateaus lack surface water and all the water sinks into ground creeks and canyons, only to emerge again just above the impermeable valley bottom.

In general, water management in such karstic regions is difficult, as the groundwater behaves similar to surface water streams and may be affected by sources of pollution that are distant and difficult to locate. Moreover, the water's self-purification capabilities in comparison to non-karstic regions are extremely limited due to the lack of proper natural filters (e.g. lush vegetation, a thick layer of soil, layers of sand and gravel underneath, etc.).

Due to the fact that the Vipava river basin hinterland is sparsely populated and with the exception of a small number of pastures (the Trnovo Forest and the Nanos and Hrušica Plateaus), the waters in the surrounding karstic regions of the Vipava river basin do not experience large-scale pressure. However, a noticeable number of vineyards in the karst region could to some extent exert environmental pressure.

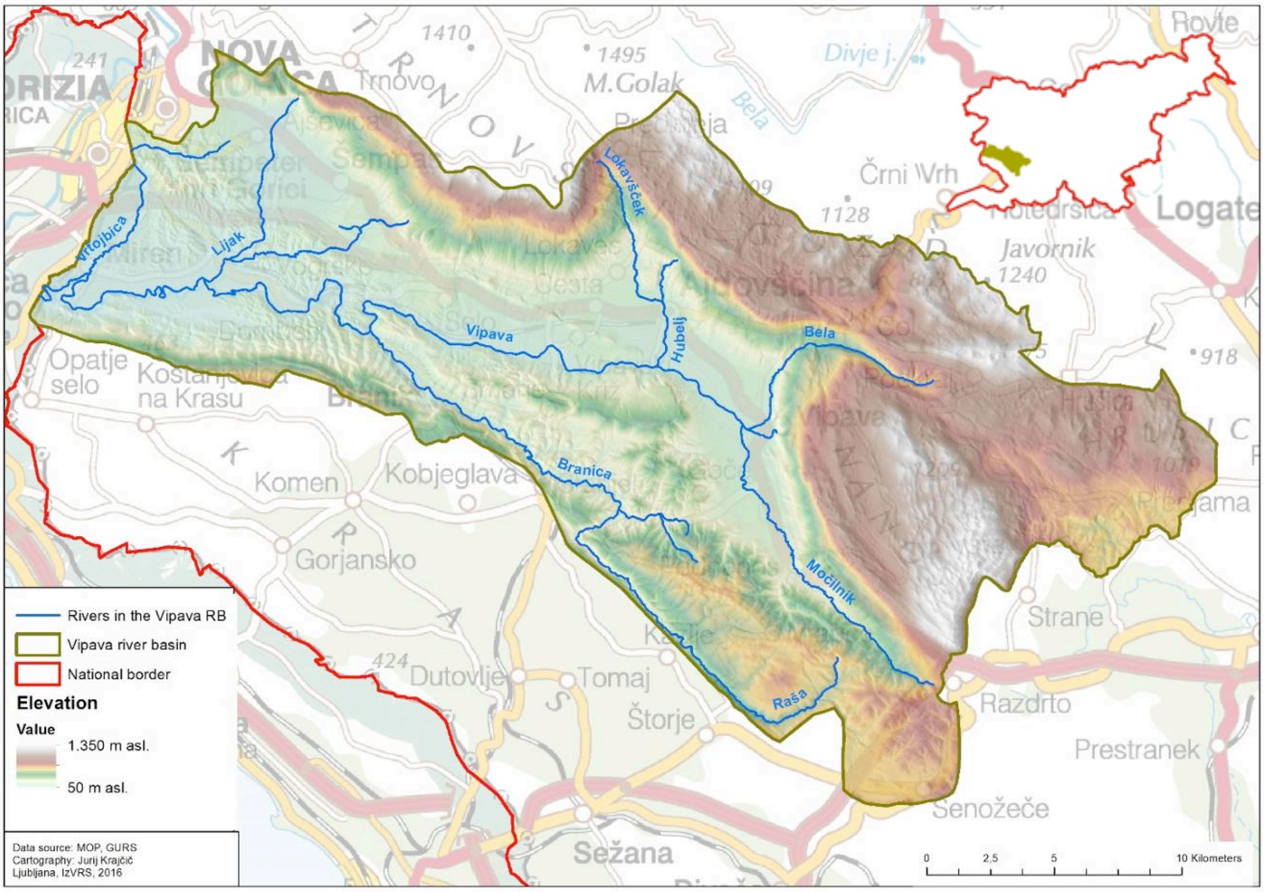


Figure 1: *Overview of the Vipava River Basin with its main watercourses and elevation, and its location within Slovenia*

2.3.1.1. Land use [33] and industrial activity

A large part of the Vipava river basin is covered by forest (61%), mostly on the slopes and higher altitudes around the main valley, and in the north and south periphery of the lower part of the basin. The second main land use in the Vipava river basin is agriculture (33%), mostly in the flatland around the Vipava River and its tributaries.

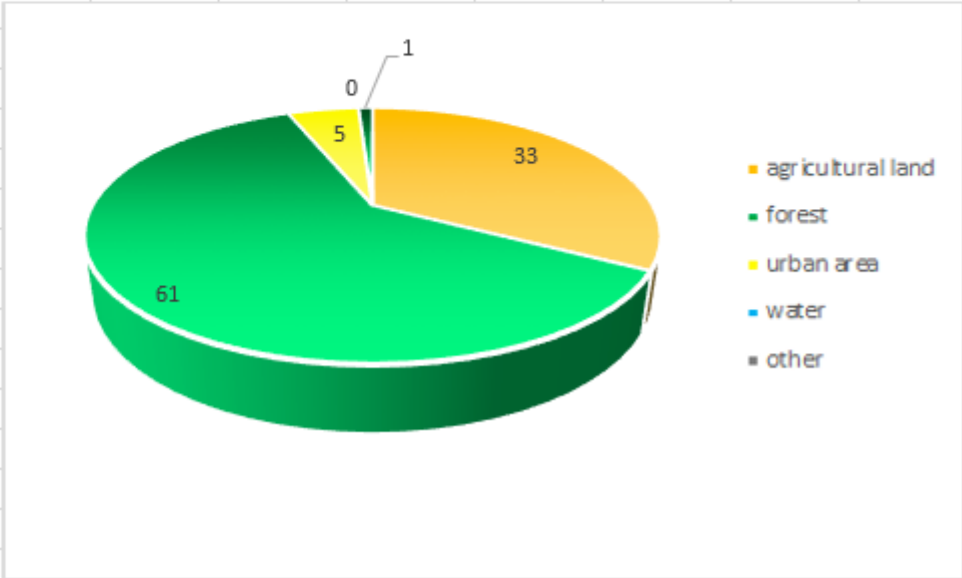


Figure 2: *Percentage of land use in the Vipava River Basin*

A comparison between land use in 2002 and 2015 shows noticeable changes. In this time, 2.1% of the river basin area were transformed from arable land to grassland and urban area and 3.5% of the area that formaly was geassland developed into forest and shrubland [33] [34]. Due to the specific geology and morphology of the area, the Vipava RB has a large number of nature conservation areas (e.g. valuable natural features, protected areas), protected at the national level by the Nature Conservation Act [35].

The most important agricultural products in the valley are fruits (especially peaches) and grapes for wine production. Other important agricultural products are early vegetables (lettuce, potato, cabbage, carrot, onion, garlic, and strawberries) due to favorable climate conditions and a vegetation period that is significantly longer compared to the continental parts of Slovenia [36].

Besides agriculture, industry is also an important sector in the Vipava RB (31% of the total GDP in the Goriška region). Industry is present in all major cities of the Vipava Valley (e.g. Ajdovščina, Vipava, Šempeter, Nova Gorica), although it is more condensed in the lower part of the basin. The town of Ajdovščina developed along the Hubelj watercourse (see Figure 1). In Ajdovščina, there are two important food processing factories. Other important industrial sectors in the valley are electronics, construction, and transport services. The number of newly established micro-, small-, and medium-sized companies during the past decade is increasing as people are developing new income opportunities, following the abandonment of agricultural activities and decreasing employment opportunities in large industry complexes.

With its rich natural and cultural heritage, the Vipava Valley (especially in the upper part) has great potential for developing ecotourism. Besides beautiful landscape, the Vipava wine road is a good starting point for countryside ecotourism. The importance of tourism for the local economy has been increasing. The number of visitors is rising every year, reaching 176,000 in 2014, the main attractions being the landscape, wine tasting, and gastronomy [36].

2.2.1.2 Climate and water

Being open to the west towards the Adriatic Sea, the Vipava river basin is subject to a strong Mediterranean climate interplaying with continental climate conditions. The sub-Mediterranean climate is moderated by occasional influxes of continental air masses from the north-east across the mountain barrier. Summers are hot and dry with occasional droughts, while winters tend to be mild and rainy with frequent bora winds, a prominent local wind which is dry, cold, and often comes in gusts with well over 100 km/h and can occasionally exceed 200 km/h, causing damage to crops and buildings, and causing problems in traffic. The section most affected by bora wind is usually the upper part of the Vipava Valley, stretching from Ajdovščina to Podnanos.

The bottom of the valley rarely sees freezing temperatures and snow is a rare occurrence as well. The average annual temperature for the reference period 1981 – 2010 at the bottom of the valley is 12-13 °C. The hottest month is July with an average temperature (1981 – 2010) of 22 °C, and the coldest month is January with an average of 3 °C. Temperatures drop with altitude; at the annual level, they are 2 °C lower on the Karst plateau and 6 °C lower in the highlands of the Trnovo Forest mountain range. The average annual precipitation in the upper part of the Vipava Valley is around 2,000 mm per year, and in the lower part and the Vipava Hills around 1,500 mm per year. For example, Figure 3 shows average monthly air temperature and precipitation for the reference period 1981 – 2010 for Bilje Meteorological Station, located at the bottom of the valley in the north-west of the basin [37].

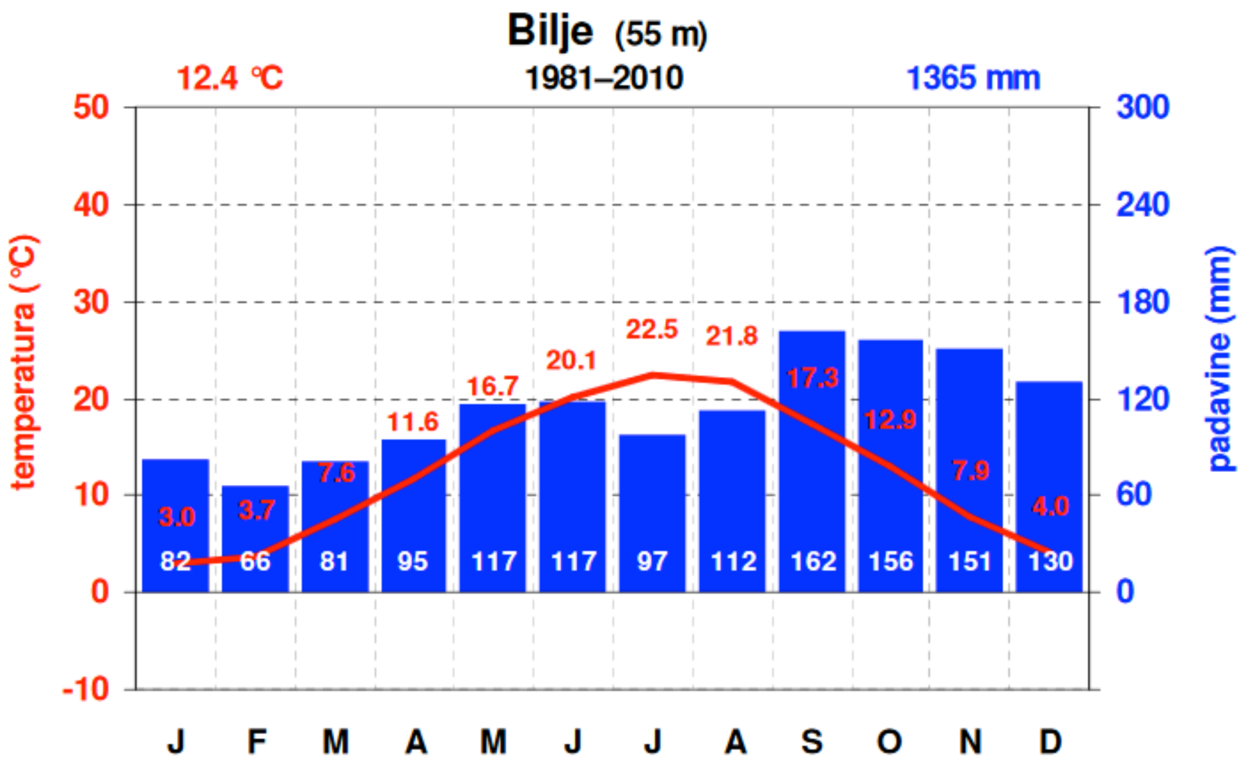


Figure 3: *Diagram for the Bilje Meteorological Station, located in north-west of the Vipava river basin, with average monthly air temperature (red numbers) and precipitation (blue numbers) for the reference period of 1981-2010*

The main water body, the Vipava River, with a length of 47 km and a mean yearly discharge of 17.3 m3/s (the 1971 – 2000 period), has a pluvial or pluvio-nival flow regime. From its right river

bank it is fed by several tributaries with strong karstic springs (e.g. Lijak, Hubelj), which are fed from the wet Trnovo Forest mountain range. The Vipava River has a short but noticeable low flow in late winter due to snowfall in the mountains, a long and persistent low flow during the summer, and two high flows, one in early spring and one in late autumn. Low-scale floods are frequent in the lower part of the valley during late autumn and larger-scale floods occur every couple of years [38].

According to national legislation by the rules on determing and classification for water bodies [39] the Vipava river basin comprises three surface water-bodies (Hubelj, Vipava Brje – Miren, and the Vipava povirje – Brje) and one heavily modified water-body (zadrževalnik Vogršček) according to the EU Water Frame Directive [21].

According to data from the river basin management plan (2015 – 2021) of Slovenia (in preparation) [27], the chemical status of surface waters in the basin is good, whereas the ecological status or ecological potential of the Vipava River is moderate in the lower part and good in the upper part. Ecological conditions of the lower part of the Vipava River are deteriorated due to high levels of nutrients and presence of specific pollutants. The chemical status of three groundwater bodies in the Vipava river basin (Obala in Kras z Brkini, Kraška Ljubljanica, and Goriška Brda in Trnovsko Banjška planota) is good [40]. However, the chemical status of groundwater aquifer system "Vrtojbensko polje" is questionable due to high levels of nitrates [41], which was confirmed also by the ASTIS project [42]. In addition to nitrates, the project's results also showed increased levels of specific pollutants such as chlorides and sulphates which are of anthropogenic origin in the groundwater aquifer system "Vrtojbensko polje".

For the implementation of the Floods Directive [31], a total of 56 potentially significant flood risks areas were demarcated in 2012 across Slovenia with regard to human health, environment, cultural heritage, and economic activity [43]. In the Vipava river basin there are five such areas (see Figure 4). According to the preliminary hazard indication map, there is the likelihood of very rare floods1 (estimated in the Vipava river basin in total area of 19.21 km2 (3.3% of the total river basin area) (see Figure 4).

[1] HQ 50 and more means the highest discharge observed – the flood extent is given for return period of 50 years, for extreme weather event [43].

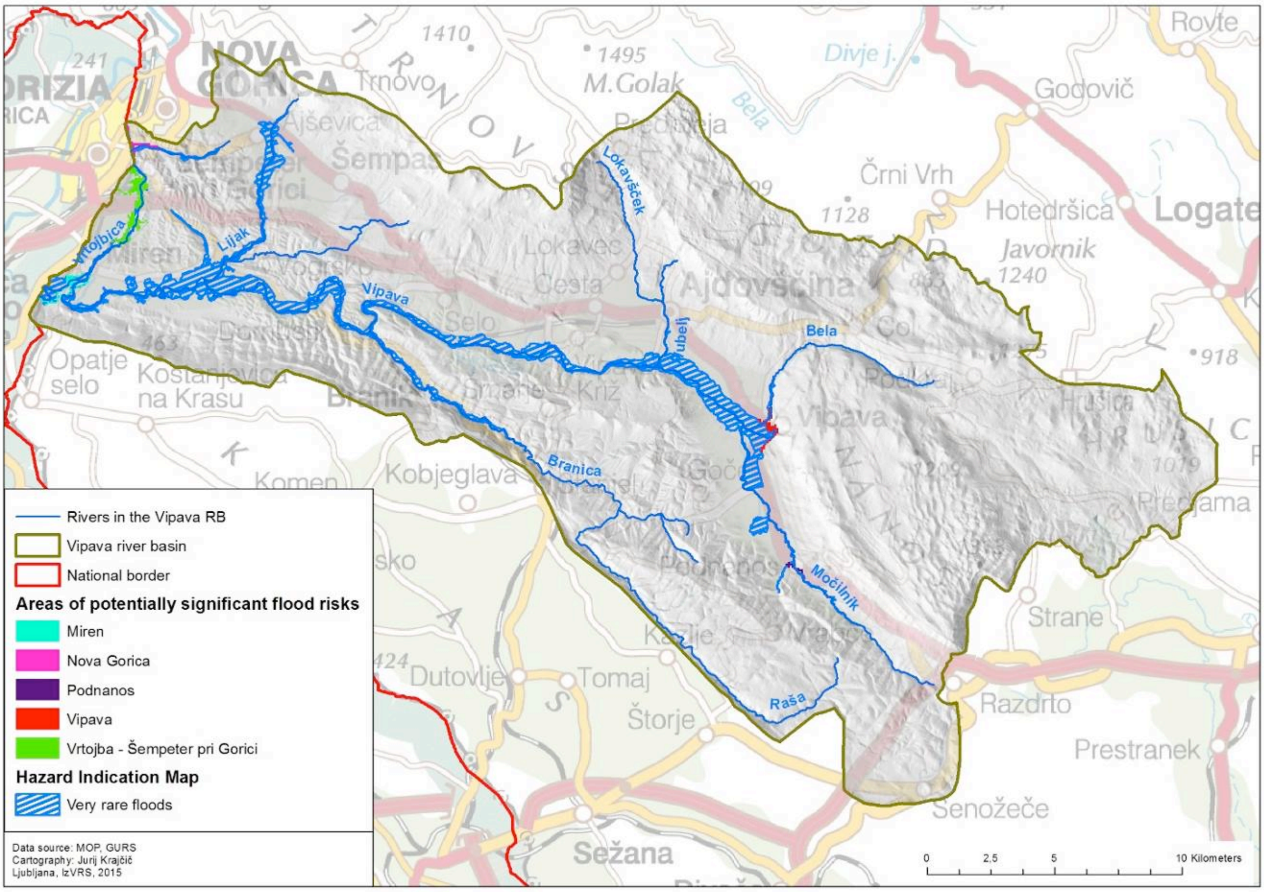


Figure 4: *Areas of potentially significant flood risks and very rare floods (HQ50 and more, marked in blue) in the Vipava River Basin*

The Vipava river basin is one of the areas most profoundly influenced by human activity in Slovenia. The upper stream of the Vipava River and its tributaries were technically regulated in the past because of floods and to increase the area of arable land. With regulation of the Vipava River, flood protection in the upper part of the basin has improved. However due to a quicker run-off towards the lower part of the basin, floods have become more frequent [45] and several catastrophic floods occurred in past years which resulted from changes in the precipitation regime, one of the consequences of climate change. There is one large Vogrščček water reservoir, built on a rather weak watercourse with the same name. The total designed volume (both lower and upper reservoir) of Vogrščček is 8.5 million m3 of water. Vogrščček has been designed to provide water for the irrigation of the lower Vipava Valley, amounting 84.5% of the total usable volume (6.8 million m3). 15.5% of the total usable volume is intended to prevent hydropeaking and flooding during high flows [46]. Although planned (Republic Green plan, 1970-1980) not all the corresponding irrigation systems were constructed. Today's capacity of Vogrščček is only 1.8 million m3 per year, which corresponds to possible irrigation of 1,400 ha of agricultural land. Due to Vogrščček's sub-optimal functioning (leakage of the barrier, low water level resulting in low pressure for optimal irrigation) only approximately 1.3 million m3 of water per year (1,000 ha of agricultural land) is used for irrigation.

Slovenia is one of the eight Member States that have failed to comply with their obligations under the Urban Waste Water Treatment Directive [47]. The main reason is that municipal wastewater treatment in the basin is not sufficient, which is reflected in poorer ecological status, especially during extreme low flows. Buildings in most of the smaller settlements still have (permeable) septic tanks instead of sewerage systems or small wastewater treatment plants. However, two municipal

wastewater treatment plants (WWTP) with total capacity of 56,500 population equivalents together with sewerage systems were constructed most recently in the basin (1) WWTP Vipava in the upper part of the basin and (2) WWTP Nova Gorica (Vrtojba) in the lower part of the basin. Surface water quality is expected to improve. Nevertheless, more WWTPs are needed in the basin, mostly on a smaller scale.

2.2.1.3 People and water uses

Urbanisation in the Vipava river basin is moderate. There is only one town, Ajdovščina, with more than 5,000 residents. The population density is quite high at the bottom of the valley and lower on the slopes that enclose the valley. The area of the Vipava river basin is divided among eleven municipalities with a total of 172 settlements [48] and a population of approximately 52,000 inhabitants. Three of the municipalities, Vipava, Renče – Vogrsko, and Šempeter – Vrtojba, are located entirely in the area of the Vipava river basin, while most of them are located partly in the Vipava river basin and partly in other river basins (Ajdovščina, Nova Gorica, Miren – Kostanjevica, Postojna, Divača, Sežana, Komen, and Idrija).

Data from water balance in the 1971–2000 period show that the overall water supply is relatively stable and secure. However, there are shortages of surface water during the summer months. Occasional droughts result in damage on crops and in yield loss, but underground aquifers, which make up the vast majority of potable water resources, are rarely notably affected [49].

The total annual runoff of the basin is approximately 545 million m3. Regarding authorized water withdrawals (or abstractions) we distinguish between two terms:

1) water use that describes the total amount of water withdrawn from its source to be used. Uses of surface water include small hydropower plants, aquaculture, fisheries, saw/mill, water used by technological plants, and individual water supply [50].

2) water consumption as the portion of water use that is not returned to the original water source after being withdrawn [51]. In 2013, the total granted water consumption from surface waters through granted water permits amounted around 33.5 million m3, around 6% of all water available from surface waters. Almost all of this quantity was allocated to irrigation (and mostly from the Vipava River).

Drinking water for households is provided by mandatory municipal public utility services (Komunala Nova Gorica d.d. in municipalities Nova Gorica, Šempeter-Vrtojba, Miren-Kostanjevica and Renče-Vogrsko and Komunalno stanovanjska družba d. o. o. Ajdovščina in municipalities Vipava and Ajdovščina) and is obtained from springs (e.g. Hubelj). The total granted withdrawal in the Vipava river basin in 2013 amounted around 6.2 million m3 through water permits. Additional 0.08 million m3 were allocated to individual water supplies. The two uses combined presents more than 99% of all water consumption from springs. An additional granted amount of 3.9 million m3 was allocated to aquaculture [51].

Water use from groundwater sources others than springs is low. In 2013 only 7,000 m3 of withdrawal was granted through water permits for individual water supplies, and additional 64,000 m3 for technological purposes. There were no concessions awarded for use of ground water in 2013 [51].

The importance of hydropower is small. There are nine small hydropower plants in the basin; most of them are on the Vipava River [51].

2.2.1.4 Climate change and expected impacts

In Slovenia, temperature measurements clearly show that the climate is warming [52]. According to the analysis presented by dr. Kajfež-Bogataj in 2005, "in the period 1951-2000, the average annual air temperature increased by 1.1 °C, and during the last 30 years, warming exceeded the limit of 1.5 °C" [53]. Analysis of water balances in Slovenia for the period 1971–2000 [54] show changes in precipitation levels in the last few years, with an increasingly pronounced autumn peak of precipitation and decreased amounts in other seasons. On average, snow cover has become rarer and the snow line has been occurring on higher altitudes, decreasing the amount of water to be retained until spring. Thus, low flows or occasional water shortages in surface waters to the start of the vegetative season have become more common, jeopardising crop yields. Even though the annual precipitation levels do not show any trend, it tends to be ever less equally distributed throughout the year; winters have been getting wetter and summers drier [38] [55] [56]. Evaporation is increasing in comparison to the 1961-1990 period [54]. As a consequence, water flow regimes are changing, with diminishing differences in river water flow regime at regional levels. Water flow trends are generally declining. A comparison of water balance elements in the period from 1971–2000 with those in the 1961–1990 period [54] also indicates an increase in evaporation and a reduction in surface water runoff. The above-listed climate changes on a regional level have not yet caused water shortages in the short term at the regional level, the risks of water provision are increasing locally. Namely, in the last years the Vipava river basin has been experiencing persistent extreme low-flow events during the summer months as well as relatively short but extreme peak discharges during heavy rainfall, causing sometimes devastating torrential floods [38] [56].

Climate change projections for Slovenia published by the Slovenian Environment Agency in 2008 [57] suggest that the average annual temperature in the Vipava Valley could increase by around 1.3 °C under the scenario A1B (Special Report on Emissions Scenarios (SRES)) by 2030 (see Figure 5 also for other scenarios). It should be noted that this increase differs between various models used to make these projections. The biggest positive trend in temperature is seen during the summer months [58]. The increase in temperature is accompanied by a reduction of precipitation in the summer and increases in the winter. Under the scenario A1B approximately a 2% rise in precipitation for winter months and a 4% reduction for summer months until 2030 is projected (see Figure 5) [58]. Moreover, summer precipitation tends to decrease with shorter but more intense rainfall with storms and torrential downpours, causing rapid surface run off of precipitation water with little infiltration into the soil.

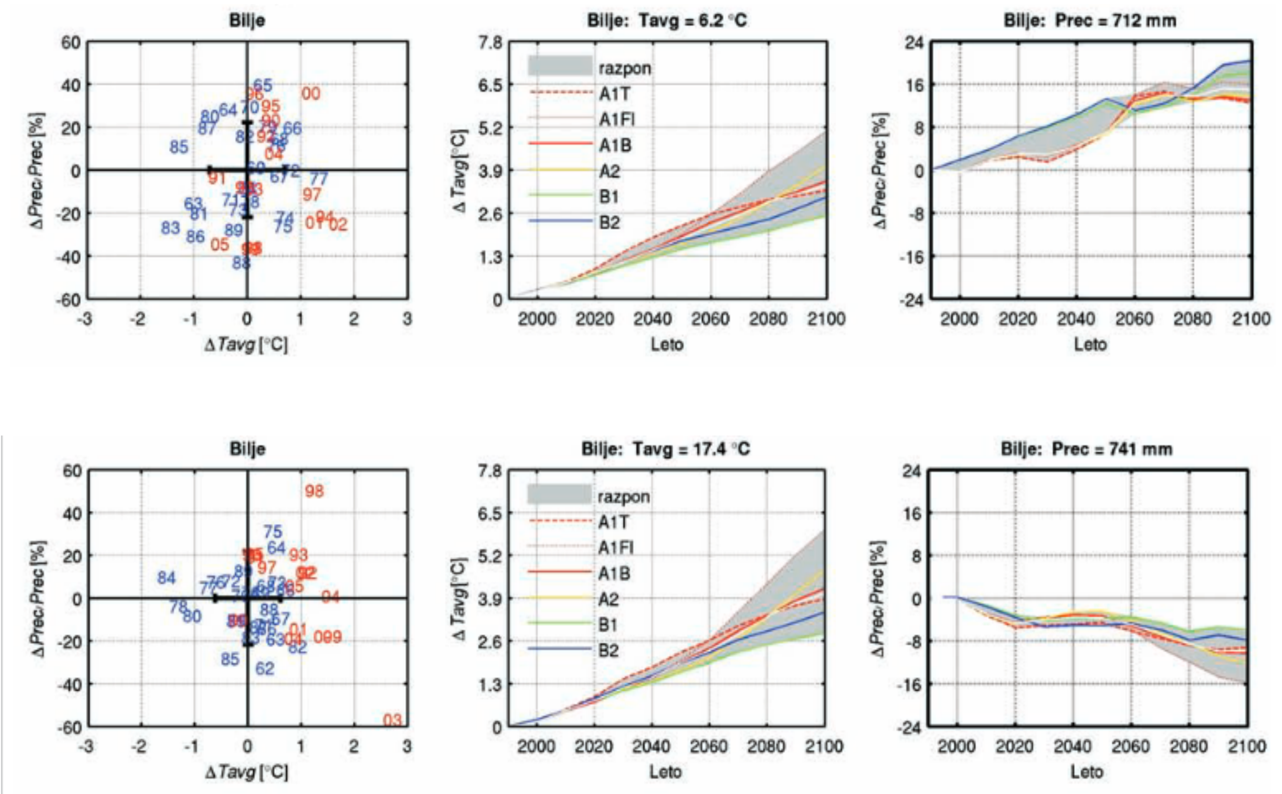


Figure 5: *Distribution of years in the period 1961-2005 according to the variations in average air temperatures (Tavg) and precipitation (Prec), in the cold (October-March) and warm (April-September) halves of the year. Cold half of year is shown above and warm half of year is shown below.*

Average in the 1961-1990 period for Bilje Meteorological Station (located 7 km south from Nova Gorica) together with the indicative projections of changes in air temperature (Tavg: middle) and precipitation (Prec: right) through the end of the 21st century, according to different scenarios of greenhouse gas emissions (SRES A1B, A1T, A1FI, A2, B1, B2).

2.2.2 Policy Context

The existing policy framework is an important starting point for river basin adaptation planning. It directs the actors' existing efforts in solving the issues at stake by complying with set objectives. Hence, the existing policies can present synergies for the implementation of further actions that are aligned with the policies' objectives and support the implementation of proposed adaptation options. This support can be based on regulatory, financial, or information-based mechanisms and instruments. Identified opportunities and barriers for the implementation of individual adaptation options prepared for the Vipava River Basin Adaptation Plan are outlined in chapter 2.4 and Part 2.

The main water management policy in the EU is the Water Framework Directive [21]. The Republic of Slovenia has completely integrated the Water Framework Directive into national legislation through the Waters Act [59]. Besides the Water Framework Directive, other directives such as the Bathing Water Directive [60], Floods Directive [31], and Marine Strategy Framework Directive [61] have been transposed in the national Waters Act [59].

Ministrstvo za okolje in prostor (The Slovenian Ministry of the Environment and Spatial Planning) is the country's main institution in water management and is responsible for preparing and implementing environmental policies and legislation. This Ministry is responsible for implementing the Water Framework Directive and preparing the river basin management plan. Adopted in 2011, the river basin management plan (2009–2015) [28] together with the programme of measures [29] is a national strategic planning document for water management. The river basin management plan specifies the mechanisms for carrying out policies by which the good status of water bodies will be achieved. Based on the determination of characteristics and status of river basin districts, and on management objectives in water protection, water management and water use are defined. In Slovenia there are two basin districts: the Danube basin district and the Adriatic sea basin district. The Vipava river basin as part of the Soča river basin belongs to the Adriatic sea basin district [28].

There are four institutions affiliated to the Ministrstvo za okolje in prostor [62]; the Direkcija za vode Republike Slovenije (Slovenian Water Agency), the Agencija Republike Slovenije za okolje (Slovenian Environmental Agency), the Geološki zavod Slovenije (Geological Survey of Slovenia) and the Inštitut za vode Republike Slovenije (Institute for Water of the Republic of Slovenia) that was in charge of the development of this plan. The Direkcija za vode Republike Slovenije and the Agencija Republike Slovenije za okolje are actively involved in drafting the next river basin management plan for the period 2016-2021 by providing the requisite expert bases. The Geološki zavod Slovenije provides support in data analysis and expert knowledge on groundwater. The Inštitut za vode Republike Slovenije is preparing methodologies related to the development of a river basin management plan. A new river basin management plan for the period 2016-2021 is in preparation and is planned to be finished and adopted in 2016.

The Direkcija za vode Republike Slovenije performs administrative, expert and developmental tasks in water management, in accordance with the regulations governing water. It performs tasks as a spatial planning authority in water management, as a consent authority, and other tasks within the context of spatial planning procedures, building construction, and environmental impact and other assessments. The Direkcija za vode Republike Slovenije, together with a concessionaire selected on the basis of a public tender, provides the water management public service. The Agencija Republike Slovenije za okolje conducts expert, analytical, regulatory, and administrative tasks related to the environment at the national level, except for tasks that are in the responsibility of the Direkcija za vode Republike Slovenije.

The Ministrstvo za okolje in prostor is responsible also for the preparation and implementation of flood risk management plan 2015-2021 (in preparation) [63]. The Flood risk management plan is a separate document from the river basin management plan and is expected to be adopted in 2016.

Apart from the Waters Act, other policies are related for water management.

The Decree on the protection of waters against pollution caused by nitrates from agricultural sources [64], which is an executive act of the Environmental Protection Act [65], and in accordance with EU Nitrates Directive [66]. It sets threshold values for nitrogen input from agricultural sources into agricultural soils and includes measures to reduce and prevent water pollution caused by nitrates from agricultural sources. In accordance with the Nitrates Directive [66], the entire territory of the Republic of Slovenia is designated as a Nitrate Vulnerable Zone.

The Decree on groundwater status [67], is another executive act of Environmental Protection Act, and is in accordance with EU Groundwater Directive [68]. It sets among other parameters the chemical and quantitative status and groundwater quality standards.

The operational program of discharge and municipal wastewater treatment for the period 2005-2017 [69] was prepared in accordance with Urban Waste Water Treatment Directive [47]. The Direkcija za vode Republike Slovenije is currently preparing a new operational programme.

Another important plan, affecting management also in the Vipava river basin, is the Natura 2000 Management programme for Slovenia for the period 2015-2020 [70], adopted in April 2015 and prepared by the Ministrstvo za okolje in prostor. Expert input was provided by the Zavod za varstvo narave Republike Slovenije (Institute for Nature Conservation of the Republic of Slovenia). The Natura 2000 Management programme is important for water management as many species and habitats are dependent on water. The framework for this programme is made up by the Birds Directive [71] and Habitats Directive [72], which are transposed in the national Nature Conservation Act [34].

Since 2008 the Slovenian agriculture and forestry strategy of adaptation to climate change and its implementation document (Action plan, 2011) [73] have been in force. Primarily it is focusing on building capacity to manage the adaptation of agriculture and forestry, education, raising awareness, consulting to farmers, and the maintenance and acquisition of new knowledge on adapting to climate changes. The strategy outlines, technological measures to reduce the vulnerability of agricultural production to drought (2008) and to reduce the impact of drought in cultivation of maize. It contains a map of agricultural land (cultivation of maize) in risk of drought, that was prepared in 2014. Nevertheless, an overall national strategy including all sectors and policies is still missing. The current practice in the occurrence of drought as a natural disaster is mainly targeted at mitigating the impacts (economic loss/economic drought). To overcome this gap, Slovenia prepared in 2014 a draft assessment of climate change risks and opportunities as a basis for the climate change adaptation action plan. This assessment will, based on climate scenarios, serve as a basic document for drafting action plans (period 2020 - 2030) and guidelines for administrators involved in water management at local, regional, and national levels.

Besides the Ministrstvo za okolje in prostor also the Ministrstvo za kmetijstvo, gozdarstvo in prehrano (the Slovenian Ministry of Agriculture, Forestry and Food of the Republic of Slovenia) is relevant for water management. The Ministrstvo za kmetijstvo, gozdarstvo in prehrano performs inter alia tasks in the areas of agriculture, rural development, plant protection, forestry, hunting and fisheries. The Ministrstvo za kmetijstvo, gozdarstvo in prehrano is also responsible for the implementation of the EU common agricultural policy. The current rural development programme 2014-2020 focuses on two main areas: i) improvement of biodiversity, and ii) improvement of water status and soil quality [74].

The Ministrstvo za kmetijstvo, gozdarstvo in prehrano has on the basis of the Freshwater Fisheries Act [75] adopted the programme for the management of fish in inland waters of the Republic of Slovenia in 2015 [76]. This programme is the basis for the fisheries and farming management plans [77], which are prepared by the Zavod za ribištvo Republike Slovenije (the Fisheries Research Institute of Slovenia) with the help of local fishing clubs. The fisheries and farming management plans, still in preparation, form the basis for the annual programs [78]. Expert bases for the programme for the management of fish in inland waters of the Republic of Slovenia are provided by the Zavod za ribištvo Republike Slovenije.

Representatives of the Ministrstvo za okolje in prostor, the Agencija Republike Slovenije za okolje and the Ministrstvo za kmetijstvo, gozdarstvo in prehrano have been directly or indirectly involved in the preparation of the Vipava river basin adaptation plan by providing relevant information on water use conflicts and the desired state for the Vipava river basin. Policy-makers within the Ministrstvo za okolje in prostor and the Ministrstvo za kmetijstvo, gozdarstvo in prehrano have also provided information on the current situation of adaptation to global change at national and river

basin level. They also provided their experience with public participation in the design of policies and potential conflicts that may appear.

2.2.3 Main Challenges

The challenges identified by stakeholders during the first stakeholder workshop were analysed and consolidated by the BeWater project team into three overarching challenges that the Vipava river basin is facing: (a) Water availability during droughts in growing season, (b) Flood risk reduction, (c) Appropriate water quality.

- **Challenge A: Water availability during droughts in the growing season**

The main challenge indicated by stakeholders is water availability in irrigation networks and rivers during drought occurrences, especially in the growing season. In the Vipava river basin meteorological, agrometeorological and hydrological droughts are present, each having a specific impact on the environment. The adverse climate conditions (higher temperatures and reduction of precipitation in in the warmer part of the year) will aggravate risks of water shortage in the future even more.

When droughts occur, a variety of activities, sectors (water users) and ecosystems can be severely impacted by water shortage, especially agriculture. When farmers can no longer use water to irrigate their crops from the two main water sources, the Vipava River and Vogrščček water reservoir, they potentially use potable water, which can cause some problems with the drinking water supply, especially in the summer months. Furthermore, when droughts occur, they can also cause damages to water distribution systems infrastructure – damaged, broken water pipes, causing unavailability of drinking water in some areas of the Vipava river basin.

Although the water demand for households is expected to stay at approximately the same level, water demand for agriculture, especially irrigation, is expected to rise in the years to come because of expected drier summers and due to plans encouraging irrigation and consequently decreasing the vulnerability of crops to droughts [79].

The main reasons why water is unavailable during droughts in growing season are listed below:

I. Droughts have been always present in the Vipava river basin in the past. Due to the impacts of climate changes they have been occurring more frequently in the last few years, thus affecting larger areas. Beside climate changes, the changed water cycle in the river basin is also a result of extensive regulations of watercourses (Vipava, Hubelj, Lijak) in 1980s and earlier, and amelioration works that drain excess water the from soil. The consequences are more rapid surface water runoff from the basin, increased flow velocity, the decreased retention functions of the riverbed and soil, and reduced water infiltration, causing a lower groundwater level.

II. Although several water reservoirs and irrigation systems were planned to be constructed in the Vipava Valley (e.g. Branica, Pasji rep, Močilnik, Malenšček-Kamenski potok, Vrtovinšček, Lokavšček, Koševec) in the 70s, due to a program to increase the level of self-sufficiency in food (called Republic Green plan, 1970-1980) only the Vogrščček water reservoir with corresponding irrigation systems for the lower part of the valley were actually constructed. The reasons were the changed priorities of the Republic of Slovenia and thus the available funds at that time were transferred into the construction of highways. After that, several plans of different water reservoirs were discussed, but not yet realized.

III. The Vogrščék water reservoir was a major intervention in the valley's water cycle, yet with undesirable results, attracting political and professional criticism for many years. The main problem is unclarified ownership of the reservoir and its infrastructure between government and the private sector, which, in the past 20 years, has resulted in poor management, improper functioning, lack of operation and maintenance funding. The result is (for details see sub-chapter 2.2.1.2) lower capacity compared to planned volume for irrigation. Together with illegal connections to irrigation system there is less water available for proper management of the irrigation system. According to stakeholders there are many challenges that need attention regarding Vogrščék among which the most important are (a) better understanding of the system functioning, (b) more transparent functioning of the system (with no illegal connections), (c) better cooperation among users (16 irrigation communities), (d) organization of optimal irrigation (irrigation time plan), and (e) technological renovation and modernization of the reservoir and connected irrigation systems.

IV. The Vipava River, as the only water source for irrigation in the upper Vipava river basin, is dependent on rainfall (flow is directly dependent on the precipitation regime in the catchment area). In dry periods, when water is needed for agriculture, there are restrictions for water abstraction from the river due to maintenance of the ecological flow (Water Framework Directive). Nevertheless, illegal water abstraction from the Vipava River occurs even during low flows, thus exacerbating the negative impacts of drought on aquatic, riparian, and wetland ecosystems (reduced water flow, flow cessation, eventually complete desiccation; resulting in not achieving good ecological status of surface waters according to Water Framework Directive). Already, some experts have claimed that the irrigation needs in the Vipava Valley are greater than the available water quantities and other water sources besides the Vogrščék water reservoir would be needed.

In the framework of the Republic Green plan (1970-1980), shelterbelts (wind barriers) were planted to minimize the impact of wind on agriculture by reducing evaporation and the impact of summer winds on soils (drying, loss of water in soil). Due to the illegal removal of already planted shelterbelts by farmers (lack of awareness) and improper agricultural practice, the deflationary effects of the bora wind are even stronger, especially in winter.

➢ Challenge B: Flood risk reduction

Floods have always occurred in the Vipava river basin and pose a bigger problem in the lower part of the river basin. Due to impacts of global change, changes in the river regime as a result of regulations of the watercourses in 1980s and building of settlements too close to the watercourses (deprivation of riparian area), severe floods are occurring more frequently and at a larger scale. Trapped and rigidly regulated watercourses (concrete banks) in the upper valley lack the needed space (floodplains) and the ability to reduce the flow velocity; hence water rapidly drains downstream causing severe floods in the lower valley.

One of the main challenges identified by stakeholders regarding flood risk management is the lack of competences between local and national authorities mostly due to unclear legislation. Most problematic are smaller watercourses not recorded in the water cadaster or the water cadaster is not properly managed at all. Additionally, municipal spatial planning and its effect on flood occurrence must be mentioned in any discussion of flood risks in the Vipava river basin. In the Vipava river basin there are eleven municipalities, but not all of them are affected by floods. Each municipality manages its own area without considering the impacts of their measures upstream or/and downstream of the watercourses and thus increasing flood risks outside their area.

Landslides, which occur everywhere in the Vipava Valley on a sloped terrain, have also an impact on floods occurrence although indirectly. The biggest and most dangerous areas for landslides occurrence are on the northern slope of the valley that descend from the Trnovo Forest (Trnovski gozd) into the valley. The landslides and also many other slope-movement phenomena originate in the current geological structure of the valley and in the formation of the terrain. However, most landslides are triggered by heavy rainfall.

Due to inappropriate spatial planning in the Vipava river basin, urbanisation of the valley slopes has increased the possibility of triggering landslides mostly due to the inappropriate regulation of storm water and hinterland water drainage. Also poor maintenance of the drainage system built more than 30 (or 50) years ago, like regulations of torrents and inadequate drainage of storm waters, contribute to triggering landslides more often. Landslides do not only threaten buildings and infrastructure, but also cause morphological changes of the terrain. Landslides often move large amounts of sediments, which does not only stay on the slopes, but also reach the fluvial network. Under extreme weather conditions, landslides may lead to torrential outbursts, debris flows or dam-break waves after a dam-breach of natural dams. As a result, floods of larger scope can occur.

➢ Challenge C: Appropriate water quality

The ecological status of the Vipava River is moderate due to high levels of nutrients and presence of specific pollutants (insufficient municipal wastewater treatment and agriculture).

One of the main reasons for the unsuitable water quality in the Vipava river basin is insufficient municipal wastewater treatment. To solve the current situation and most importantly due to compliance with legislative requirements, two waste water treatment plants (WWTPs) were constructed recently, in the upper valley WWTP Vipava (at the stage of trial operation) and in the lower valley WWTP Nova Gorica (Vrtojba). However, there is still unsolved problems of insufficient municipal wastewater treatment in small and dispersed settlements. This problem is evident in the catchment area of the Vogrščκek reservoir where monitoring of water quality confirmed presence of faecal coliforms [80]. The source of contamination are most probably septic tanks overflows in the catchment area. Since water in the Vogrščκek water reservoir occasionally contains too many coliforms, the use of water for irrigation purposes is limited. In the case of the Vogrščκek reservoir stakeholders have also highlighted the improper connection of the irrigation system to the floor outlet, resulting in (a) exceptionally cold water unsuitable for irrigation, and (b) water full of sediments unsuitable for irrigation (fruits like peaches and vegetables must be cleaned constantly) [81] [82]. These issues add to the challenge of water availability (challenge A).

When Vipava River and its tributaries (Lijak, Hubelj, etc.) were regulated and canalized in 1980s in order to increase area of arable land, the length of the Vipava River was shortened from 50 to 47.7 kilometres mostly due to the elimination of meanders. With regulations, many habitats for aquatic and riparian plants and animals disappear. The result is lower self-cleaning ability of watercourses resulting also in moderate ecological status.

In connection with the already mentioned excessive water abstraction from the Vipava River for irrigation, problems with maintaining ecologically acceptable flows and in this context achieving a good ecological status become an issue when droughts occur.

A pre-condition for water ecotourism development like natural bathing sites on the Vipava River is appropriate bathing water quality. With bathing waters on the Vipava River microbiologically unsuitable, the desired ecotourism cannot develop.

2.3 Participatory development of the River Basin Adaptation Plan

2.3.1 Development process

The development of the river basin adaptation plan for the Vipava river basin is the result of an intensive stakeholder engagement process. The participation and integration of a wide group of stakeholders from various sectors throughout the whole development process has had a crucial role in the identification and evaluation of water management options and all the necessary preparatory steps which took place in an iterative way.

Due to inherent project limitations [83] together with challenges with different levels of knowledge, and differing values, assumptions and terminologies among experts, scientists and stakeholders, a methodology for identification and selection of stakeholders was developed [83] with the help of the Stakeholder Integrated Research (STIR) approach [84]. As such a supporting management tool in the form of a stakeholder database was created [83] and used for the identification of all relevant stakeholders depending on the objective of the stakeholder engagement process.

A wide range of stakeholders were part of process, actively participated and provided concrete input to the identification, formulation and evaluation processes of water management options in several stages of the participatory co-creation process that included three professionally facilitated workshops, follow-up interviews, individual and group sessions, and an additional open consultation. Parallel to the stakeholder engagement, an awareness campaign in the form of tailor-made mobile exhibition took place in the Vipava river basin with the aim of raising social awareness and to encourage capacity building, empowerment, and social formation in water management challenges and adaptation (see Annex I and II for details). A detailed methodological overview with a graphical representation and detailed description is given in chapter 2.3.2.


Development of river basin
2014
January–March
1st general project meeting in Barcelona
Identification and mapping of river basin stakeholders and key actors
April–June
1st stakeholder workshop on identifying the current and desired status of the river basin
Review and analysis of river basin adaptation plans and strategies from around the world
2015
January–March
Stakeholder consultation on draft narratives and the basin's graphical representation (fuzzy cognitive map)
April–June
Finalisation of river basin narrative, fuzzy cognitive map, and main challenges
Formulation of water management options to tackle challenges
2nd stakeholder workshop on evaluating water management options
2016
January–March
Characterisation of policy and stakeholder basis of water management options
Assessment of water management option synergies and co-benefits
Design of draft bundles of water management options
April–June
3rd stakeholder workshop on desired content and implementation of the River Basin Adaptation Plan
Finalisation of adaptation pathways and bundles of water management options

adaptation plan

July–September

Stakeholder interviews on the river basin context and challenges

October–December

2nd general project meeting in Nicosia

July–September

Finalisation of water management options

Impact assessment, multi-criteria analysis and economic assessment of water management options

October–December

Stakeholder consultation event to present and gather opinions on final water management options

3rd general project meeting in Barcelona

Finalisation of impact assessment, multi-criteria analysis and economic assessment

July–September

Completion of River Basin Adaptation Plan

Next steps

Development of policy recommendations to support river basin adaptation

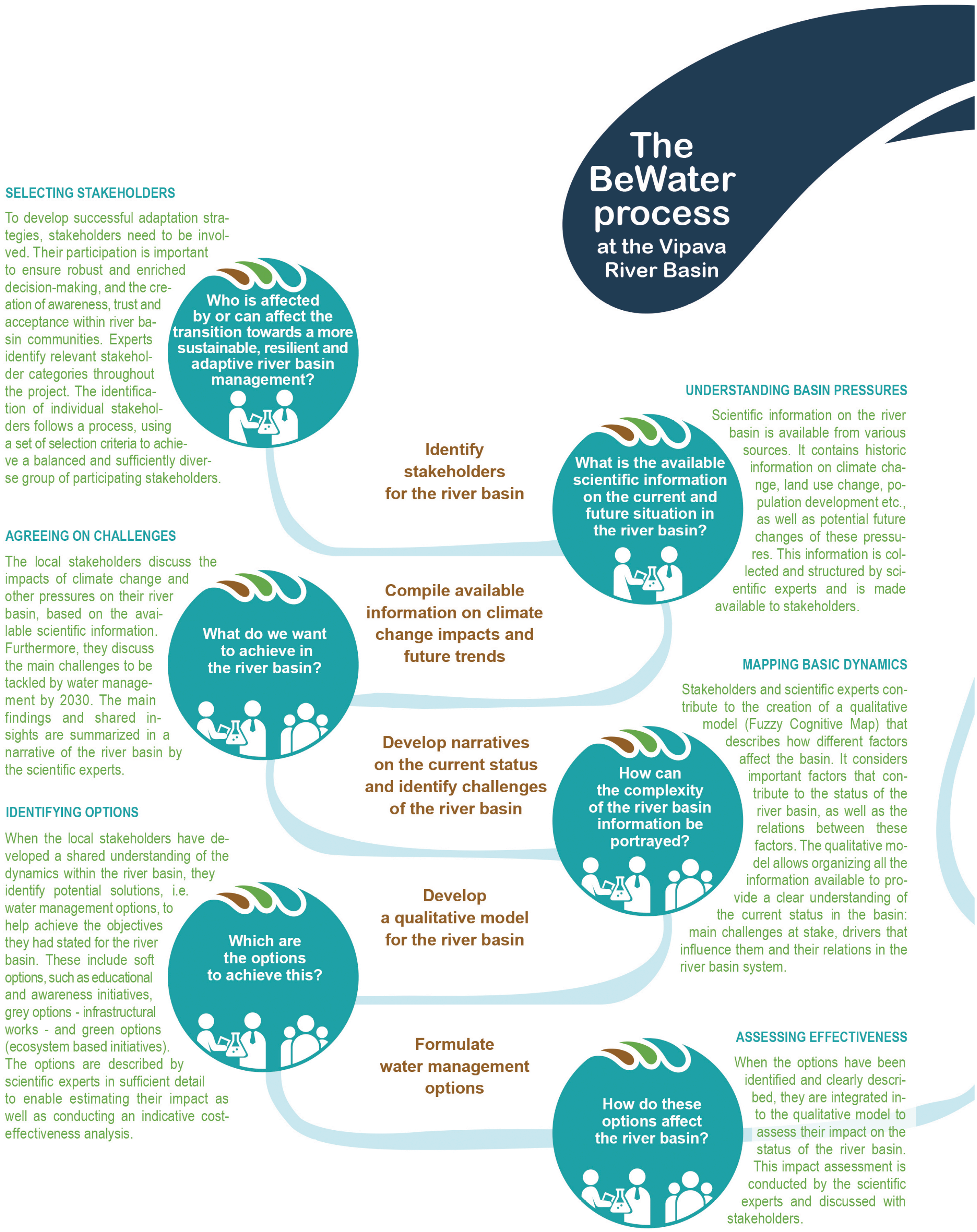
Compilation of lessons learned during the River Basin Adaptation Plan development process

Local policy forum to present river basin adaptation plan and highlight potential paths forward

European policy workshop in Brussels to highlight BeWater outcomes and key messages for policy makers

River basin adaptation conference and final project meeting in Nova Gorica, Slovenia

2.3.2 Methodological steps followed




EVALUATING OPTIONS
To evaluate the water management options, the stakeholders select the criteria on which the options will be evaluated, as well as the relative weight of each criterion. The information from the multi-criteria analysis is combined by scientific experts with the outcome of the options' impact assessment and results in the identification of options that have a desirable impact on the river basin, according to the local stakeholders.
Assess the impacts of the options through the qualitative model
Which options have desirable impacts on the river basin?
REVIEWING THE POLICY FRAMEWORK
Policies and programmes on the local, national and EU level can hinder or support the implementation of the options. Their potential role is determined by a scientific expert evaluation of whether the policy objectives, targets and timescales are in line with those of the options, what funding is available, and if eligibility or selection criteria create barriers to adopting the options.
Evaluate the options based on multiple decision criteria
How do the options fit within the relevant policy and decision-making frameworks?
IDENTIFYING POLICY ACTORS
As local stakeholders and policy actors will be directly involved in or affected by the implementation and maintenance of the options, their willingness and capabilities to support the implementation of the options are important to inform the selection and design of options. They are validated via interactive exercises with them.
Evaluate the role of existing policies in the implementation of the options
How could stakeholders be involved in the implementation of the options?
BUNDLING OPTIONS
Implementing multiple options together can result in different impacts than the individual options would produce on their own. These potential interactions are assessed using scientific expert judgment and validated via interactive exercises with the local stakeholders. Using these outcomes, previously determined basin challenges and main sectors affected by these challenges, the options are grouped into bundles.
Identify key stakeholders and their potential roles in implementing the options
Which synergies or conflicts arise between the options and how can they be grouped together?
DEVELOPING AN IMPLEMENTATION TIMELINE
The timeline for implementing each of the options within a bundle is based on their effectiveness over time, local stakeholder preferences and the policy framework. Developing the timeline for implementation takes into account factors such as feasibility, acceptability, Multi-Criteria Analysis results, costs, policy synergies. The initial scientific expert assessments were verified by the local stakeholders.
Assess co-benefits and conflicts arising between options in order to group them in bundles
When should the options be implemented?
FINALIZING THE ADAPTATION PLAN
Based on existing examples of adaptation plans in other river basins and an open dialogue between stakeholders and academics, the content and design most relevant to the local reality in the river basin are determined and integrated into a tailored river basin adaptation plan.
Assess the optimal timing for implementing the options
How can all this information be integrated and presented in the most effective way?
River Basin Adaptation Plan

The first step of the stakeholder engagement process was to identify relevant stakeholders in the Vipava river basin. With the selection criteria (e.g. gender, age, organizational affiliation and sector) stakeholders from national to local level, including civil society, scientists, public administrators (policy makers and implementers, institutional administrations and local governments), water sector actors (e.g. service providers) and other related sectors (e.g. agriculture, tourism, energy) were identified [83]. Afterwards, direct contact through e-mail, phone, and meetings was established.

Further information on the methodology and results introduced within this adaptation plan, as well as the BeWater project more generally, can be found on the project website (www.bewaterproject.eu).

Within the project three stakeholder workshops were organized. Objectives, outcomes, and other details are summarized in table 4.1.

Table 4.1: *Table of conducted workshops*

Date and title of workshop	No. of participants and sectors	Objectives	Outcomes
10th June, 2014 **1st Stakeholders Workshop**	32 a) water management, b) agriculture, c) public administration, d) infrastructure, e) energy, f) nature conservation, g) tourism, h) fishery, i) health, j) business and economy, k) civil society, l) municipalities.	a) Inform stakeholders about the BeWater objectives and expected results b) inform stakeholders on what is known about the current status of the Vipava river basin and expected impacts of global change c) gather information on stakeholder perspective of the issues and challenges in Vipava river basin in the medium-long term d) to clarify objectives (vision) for the Vipava river basin for 2030 e) to discuss on water management options aimed at achieving those objectives in the Vipava river basin by 2030	Three main challenges were identified: a) water availability during droughts in growing season; b) flood risk reduction; c) appropriate water quality.
27th May, 2015 **2nd Stakeholders Workshop**	12 a) agriculture, b) public administration, c) water management, d) municipalities.	a) To discuss the progress of the Bewater since the first workshop (June 2014); b) To collect stakeholders' comments on the formulated water management options based on the input of the first workshop; c) For stakeholders to evaluate the options through a social evaluation in a form of an on-the-spot multi-criteria analysis.	a) Selection of 13 criteria for assessing MCA; b) determination of relative importance of selected criteria; c) on-the-spot multi-criteria analysis was performed and results were discussed.
23th March, 2016 **3rd Stakeholders Workshop**	21 a) nature conservation, b) regional development, c) municipalities, d) education, e) agriculture, f) water management.	a) Identification of potential synergies and conflicts between water management options; b) Revision of prepared bundles by stakeholders; c) To discuss potential implementation barriers and opportunities.	a) Determination of synergies and conflicts between water management options; b) final selection of water management options in bundles; c) final timeline for implementing individual water management options.

At the first workshop experts provided participants information on the status of Vipava river basin and results of scientific research on the impacts of global change in the basin, with a 2030 horizon. Afterwards participants were asked to identify a medium-to-long term challenges for the Vipava river basin and their vision on its future status. In addition, participants proposed several preliminary options to address these challenges. Analysis of the first workshop showed some informational gaps, which were tackled by 14 additional interviews in October and November 2014 with policy representatives and key stakeholders that were not able to attend the first workshop. The objective of the interviews was to gain information about the current situation of adaptation in the region, personal experience with public participation in the design and especially the implementation of policies/natural resources management, and potential challenges that may appear.

The information collected on the current state and the future expectation regarding water management (according to the stakeholders) in the Vipava river basin was organized and synthesized by building a narrative of the Vipava river basin. This narrative was complemented with a graphical representation in the form of a fuzzy cognitive map (see [85] for details).

Text box 2: Description of the fuzzy cognitive mapping method

To evaluate the water management options against the three challenges expressed by the stakeholders, a method called Fuzzy Cognitive Mapping was applied. A Fuzzy Cognitive Map is a graphical representation of a system - in this case the Vipava river basin - where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the sign and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system based on the understanding of individuals. Fuzzy cognitive maps allow all the information available on the basin to be organized in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them and their relationships in the system. The maps were constructed with inputs from stakeholders from different backgrounds. Besides clearly describing the river basin, the map was used to assess the impacts of the water management options on the river basin. In this way, the BeWater Project team was able to estimate of the impacts of the water management options and their effectiveness towards each of the three challenges.

The initial map prepared was consulted with the stakeholders (February 2015). Overall 19 stakeholders, also present at the first workshop or included in the additional interviews that followed, commented and suggested improvements of the map which resulted in factors and relationships being added or modified. After that a final map was produced (see Figure 5).

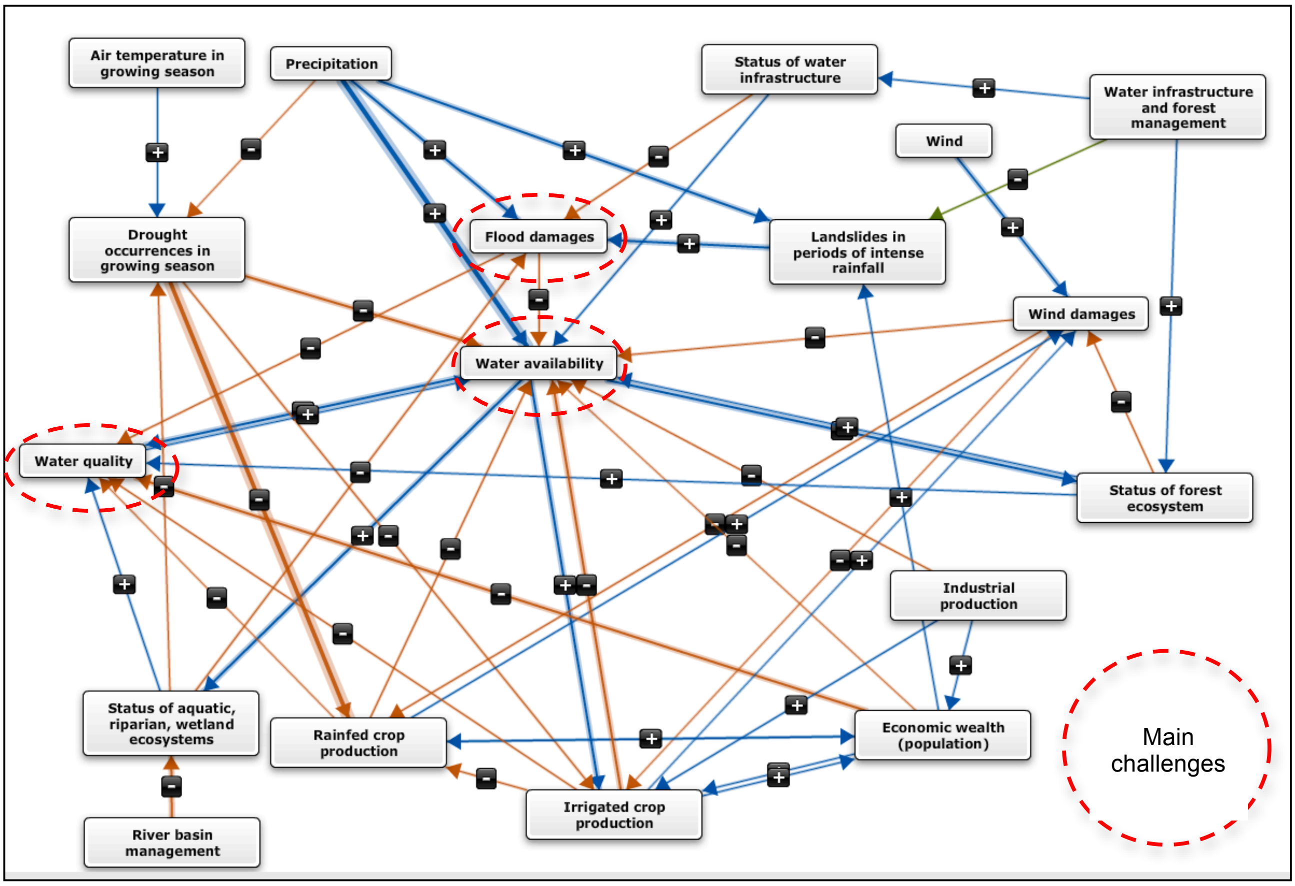


***Figure 5**: Fuzzy Cognitive Map of the Vipava river basin with identified three overarching challenges*

Next, water management options suggested by stakeholders during the first workshop were characterised using a fixed set of descriptors that mainly refer to the implementation of water management options (the parts of the RB, the sectors and land uses concerned, time frame, costs, type of approach, feasibility, acceptability, the relation to global change and to extreme weather events). This format allowed to cluster long list of options, based on the similarity of descriptors and challenges that they address in a refining process. By clustering water management options, based on the similarity of descriptors and challenges that they address and refining process, 21 options were developed to the point that allowed further analysis. A so-called impact analysis of individual options was conducted by experts using a fuzzy cognitive map (see Text box 2).

In the second workshop the 21 formulated water management options were presented to the participants. In order to evaluate and rank the formulated options from most to least preferred, participants selected 13 criteria and determined their relative importance by assigning points from one (1) to ten (10), with ten (10) representing the greatest importance and zero (0) if a criterion was not considered important. Once the stakeholders had selected and weighted the criteria, they were asked to review scoring functions for the criteria [83]. Afterwards an on-the-spot multi-criteria analysis was performed and discussed.

Text box 3: Description of multi-criteria analysis

Water management options have quite different characteristics and impacts on the water basin and local communities. Selecting the specific options that should be included in the river basin adaptation plan is a complex endeavour. To support this process, a participatory multi-criteria analysis was conducted. During a workshop, stakeholders were asked to select the evaluation criteria to decide how well options perform, as well as the importance of each of these criteria in relation to each other. Criteria referred to both the design of the water management options and their expected impacts on the river basin, as estimated with the fuzzy cognitive map. The scores and weights of the criteria given by the stakeholders were combined with the characterization of the water management option and the outcomes of the impact assessment to evaluate the water management options prepared by experts and the research team. The evaluation results are presented on a scale of 0-100 with a 0 indicating the least preferred evaluation outcome and a value of 100 as the most preferred evaluation outcome.

After performing the analysis, the outcomes of the multicriteria analysis were discussed, allowing for the integration of participants' perspectives for interpreting the final prioritization of options. The main comments of the stakeholders were that some individual water management options were ranked as high or low, depending on which of the three challenges they address. Experts reviewed all the comments carefully and where needed changes in impact assessment were made. As for the comments on the list of water management options, participants expressed some doubts about one particular option, which was later deleted, and a list of 20 water management options remained. The overall results of the multi-criteria analysis are shown in the figure below. For each option, evaluation results are presented as described in the description of Multi-criteria Analysis (see Text box 3).

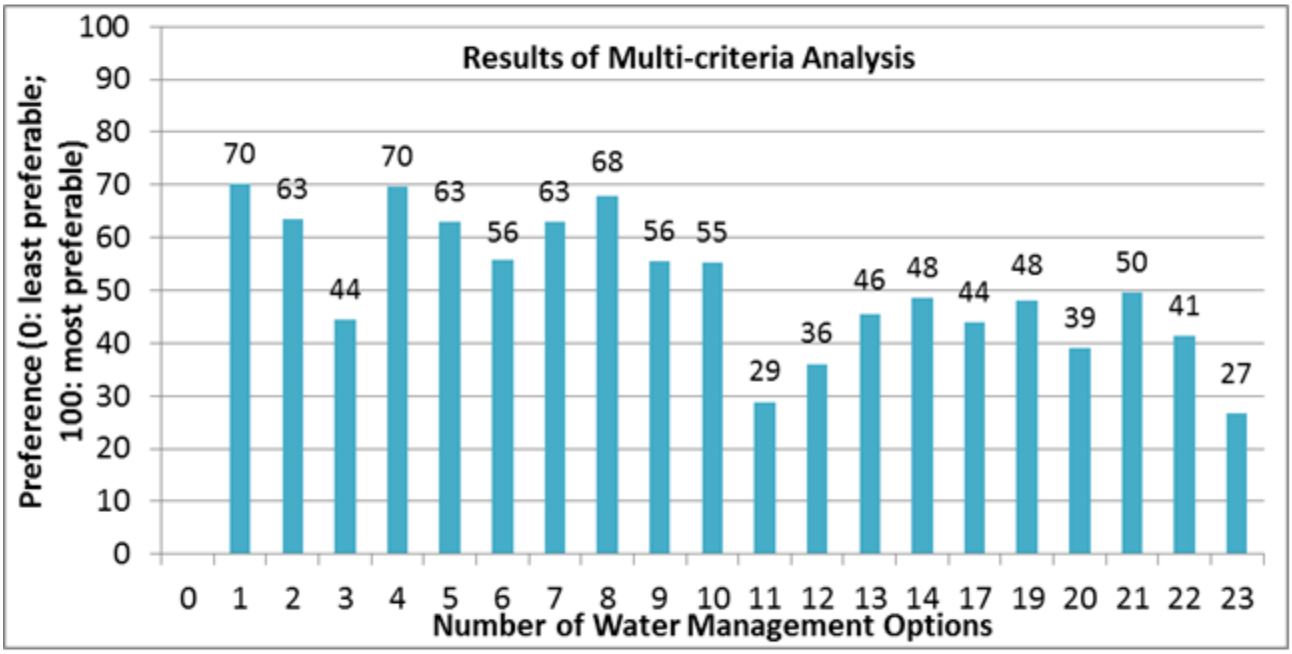


***Figure 6**: Results of Multi-criteria analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment. Numbers refer to the water management options in Table 4.2*

In the process of characterisation of water management options, a more detailed description on the steps or actions was developed by experts. This was the basis for an economic analysis or so called cost assessment from the beginning of their implementation plan (2018) towards 2030, i.e. a 13-year time horizon, which was the same for all water management options and could correspond to the project's objectives. The information on steps and costs for each water management option can be found in Part 2. The results of this assessment are considered to be indicative only, because a detailed assessment for 20 options was not feasible with the given project resources. Hence, the results of the cost assessment must be interpreted with care. A more detailed assessment of costs and benefits is recommended before these options could be implemented.

The objectives of the open stakeholder consultation (October 2015) was to present the latest version of the water management options; to receive feedback and collect input for further substance to options with an eye on validation and implementation, to sequence options (in the years from 2018 to 2030), and to disseminate current outcomes of the BeWater project. There were 16 participants actively attending the event, representing public administration, forestry, nature conservation, industry, and agriculture. The participants suggested some improvements for implementations steps that were considered in the descriptions of the water management options and additional or different implementation bodies. Some participants have already indicated various combinations of options. At the end, participants had the opportunity to indicate a timeline for the implementation of the individual water management options.

Afterwards, experts identified potential co-benefits between the individual options. Co-benefits were identified if the combined implementation of options amplified the total impact-related benefits, compared to the benefits gained from implementing each option individually. Based on the co-benefits, seven bundles were formulated. With the help of a methodology developed among the experts, optimal timing for implementing individual water management options within each bundle was prepared. The so called ''adaptation pathway'' is a combination of options and their implementation prioritisation over the short, medium, and long-term, with regards to achieving a set of pre-specified objectives under uncertain changing conditions [86]. The ''adaptation pathway'' takes into account factors like policy synergies, co-benefits or conflicts between the options, acceptability, feasibility, results from multi-criteria analysis (second workshop), and associated costs (see Table 4.2).

In the third workshop participants identified potential synergies and conflicts between the water management options that were combined by experts into seven sector- or challenge-specific bundles. Bundles contain individual interlinked options each other with the “adaptation pathways”. Participants also commented on prepared bundles of water management options and the proposed implementation timeline of individual options within the bundles. The aim was to increase the effectiveness of implementing bundles of options compared to implementing individual water management options. All suggestions given by participants that showed no discrepancy with the results of experts were taken into account in the subsequent steps. If the comparison showed a two- or more-degree difference (e.g. low conflict vs. low co-benefit or high conflict vs. no interlinkage), this was counted as a discrepancy and hence a detailed revision followed. For the final results please see Chapter 2.4. Comments given on the content of the water management options (e.g. suggesting improvements toward better definition of the options) were not taken into account if there was a possibility of altering the results of the analysis conducted in previous steps.

With the help of stakeholders thoughts and ideas on the desired content and implementation of the adaptation plan for the Vipava river basin were gathered. There were some suggestions to include new water management options as well as to amend the content of existing options to an extent that would alter the social and economic assessment done in previous steps. Such comments could not be added at this stage of the project but are mentioned in chapter 2.3.3. Relevant

comments given to the content of the River Basin Adaptation Plan are already incorporated in the structure of this document. Suggestions on stakeholder interest in taking forward water management options or even the individual bundles given by participants are included in chapter 2.4.3.

2.3.3 Further considerations

As described above in chapter 2.3, the formulation and detailed analysis of the options consisted of a particular set of steps based on the participatory approach. After the formulation of options, their detailed description allowed for the social and economic assessment. The final list of options was presented to the broader public (October 2015) and additionally to the Agencija Republike Slovenije za okolje (Slovenian Environmental Agency) at an informal meeting in Nova Gorica in January 2016. In March 2016 also the third workshop followed based on the final list of options. As some new stakeholders attended the events and the meeting, some new insights were shared with the experts. Due to the methodology prepared within the BeWater project, new ideas like for e.g. the extension of the options or adding new options, that could alter the results of previous analysis, could not be integrated in the Vipava River Basin Adaptation Plan. Therefore we mention the main ideas or new options within this chapter and give the base for improvements of the content of the River Basin Adaptation Plan in the near future.

Although it was pointed out at the first workshop (June 2014) that there were no problems with drinking water supply, one of the stakeholders participating the third workshop pointed out the problem of using drinking water also for irrigation and for technological purposes. This becomes an issue mostly during drier periods (summer) when the water consumption is at highest and people use drinking water also for other uses (irrigation, watering the garden, washing the car, etc.). This issue should be addressed in a way that basic supply should not be threatened by means of prohibiting the use of drinking water for irrigation. Also water saving techniques could be applied at the household level (e.g. turn off the tap when brushing teeth, invest in water-efficient household products, …) and in industry (e.g. closed water circuit). By doing so, the economical efficiency of the operation of the Ultraviolet Water Purification Plant at the Hubelj water spring would increased.

Regarding flood risk reduction the main comment was that integrated options for reducing floods are missing. At the first workshop the preparation of a harmonised flood risk study was proposed, and would contain a number of measures to govern the long-term flood protection for the whole Vipava river basin, not just its parts. Due to limited resources (lack of detailed data) it was not possible to develop this proposal to such an extent that the social and economic analysis could be possible. Still, as mentioned in chapter 2.2.2, the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) is preparing flood risk management plan 2015-2021 (in preparation) [63] and programme of measures that will include also Vipava river basin where problems of floods were recognized also at the national level. The flood risk management plan is expected to be adopted in 2016. Within the draft flood risk management plan five areas with significant impact of floods have been identified in the Vipava river basin (see Chapter 2.1.2). In 2014, already three of five flood hazard maps and flood risk maps have been prepared for the Vipava river basin [87].

2.4 Adaptation actions

2.4.1 Adaptation actions

Table 4.2 below lists 20 water management options (WMOs) developed for the Vipava river basin and presents a selection of additional information associated with each option. While the options are grouped together in bundles in chapter 2.4 according to their synergistic interactions with one another and the common objective they contribute to, this table provides an overview of information that is specific to individual options in the columns. This information can be used by decision-makers when determining which single option(s) would be most appropriate to achieve their targeted objectives.

More specifically, table 4.2 associates each option with one or more of the challenges identified for the Vipava basin (see also Chapter 2.2.3) and a score from the multi-criteria analysis. This score is based on the characterization of the option, the result of an assessment of the option's impact when applied in the river basin, and stakeholder evaluations ('weights') of the importance of the various possibilities for option features and impacts. A higher score from the multi-criteria analysis (ranging from 0 to 100) represents a stronger overall performance in coparison with alternative options in view of the criteria important to local stakeholders (see Text box 3 for more information about the multi-criteria analysis).

Each option is further characterized by a set of additional implementation-oriented factors, such as its feasibility, acceptability, and policy synergies. These factors help to determine whether there will be barriers to the option's implementation or, conversely, if there may already be elements in place that facilitate its implementation. Costs represent an indicative estimate of the full cost of implementing the water management option and can be used to determine which options fall within a given allocated budget. The co-benefit gives the score of combined implementation of options amplifies the total impact-related benefits, as compared to the benefits which would arise from implementing each option individually. Finally, the priority associated with each option is a combination of how an option performs according to stakeholder preferences and implementation-oriented factors evaluated through expert opinion.

The information presented below also enables stakeholders to compare the various options and identify individual ones that fulfill desired expectations, such as selecting an option which addresses a specific challenge within certain cost limitations, while meeting an individual criterion such as having high "acceptability". Based on the value of each criteria:

- The majority of options (16) were identified to cope with the challenge of water availability during droughts in the growing season (challenge A), followed by 13 options coping with the appropriate water quality (challenge C). Half of the options (ten out of 20) were identified to cope with the challenge of reducing flood risks (challenge B); however several options are addressing more than one challenge.
- Option 1, 4, and 8 performed particularly well in the multi-criteria analysis and are therefore presented mostly with high priorities. Nevertheless, option 8 is involved with high costs and low feasibility and is therefore presented with medium priority.
- Option 11 and 23 performed relatively poor in the multi-criteria analysis and are therefore presented with low or medium priorities. Both options are involved with high costs and low co-benefit with other options.

A detailed description of all 20 options is provided in the Part 2 of the document.

Table 4.2: *Overview of the identified water management options for Vipava river basin*

#		Name of Water Management Option	**Challenges** (A-Water availability during droughts in growing season; B-Flood risk reduction; C-Appropriate water quality)	**MCA results** (0: least preferable; 100: most preferable)	**Feasibility** (0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	**Acceptability** (1<: low, 1: medium, >1: high)	**Policy synergies** (0: none, 1: medium, 2: high)	**Costs** (€: low (<200,000 eur), €€: medium (200,000-1,000,000 eur), €€€: high >1,000,000 eur))*	**Co-benefit** (>1: high, 1: medium, <1: none or conflicts)	**Phasing Priority level**
1		Establish an inter-municipal expert working group for the Vipava river basin	A, B, C	70	1	2	2	€	1.29	High
2		Awareness campaign focused on educating experts involved in surface water management for sustainable water management	A, B, C	63	1	2	2	€€	1.40	High
3		Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices	A, C	44	1	2	2	€€	1.30	High
4		Awareness campaign for local public on impact of their activities on the river	A, B, C	70	1	2	2	€	1.50	High
5		Improve the financing system for water infrastructure	A, B	63	1	1	2	€	1.67	High
6		Upgrade and update the existing network for monitoring the status of water environment	A, B, C	56	1	1.5	2	€€	0.77	High
7		Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage	A, C	63	1	1	2	€	1.11	High
8		Construction of water reservoirs on the watercourses in the upper part of the river basin	A, B	68	0	1	1	€€€	0.73	Medium

#		Name of Water Management Option	Challenges (A-Water availability during droughts in growing season; B-Flood risk reduction; C-Appropriate water quality)	MCA results (0: least preferable; 100: most preferable)	Feasibility (0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability (1<: low, 1: medium, >1: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 eur), €€: medium (200,000-1,000,000 eur), €€€: high >1,000,000 eur))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Phasing Priority level
9		Construction of dry reservoirs	B	56	1	1	1	€€€	1.60	High
10		Reconstruction of existing water reservoir Vogršček	A	55	1	1.5	2	€€€	1.22	High
11		Development of new irrigation systems	A	29	0	1	1	€€€	0.45	Low
12		Reconstruction of existing irrigation system	A	36	1	2	2	€€€	0.50	High
13		Restoration of Vipava river and its tributaries	A, B, C	46	1	1	2	€€€	0.82	High
14		Restoration of old meanders and oxbows of Vipava river and its tributaries	A, B, C	48	1	2	2	€€€	0.67	Medium
17		Reconstruction of stabilizing and transverse constructions from natural stone in the smaller tributaries of Vipava river	B	44	2	2	2	€	0.67	High
19		Improving the system of payment for water used for irrigation	A, C	48	1	1	1	€	1.17	High
20		Preservation of existing and introduction of new shelterbelts	A, C	39	1	2	2	€€€	1.14	High

#		Name of Water Management Option	Challenges (A-Water availability during droughts in growing season; B-Flood risk reduction; C-Appropriate water quality)	MCA results (0: least preferable; 100: most preferable)	Feasibility (0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability (1<: low, 1: medium, >1: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 eur), €€: medium (200,000-1,000,000 eur), €€€: high >1,000,000 eur))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Phasing Priority level
21		Removal of invasive non-native species	C	50	1	1.5	1	€	1.20	High
22		Construction of municipal wastewater treatment plants and sewage systems	C	41	1	2	2	€€€	1.33	High
23		The cultivation of crops that are resistant to climate changes (drought, pests and diseases)	A, C	27	2	0.5	2	€€€	0.13	Medium

*Remarks: €: low costs mean under EUR 200,000.00, €€: medium costs mean between EUR 200,000.00 and EUR 1,000,000.00, €€€: high costs mean above EUR 1,000,000.00.

2.4.2 Political context

All 20 options were cross-checked with five relevant sectoral programmes related to water management in Table 4.3. Some programmes are already adopted and some are still in preparation. Among the sectoral programmes, drafts of river basin management plans for the Danube and the Adriatic Sea Basins (2015 – 2021) [29] and a flood risk management plan [63] are still in preparation. It is expected that both key plans, prepared by the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) will be adopted by Vlada Republike Slovenije (The Government of the Republic of Slovenia) by the end of 2016. The Natura 2000 Management Programme [70] and Programme for the Management of Fish in Inland Waters of the Republic of Slovenia (Inland Fisheries Programme) [76] were adopted in 2015 for the periods until 2020 and 2021, respectively. A Draft Plan for Development of Irrigation until 2020 (Irrigation Plan) [79] is still considered among the sectors.

As expected, more than half of the options show synergies with the objectives of draft river basin management plan or even overlap with some of the proposed measures [29]. There are also two options (no. 8 and 11) in conflict with the objectives of draft river basin management plan. Reasons behind such conflicts are due to differing views of the stakeholders and opinions on how best to adapt to the impacts of global change. As mentioned already in chapter 2.1, existing conflicts among water related objectives (e.g. improving flood/erosion risk protection, optimizing water use, improving ecological status) have been recognized. These conflicts pose a challenge for development of an integrated and sustainable water management.

If options already show synergies with the objectives of cross-checked sectoral plans, support for the actual implementation exists. This support can be based on regulatory, financial, or information-based mechanisms and instruments. For options lacking such synergies, more effort and additional support from relevant actors would be needed.

Table 4.3: *Cross check of the identified water management options for Vipava River Basin with relevant sectoral programmes*

No.	Short name of water management options (WMO)	Draft river basin management plan	Draft flood risk management plan	The Natura 2000 Management Programme	Inland Fisheries Programme	Irrigation plan
WMO 1	Establish an inter-municipal expert working group	**1**	**0**	**0**	**0**	**1**
WMO 2	Awareness campaign for water management experts	**1**	**0**	**0**	**0**	**0**
WMO 3	Awareness campaign for farmers	**1**	**0**	**1**	**0**	**0**
WMO 4	Awareness campaign for local public	**1**	**0**	**1**	**0**	**0**
WMO 5	Improve the financing system for water infrastructure	**1**	**1**	**0**	**0**	**0**
WMO 6	Upgrade and update the monitoring network	**1**	**0**	**1**	**0**	**0**
WMO 7	Setting up monitoring for water abstractions	**1**	**0**	**0**	**0**	**0**
WMO 8	Construction of water reservoirs	**-1**	**1**	**1**	**0**	**1**
WMO 9	Construction of dry reservoirs	**0**	**1**	**0**	**0**	**0**
WMO 10	Reconstruction of water reservoir Vogrščck	**0**	**1**	**1**	**0**	**1**
WMO 11	New irrigation systems	**-1**	**0**	**0**	**0**	**1**
WMO 12	Reconstruction of existing irrigation system	**0**	**0**	**0**	**0**	**1**
WMO 13	Restoration of Vipava river and its tributaries	**1**	**1**	**1**	**1**	**0**
WMO 14	Restoration of Vipava river and its tributaries	**1**	**1**	**1**	**0**	**0**

No.	Short name of water management options (WMO)	Draft river basin management plan	Draft flood risk management plan	The Natura 2000 Management Programme	Inland Fisheries Programme	Irrigation plan
WMO 17	Reconstruction of stabilizing and transverse constructions	0	1	1	0	0
WMO 19	Improve the system of payment for water use	1	0	0	0	0
WMO 20	Preservation and introduction of shelterbelts	0	0	1	0	0
WMO 21	Removal of invasive non-native species	1	0	1	1	0
WMO 22	Construction of municipal wastewater treatment plants	0	0	0	0	0
WMO 23	Cultivation of climate change resistant crops	0	1	1	0	0

Legend:

1	synergy with sectoral plan
-1	conflict with sectoral plan
0	no synergy with sectoral plan

2.4.3 Presentation of bundle factsheets

The aim of the bundling of the individual options was to increase the effectiveness of implementing bundles of options compared to implementing individual options. Namely, the evidence from studies of adaptation to past and current climate variability indicates that adaptation measures are rarely adopted singly [88]. Instead, bundles of adaptation options are adopted together, in an attempt to address the multiple impacts of global change on the socio-ecological systems of the river basin. Although many of the options could be implemented individually to achieve the addressed objectives, some of the options are missing complementary options to give the desired results. This was also noticed by stakeholders within the participatory process. However, not all adaptation options are necessarily compatible with one another [88].

The identified adaptation options for the Vipava River Basin Adaptation Plan were bundled with one another based on: 1) options addressing water management relevant sectors (water management, agriculture, tourism and nature conservation) and 2) their co-benefits and conflicts. Experts assessed the impact of different combinations of adaptation options in relation to the implementation of individual options. Based on this co-benefits analysis, groups of adaptation options with high or low co-benefits were grouped together.

Implementation timeline of the bundled adaptation options was assessed, based on their effectiveness over time and local preferences. This assessment aimed to identify when each option would best be implemented within each bundle.

For individual water management options, information about synergies with other policies and suggestions on stakeholder involvement was specified in Part 2.

The seven bundles, developed within this process, address sectors that were recognized by experts and stakeholders as relevant for the uptake in the adaptation plan:

1. Organisation of Sustainable Water Management
2. Implementation of Sustainable Water Management
3. Flood Risk Reduction
4. Improving Conditions for Agriculture Taking Climate Change Impacts into Account
5. Adaptation of Agriculture to Climate Change Impacts
6. Development of Sustainable Tourism
7. Implementation of Nature Protection Management

Factsheets of the bundles of adaptation options are presented below and provide summarised information for each bundle, including:

- the focus of the bundle
- the proposed combination of adaptation options per bundle
- the “adaptation pathway”, representing the implementation of the options in short-term (2018), mid-term (2021), and long-term (2025), and
- the way forward, i.e., implementation avenues.

2.4.3.1 Organisation of sustainable water management

Focus of the bundle

Organisation of sustainable water management is the precondition for implementation phase of sustainable water management. This bundle aims to prepare currently missing integrated plans that are applicable for an individual river basin. Spatial planning and raising awareness among water management experts are crucial options for the preparation of those plans. Other options provide needed information about the scope and intensity for water management options that are directly addressing implementation phase of sustainable water management. The bundle addresses all three identified challenges: water availability, flood risk reduction, and appropriate water quality.

Proposed combination of options

Context

Water management options included in this bundle have in common that they all aim to establish the organization of sustainable water management at the river basin level. The water management options present all co-benefits, with the WMO 1 to 5 and WMO 6 and 7 scored with high co-benefit and others as low co-benefit.

The WMOs 1, 5, 6, and 7 are providing information for preparation of integrated plans at the river basin level. Hence spatial planning, improvement of expert knowledge, financing of options and monitoring of water status and water abstractions are covered.

Water Management Options

1	Establish an intermunicipal expert working group	The task of the inter-municipal working group is to direct spatial planning considering water management in the river basin. Representatives of each local authority with external help of requisite expert knowledge will be included in working group. The position would last through the financial cycle of river basin management plan.
2	Awareness campaign for water management experts	The objective of the awareness campaign for water management experts in the first place is to educate them on impacts of their work on hydromorphological pressures. The second objective is to educate them about more sustainable techniques in designing interventions on watercourses. The last objective is to collect existing good practices with suggestions for improvements and a complementing database of good practices.
5	Improve the financing system for water infrastructure	The objective is to determinate a contribution key and to set legal bases for the eligible use of funds for financing water infrastructure. The objective is also to improve system of financing water infrastructure in a way so as to help achieve the objectives of sustainable water management and of the river basin management plan.
6	Upgrade and update the monitoring network	The objective is to review all of existing monitoring stations and their status and in the second phase to upgrade the network system with new stations where needed.
7	Setting up monitoring for water abstractions	The objective is to verify existing water rights in Vipava river basin and to verify actual water consumption. This is precondition for monitoring illegal water abstractions.

'adaptation pathway'

With the creation of an inter-municipal expert working group (WMO 1), the much needed cooperation between municipalities and experts and the main objectives are first set. Together with WMO 2, an awareness campaign focused on educating experts, and WMO 5, the improvement of the financing system, they should be implemented first, in the first year (short term). Despite minor barriers due to limited financial capacities or the varying levels of acceptability according to stakeholders, they show many policy synergies. They form the basis for the organisation of an integrated and sustainable water management plan addressing the whole Vipava river basin.

For monitoring of actual water consumption at holders of water rights (WMO 7) minor barriers due to possible restriction of water use and medium acceptability by stakeholders exist. Still due to the lowest costs, this option (WMO 7) should be implemented next, especially during a period of low natural flows, and repeated every 5 years.

When the facts regarding water consumption are identified, the upgrade of the existing monitoring network (WMO 6) should be implemented in the mid-term due to limited financial capacities. With both options (WMO 7 and 6), more representative data can help to better understand the current situation in the Vipava River Basin as the basis for improvement of river basin management.

The upgrade and update of the existing monitoring network for assessing the status of the water environment (WMO 6)

should be implemented after WMO 5. WMO 5, the improvement of the financing system, will make the implementation of the rather costly option WMO 6 feasible, as it reduces the highest implementation barrier, the costs of WMO6. Therefore, the acceptability of WMO 6 for stakeholders will probably improve over time, once the funding sources are secured.

Way forward/implementation avenues

The bundle is showing an overall policy synergy with draft river basin management plan. There are also some synergies with the Natura 2000 management programme [70] and also the flood risk management plan [63]. The resolution on the national environmental action programme (2005–2012) [89], and others (e.g.: local self-government act [90]) allow for the establishment of groups of stakeholders (WMO 1) to help achieve the objectives of the regional development programme of Northern Primorska (Goriška development region) 2014-2020 [91] in planning a comprehensive spatial development of the region.

Many of the water management options included in the bundle could be funded through different financial mechanisms such as Horizon 2020, The INTERREG MED Programme 2014-2020, depending on the priorities and challenges they address.

The main identified actors that need to be involved in the implementation of this bundle can be divided into national and local actors. National actors that are most important for this bundle are the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) with its bodies, especially the Direkcija Republike Slovenije za vode (Slovenian Water Agency) and the Agencija Republike Slovenije za okolje (Slovenian Environmental Agency). At the local level active involvement of municipalities together with regional development agencies and users of water infrastructure must be assured.

During the third workshop (March, 2016) the municipalities, the Water Management Company with state concession to provide the water management public service, and the health sector through the Nacionalni laboratorij za zdravje, okolje in hrano (National Laboratory of Health, Environment and Food) and Nacionalni inštitut za javno zdravje (National institute of public health) indicated their willingness to take up the bundle or individual water management options with differing roles in the implementation process.

2.4.3.2 Implementation of sustainable water management

Focus of the bundle

In the past, the water management sector had the main objective to provide flood safety of people and their property. After the adoption of the Water Framework Directive in 2006 the component of ecological status was legally included in water management. The bundle addresses the physical part of sustainable water management. Each individual water management option included has beside the regulatory part, also the part which addresses the ecological status of water management. The bundle addresses all three identified challenges: water availability, flood risk reduction, and appropriate water quality.

Proposed combination of options

Context		
Water management options included in this bundle present concrete options where actual improvements of water management status can be made. The majority of options are complement with each other and have scored co-benefit, only a few scored no interlinkage and few scored low conflict. Pairs WMO 13 and 17 and WMO 14 and 17 have scored as low conflict due to possible prevention of sediment transport as a crucial element of natural hydromorphology		
Water Management Options		
13	Restoration of Vipava river and its tributaries	The objective is to establish the original state of the Vipava river and its tributaries with removal of transversal and longitudinal protection objects. It proposes 16 potential locations for the restoration of the Vipava river and seven locations of its tributaries in total length of 21,926 m.
14	Restoration of old meanders and oxbows	The objective is to establish the original state of old meanders and oxbows with restoration of the former connection of the main watercourse with its old meander and oxbow. It proposes restoration of old meanders on nine potential locations in total length of 2,721 m.
17	Reconstruction of stabilizing and transverse constructions	The objective is to locate existing transversal and stabilizing construction in the tributaries of Vipava river and set a priority for their reconstruction. Their function is to stabilize the water bed and prevent erosion. Reconstruction is conceived with the use of all known sustainable techniques.
20	Preservation and introduction of shelterbelts	The objective is to preserve existing and introduce new shelterbelts. Implementation of shelterbelts includes trees seedlings (four seedlings per meter of approx. 50 cm high), with their marking and protection with poles.
22	Construction of municipal wastewater treatment plants	Agglomerations under 2,000 population equivalent (PE) – overall 21,225.44 PE is without the existing public sewage system, 21.137,05 PE is without the existing WWTP. Agglomerations above 2,000 PE – overall 4,767.36 PE is without the existing public sewage system, 5,207.80 PE is without existing WWTP.

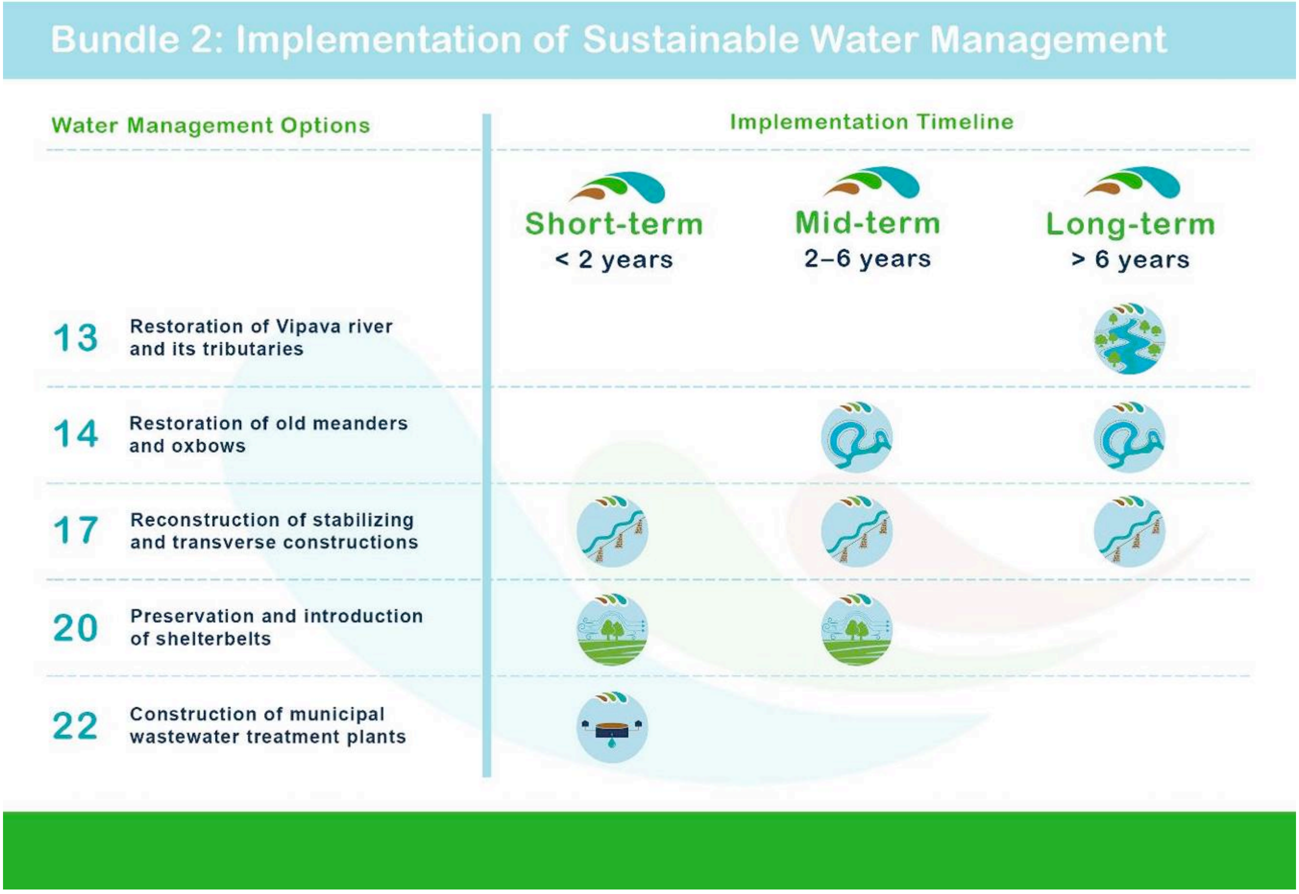
'adaptation pathway'

The reconstruction of stabilizing and transverse constructions in the Vipava's tributaries (WMO 17) and construction of missing sewage and municipal wastewater treatment plants across the river basin (WMO 22) should be implemented or be begun in the first year, respectively. Although there are barriers due to high costs, constructing sewage and municipal wastewater treatment plants across the river basin (WMO 22) shows high policy synergies. WMO 22 can reduce water pollution (organic, nutrients, pathogens) and result in better water quality. At the same time (in parallel), reconstruction of stabilizing and transverse constructions in the Vipava's tributaries (WMO 17) should be implemented. WMO 17, concentrated to specific areas in Vipava river basin, result in low costs, with no major barriers for implementation and showing many policy synergies. As maintenance works must be continuously conducted, the phasing is adapted accordingly.

With minor barriers due to low awareness of farmers, and also limited financial capacities, the option of preserving existing and introducing new shelterbelts (WMO 20) should be implemented next. As more time is needed for trees to function as shelter and wind breakers, the option should be implemented in first potential location (proposal of four potential locations is prepared, see description of WMO in Part 2) in the second year, followed by the third, fourth, and fifth year for the remaining three proposed locations.

Minor barriers due to high costs and varying acceptability of stakeholders also accompany next two proposed options,

restoration of old meanders and oxbows (WMO 14) and restoration of Vipava river and its tributaries (WMO 13). Although in low conflict with WMO 17, as sediment transport is prevented downstream, both options show low co-benefits with WMO 20, as shelterbelts can be also part of riparian vegetation. They would improve the ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization, and provision of habitat for biodiversity).



Way forward/implementation avenues

Options no. 13 and 14 showing synergies with the river basin management plan [29], flood risk management plan [63] and the Natura 2000 management programme [70]. Option no. 13 shows synergies with the programme for the management of fish in inland waters [76]. Option no. 20 shows synergies with the Natura 2000 management programme [70]. Construction of municipal wastewater treatment plants (WMO 22) follows the requirements of the operational program of discharge and municipal wastewater treatment [69].

Option no. 17 could be financed through the Vodni sklad (Water fund). Other options could be covered through other mechanisms such as INTERREG MED Programme 2014-2020, funding via the Common Agricultural Policy, European Regional Development Fund, and the Cohesion Fund.

The main actor identified for the implementation of this bundle is the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and its bodies the Direkcija Republike Slovenije za vode (Slovenian Water Agency) and the Agencija Republike Slovenije za okolje (Slovenian Environmental Agency). Beside options directly connected to the water sector there is option no. 20, where the Ministrstvo za kmetijstvo gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food) and the Zavod za gozdove Slovenije (Slovenia forest service) should actively cooperate and support its implementation. As in practice municipalities play a main role in implementation of option no. 22.

During the third workshop (March, 2016) the municipalities, the water management company, the Služba vlade RS za razvoj in evropsko kohezijsko politico (Government office for development and European cohesion policy), and the health sector representatives the Nacionalni laboratorij za zdravje, okolje in hrano (National Laboratory of Health, Environment and Food) and the Nacionalni inštitut za javno zdravje (National institute of public health) indicated their willingness to take up the bundle or individual water management options with differing roles in the implementation process.

2.4.3.3 Flood Risk Reduction

Focus of the bundle

With settlement expansion (urbanization) and the need for increasing farmland in the past took Vipava river and its tributaries the needed space that was used as natural inundation area. In the lower parts of Vipava river basin there are flood areas practically all through the valley. The bundle includes water management options addressing flood protection and so coinciding with a challenge of flood risk reduction. This bundle works in a curative way of past interventions and in preventive way to avoid new mistakes.

Proposed combination of options

Context

Water management options included in this bundle have the objective of reducing flood risks and the majority of them are complementary with each other and have a scored co-benefit.

Due to the high number of WMOs included it is undersandable that not all included WMOs have a scored co-benefit. Low conflicts are shown for pairs WMO 8 and 13, WMO 8 and 14, WMO 13 and 17, and WMO 14 and 17. The reason for this is that WMOs 8 and 17 can have a negative effect on the ecological state of water. This is in contradiction to the objectives of WMOs 13 and 14 of restoring natural hydromorphology.

Ten pairs out of 45 combinations of water management options have scored no interlinkage as no co-benefit or conflict was assessed between them.

Water Management Options

1	Establish an intermunicipal expert working group	The task of the inter-municipal working group is to direct spatial planning, considering water management in the river basin. Representatives of each local authority with external help of requisite expert knowledge will be included in working group. The position would last through the financial cycle of river basin management plan.
2	Awareness campaign for water management experts	The objective of the awareness campaign for water management experts in the first place is to educate them on the impacts of their work on hydromorphological pressures. The second objective is to educate them about more sustainable techniques in designing interventions on watercourses. The last objective is to collect existing good practices with suggestions for improvements and a complementing database of good practices.
5	Improve the financing system for water infrastructure	The objective is to determinate the contribution key and to set legal bases for the eligible use of funds for financing water infrastructure. The objective is also to improve the system of financing water infrastructure in a way so as to help achieve the objectives of sustainable water management and of the river basin management plan.
6	Upgrade and update the monitoring network	The objective is to review all of existing monitoring stations and their status and in the second phase to upgrade the network system with new stations where needed.
8	Construction of water reservoirs	The objective is to construct water reservoirs that are already part of the “Development Plan for Irrigation till 2020”. There are planned four new water reservoirs in the Vipava river basin: • Košivec – in municipality Ajdovščina, volume 1.176 million m^3 • Vrnivec – in municipality Ajdovščina, volume 1 million m^3 • Svinjšček – in municipality Ajdovščina, volume 1 million m^3 • Pasji rep – in municipality Vipava, volume 2.5 million m^3
9	Construction of dry reservoirs	The objective is to identify areas that require increased protection against floods and identify potential locations for building dry reservoirs.
10	Reconstruction of water reservoir Vogršček	The objective is to reconstruct the Vogršček water reservoir. The “Reconstruction of the Vogršček Barrier” is already planned and now documentation is being prepared.

13	Restoration of Vipava river and its tributaries	The objective is to establish original state of the Vipava river and its tributaries with removal of transversal and longitudinal protection objects. It proposes 16 potential locations for restoration of Vipava river and seven locations of its tributaries in total length of 21,926 m.
14	Restoration of old meanders and oxbows	The objective is to establish the original state of old meanders and oxbows with the restoration of the former connection of the main watercourse with its old meander and oxbow. It proposes restoration of old meanders in nine potential locations in a total length of 2,721 m.
17	Reconstruction of stabilizing and transverse constructions	The objective is to locate existing transversal and stabilizing construction in the tributaries of Vipava river and set the priority for the reconstruction. Their function is to stabilize water bed and prevent eroison. Reconstruction is conceived with the use of all known sustainable techniques.

‘adaptation pathway’

With the creation of an inter-municipal expert working group (WMO 1), the much needed cooperation between municipalities and experts is set first. Together with options no. 5, the improvement of the financing system, and 2, the *awareness campaign focused on educating experts, they should be implemented first, in the first year (short term). Despite minor barriers due to varying levels of acceptability among stakeholders, they show many policy synergies. WMO 5, improving the financing system, will make the implementation of the rather costly options (WMO 6, 8, 9, 10, 13, and 14) more feasible.*

Despite minor barriers due to high costs, reconstruction of the existing Vogrščček water reservoir (WMO 10) as such is already envisaged by the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and is consequently in the short term (in first two years’ time).

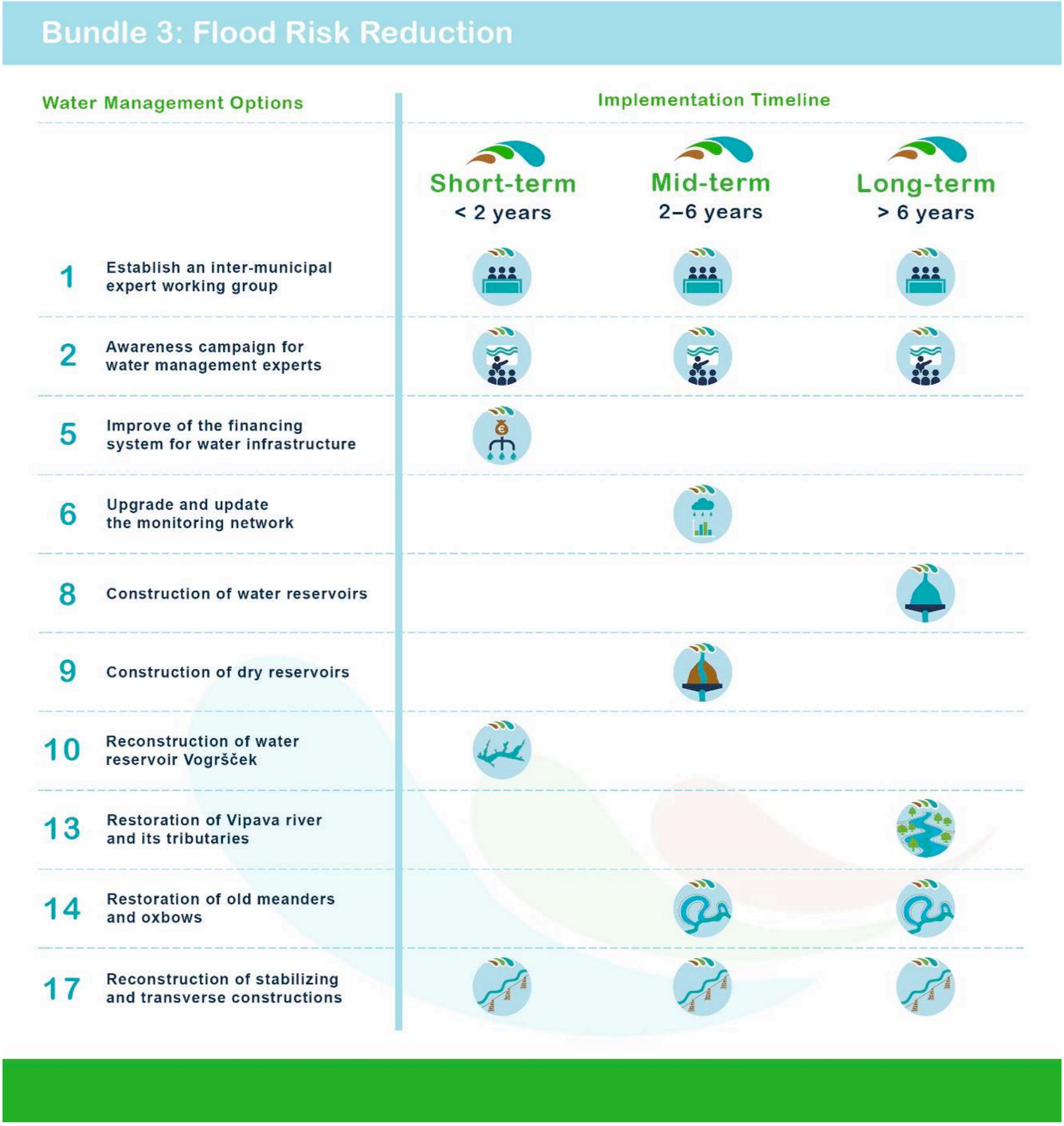
WMO 10 is followed by the reconstruction of stabilizing and transverse constructions in the Vipava's tributaries (WMO 17), which must be continuously maintained. WMO 17, concentrated on specific areas in the Vipava river basin, results in low costs, no major barriers for implementation, and the potential for many policy synergies. This option shows also high co-benefits with WMO 2 (considering more sustainable techniques).

The upgrade and update of the existing monitoring network for assessing the status of the water environment (WMO 6) should be implemented after WMO 5, but not necessarily after WMO 10 and 17. Namely, WMO 5, as written above, will make the implementation of the rather costly option WMO 6 feasible, as it reduces the highest implementation barrier, the costs of WMO 6. Therefore, the acceptability of stakeholders for WMO 6 could probably improve over time, once the funding sources are secured.

The option WMO 14 (restoration of old meanders and oxbows) should be implemented before WMO 13 (restoration of the Vipava river and its tributaries) due to higher acceptability among stakeholders. Both of the options would be implemented gradually, starting with WMO 14 in the third year and continuing with the implementation, when, later, WMO 13 would be put into motion. Both options show high co-benefits, improving the status of water and riparian ecosystems in larger scale.

Dry reservoirs (WMO 9), if backed up with the analysis, could be implemented in a later stage. If the rates of changes (flood events) increase and the Flood risk management plan recognizes the need for the implementation of such reservoirs, then option 9 could be brought forward. If the rates of changes are slower, then the implementation can be delayed or even abandoned. This option shows low co-benefits with WMO 1 and high co-benefits with WMO 2, as with proper planning and the use of more sustainable techniques considering water management in the project design possible negative impacts on the environment and society can be minimized.

Multifunctional water reservoirs (WMO 8) can only in a small part help reduce floods downstream and are so placed at the very end of the option list. Although many synergies with policy objectives do exist, major barriers due to high implementation costs and varying acceptability of stakeholders have been identified. This option, like WMO 9, shows co-benefits with WMO 1 and 2 for the same reasons, but shows conflicts with WMO 13 and 14 as water reservoirs on watercourses will affect structural water quality.



Way forward/implementation avenues

Options show synergies with the river basin management plan, except water management options 9, 10, and 17, where there is no connection with sectoral plans. WMO 8 is in conflict with the river basin management plan [29] due to the measure of restricting the granting of water rights that poses a precondition for the construction of water reservoirs. The flood risk management plan [63] has synergies with most water management options, but with WMO 1, 2, 6 no connection has been detected. Except for WMOs 1, 2, and 5, where no connection detected, other options are in synergy with the Natura 2000 Management Plan [70]. WMO 13 is in synergy with the programme for the management of fish in inland waters [76]. WMOs 1, 8, and 10 are in synergy with the national irrigation strategy in preparation [79]. The spatial plan of municipality ajdovščina and its amendments [92], together with draft spatial plan of the municipality of Ajdovščina (June 2014), plans for two water reservoirs, Koševec and Vrnivec (WMO 8). WMO 8 is also supported by the development programme of Northern Primorska (Gorizia development regions) 2014-2020 [91] within the measure A2P1, which plans a selection of the optimal project solutions of flood safety measures, which will allow multipurpose use and integration of financial resources across sectors and, consequently, best solutions from a technical, environmental, and economic point of view.

Funding of water infrastructure could be provided by the Water fund. Other water management options could be financed through other mechanisms, such as development programme of Northern Primorska [91], Horizon 2020, INTERREG MED Programme 2014-2020, CAP/European Agricultural Fund for Rural Development (EAFRD), European Regional

Development Fund (ERDF) and Cohesion Fund.

Identified main actor for the implementation of this bundle is the Ministrstvo za okolje in prostor and its bodies, mainly the Direkcija Republike Slovenije za vode and the Agencija Republike Slovenije za. The Inštitut za vode Republike Slovenije and the Zavod Republike Slovenije za varstvo narave could be involved in the options of restoration (WMO 13, WMO 14) and reconstruction of objects on watercourses (WMO 17). Reconstructing and building new water reservoirs is an area where the Ministrstvo za kmetijstvo, gozdarstvo in prehrano and the Ministrstvo za should actively cooperate and support implementation. An important actor for the implementation of WMO 5 is the ministry responsible for finances. At the local level municipalities and regional development agencies could contribute to the success of this bundle.

During the third workshop (March, 2016) the municipalities, the water management company, the Služba vlade za razvoj in evropsko kohezijsko politiko, and health sector representatives the Nacionalni laboratorij za zdravje, okolje in hrano, and the Nacionalni inštitut za javno zdravje indicated their willingness to take up the bundle or individual water management options with differing roles in the implementation process.

2.4.3.4 Improving conditions for agriculture taking climate change impacts into account

Focus of the bundle

Agricultural land makes up 33% of the total Vipava river basin area. The impact of climate changes on the agriculture sector is important and must be taken into consideration. They are reflected in agricultural droughts and in pressures on water use in the growing season (especially in summer months). The bundle includes water management options addressing improvements in agriculture to the existing and forthcoming conditions, considering global change. Options included have the objective to optimise agricultural practices. This bundle addresses two identified challenges: water availability and appropriate water quality.

Proposed combination of options

Context

Water management options included in this bundle have the objective of improving conditions for agriculture that lack water for irrigation. Objectives of proposed water management options included in the bundle primarily address the challenge of water availability. The majority of options complement each other and have scored co-benefits.

Water management options

1	Establish an intermunicipal expert working group	The task of the inter-municipal working group is to direct spatial planning considering water management in the river basin. Representatives of each local authority with external help of requisite expert knowledge will be included in the working group. The position would last through the financial cycle of river basin management plan.
3	Awareness campaign for farmers	The objective is to analyse existing agricultural practices together with suggestions for improvement. It is also to prepare guidelines for proper agricultural practices considering changing climate conditions.
7	Setting up monitoring for water abstractions	The objective is to verify existing water rights in Vipava river basin and actual water consumption. This is precondition for monitoring illegal water abstractions.
8	Construction of water reservoirs	The objective is to construct water reservoirs that are already part of the "Development Plan for Irrigation till 2020". There are planned four new water reservoirs in the Vipava river basin: • Koŝivec – in municipality Ajdovščina, volume 1.176 million m^3 • Vrnivec – in municipality Ajdovščina, volume 1 million m^3 • Svinjšček – in municipality Ajdovščina, volume 1 million m^3 • Pasji rep – in municipality Vipava, volume 2.5 million m^3
10	Reconstruction of water reservoir Vogrščček	The objective is to reconstruct the Vogrščček water reservoir. The "Reconstruction of the Vogrščček Barrier" is already planned and documentation is in preparation.
11	New irrigation systems	The objective is to develop new irrigation systems that are part of "Action plan for development of irrigation in Republic of Slovenia until 2020". There are 3,979.00 ha of new irrigation systems planned in the Vipava valley together with WMO 8 mentioned water reservoirs.
12	Reconstruction of existing irrigation system	The objective is to verify status of 1546 ha of existing irrigation systems in the Vipava valley and to recognize needs and scope of reconstruction works which will take place in the second phase of the option.
19	Improve the system of payment for water use	The objective is to improve the system of payment in a way to collect more money for water used for irrigation. A possible solution proposed by the option is to lower the limit of yearly consumption (from 5,000 m^3 to 2,500 m^3), when farmers do not need to pay for actual water use.

'adaptation pathway'

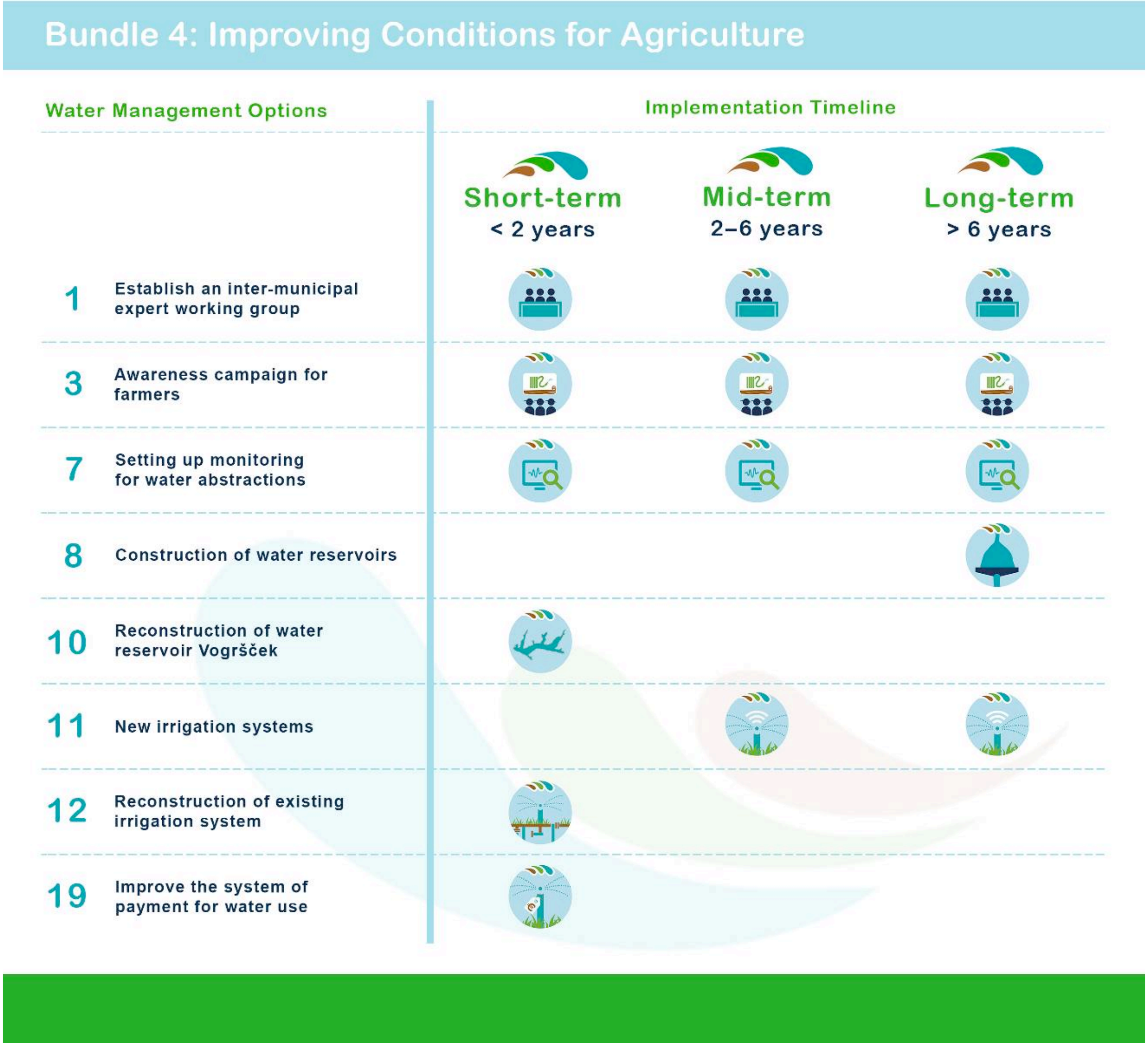
With the establishment of an inter-municipal expert working group (WMO 1), the much needed cooperation between municipalities and experts and the main objectives for agriculture is first set. Together with the options of setting up monitoring on actual water use (WMO 7) and raising awareness (WMO 3), they should be implemented first, in the first year (short term). Despite minor barriers due to limited financial capacities or varying acceptability according to stakeholders, they show many policy synergies. They form the basis for the preparation of more concrete options that would improve the conditions for agriculture production.

Despite minor barriers due to varying acceptability among stakeholders and low policy synergies (lacking strong political support/back-up), improvements to the system of payment for water used for irrigation (WMO 19) should also be implemented in the first two years' time. This option could make financing the operation of irrigation systems (WMO 12 and 11) more feasible.

Despite minor barriers due to high costs, the reconstruction of the existing Vogrščček water reservoir (WMO 10) as such is already envisaged by the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and is consequently placed in the short term (first two years' time).

WMO 10 is logically followed by reconstruction of existing irrigation systems derived from Vogrščček (WMO 12) that despite limited financial capacities shows strong support from stakeholders and many policy synergies. New irrigation systems (WMO 11) derived from the Vogrščček water reservoir would follow in the mid-term if there is shown a clear need by stakeholders (farmers). Due to the identified low feasibility and low preference regarding the results of multi-criteria analysis, the priority level for this option is low.

Although synergies with policy objectives do exist, major barriers due to high implementation costs and varying acceptability of stakeholders have been identified for implementing new water reservoirs (WMO 8) and are as such placed at the very end of the option list. It is more reasonable to verify the functionality and optimal utilization of existing irrigation infrastructure (WMO 10, WMO 12) before investing in new water reservoirs and irrigation systems derived from new reservoirs (WMO 11).



Way forward/implementation avenues

Water management options show synergies with the river basin management plan, except for WMOs 10 and 12, which do not show any connections. WMOs 8 and 11 show a negative connection with the river basin management plan [29] due to the measure of restricting the granting of water rights, as is a precondition for the construction of water reservoirs and building new irrigation systems. WMOs 8 and 10 are in synergy with the flood risk management plan [63]. The Natura 2000 management programme [70] is in synergy with WMOs 3, 8, and 10. WMOs 1, 8, 10, 11, and 12 are in synergy with the national irrigation strategy in preparation [79]. WMO 1 is in synergy with the resolution on the national environmental action programme (2005–2012) [89], and others (e.g.: the local self-government act [90]) that allow the establishment of such associations. Option could help achieve objectives of programme 5.1 "A comprehensive spatial development of the region" of regional development programme of Northern Primorska (Goriška development region) 2014-2020 [91]. WMO 3 is supported also by the national adaptation strategy for forestry and agriculture (2008) [94] and its implementation document action plan from 2011 [95] - Pillar II: education, awareness, and counselling. Measures that are already in place and are planned in the future: 7. Raising awareness of farmers of the impact of climate change on agriculture. The spatial plan of municipality Ajdovščina and its amendments [92], together with the draft spatial plan of the Municipality of Ajdovščina (June 2014) plans two water reservoirs, Koševec and Vrnivec (WMO 8). This option is also supported by the regional development programme of Northern Primorska (Goriška development region) 2014-2020 [91] within a measure that plans a selection of the optimal project solutions of flood safety measures, which will allow for multipurpose use and the integration of financial resources across sectors and, consequently, best solutions from a technical, environmental, and economic point of view.

Funding for water infrastructure could be provided by the Vodni sklad (Water fund). Other water management options can be financed through other mechanisms, such as the Rural Development Plan 2014-2020, the Development Programme of Northern Primorska [91], Horizon 2020, the Common Agricultural Policy, and the European Regional Development Fund.

The main actor identified for the implementation of the bundle is the Ministrstvo za kmetijstvo gozdarstvo in prehrano

(Ministry of Agriculture, Forestry and Food) with its Svetovalna služba (Advisory Service) and the Kmetijsko gozdarska zbornica Slovenije (Chamber of Agriculture and Forestry of Slovenia). On the part of water rights, the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) with its Direkcija Republike Slovenije za vode (Slovenian Water Agency) and the Agencija Republike Slovenije za okolje (Slovenian Environmental Agency) should take over the main role. The Inštitut za vode Republike Slovenije (Institute for Water of the Republic of Slovenia) could be included. With water management options, where big interventions are planned, the Zavod za varstvo narave RS (Institute of the republic of Slovenia for Nature Conservation) plays the main role. At the local level municipalities and regional development agencies could serve as the main actors for this bundle.

During the third workshop (March, 2016) local farmers and the Biotehniška šola (Biotechnical School) indicated their willingness to take up the individual water management options (irrigation and the awareness campaign respectively) with differing roles in the implementation process.

2.4.3.5 Adaptation of agriculture to climate change impacts

Focus of the bundle

Agricultural land comprises 33% of the total Vipava river basin area. Impacts of climate changes on the agriculture sector are important and need to be taken into consideration. They are reflected in agricultural droughts and in pressures on water use in the growing season (especially in summer months). The bundle includes water management options addressing the adaptation of agriculture and its practices to the existing and forthcoming conditions in terms of global climate change. This bundle addresses two identified challenges: water availability and appropriate water quality.

Proposed combination of options

Context

Water management options included in this bundle have the objective of adapting agriculture to the impacts of global change. The options aim to lower water consumption. All options show co-benefits when implemented together.

Water Management Options

1	Establish an intermunicipal expert working group	The task of the inter-municipal working group is to direct spatial planning considering water management in the river basin. Representatives of each local authority with the external help of requisite expert knowledge will be included in the working group. The position would last through the financial cycle of the river basin management plan.
3	Awareness campaign for farmers	The objective is to analyse existing agricultural practices together with suggestions for improvement. The objective is also to prepare guidelines for proper agricultural practices considering changing climate conditions.
20	Preservation and introduction of shelterbelts	The objective is to preserve the existing and introduce new shelterbelts. Implementation of shelterbelts includes tree seedlings (4 seedlings per meter of approx. 50 cm high), with their marking and protection with poles.
23	Cultivation of climate change resistant crops	The objective is selection of new varieties and alternative crops that are more adapted to the climatic conditions influenced by global changes. It includes a review and analysis of suitable crops and also a market analysis if there exists a market for those crops.

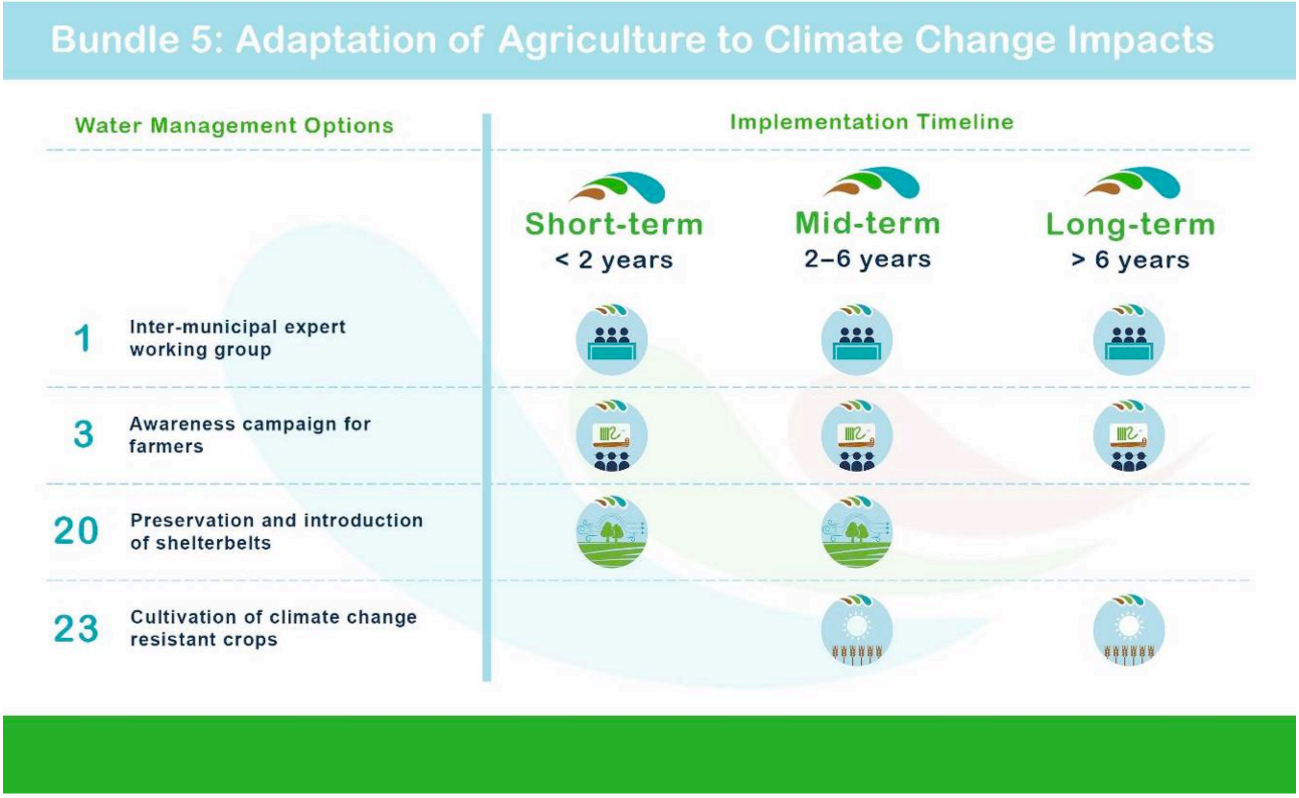
'adaptation pathway'

With the creation of an inter-municipal expert working group (WMO 1), the much needed cooperation between municipalities and experts with the main objectives for the awareness campaign is first set.

Although there are minor barriers identified due to ensuring the active involvement of all local farmers (need for financial initiatives), raising awareness among farmers (WMO 3) shows many policy synergies and is expected to be established in the beginning and continued for several years to come.

The preservation of the existing and introduction of new shelterbelts (WMO 20) should be implemented after WMO 3. WMO 3 will make farmers more aware of the positive effects of shelterbelts.

The cultivation of crops that are resistant to climate change (WMO 23) is involved with high costs and has varying acceptability amongst stakeholders. Therefore, the implementation of this option should start mid-term with the precondition that such crops are available for cultivation.



Way forward/implementation avenues

Water management options except WMO 20 present synergies with river basin management plan. WMO 23 is in synergy with the flood risk management plan. WMOs except WMO 1 are in synergy with the Natura 2000 management programme [70]. WMO 1 is in synergy with the resolution on the national environmental action programme (2005–2012) [89], and others (e.g.: local self-government act [90]) that allow for the establishment of such associations. Options could help achieve the objectives of programme 5.1 “A comprehensive spatial development of the region” of the regional development programme of Northern Primorska (Goriška development region) 2014-2020 [91]. WMO 3 is also supported by national adaptation strategy for forestry and agriculture (2008) [94] and its implementation document action plan from 2011 [95] - Pillar II: Education, awareness, and counselling. Measures that are already in place and are planned in future: 7. Raising the awareness of farmers of the impact of climate change on agriculture.

Funding could be provided by the development programme of Northern Primorska [91], Horizon 2020, INTERREG MED Programme 2014-2020 and the Common Agricultural Policy.

The main actor identified for the implementation of this bundle is the Ministrstvo za kmetijstvo gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food) and its Svetovalna služba (Advisory Service) and the Kmetijsko gozdarska zbornica Slovenije (Chamber of Agriculture and Forestry of Slovenia) and the Zavod za gozdove Slovenije (Slovenia Forest service). The Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and its bodies can be partners especially in implementing WMO 20 (determination of the operator of shelterbelts). At the local level municipalities and the Regional Development Agency could be the main actors for this bundle.

During the third workshop (March, 2016) local farmers and the Biotehniška šola (Biotechnical School) indicated their willingness to take up the individual water management options with differing roles in the implementation process. The local farmers would be involved in the cultivation of crops, the implementation of shelterbelts, and the awareness campaign. The Biotehniška šola (Biotechnical School) declared an interest in being a part of the awareness campaign.

2.4.3.6 Development of sustainable tourism

Focus of the bundle

With its rich natural and cultural heritage, the Vipava valley, especially in the upper part, has a great potential for the development of ecotourism. There is a substantial desire from stakeholders for the further development of such tourism. Sustainable water management is the basis for improving water quality and indirectly enriching habitats and biodiversity. Water management options in the bundle beside the primary objectives of addressing the identified challenges also address the objective of sustainable tourism development.

Proposed combination of options

Context

The water management options included do not directly address tourism development but they provide the basis for sustainable tourism, which will support more sustainable water quality and quantity management in touristic areas.

The majority of WMOs are complement with each other and have scored co-benefits. 21 combinations out of 45 have scored no interlinkage as no co-benefit or conflict was assessed between them.

Low conflicts are shown for pairs WMO 8-13 and WMO 8-14, the reason being that WMO 8 can have a negative effect on the ecological state of water. This is in contradiction to the objectives of WMOs 13 and 14 of restoring natural hydromorphology.

Water Management Options

1	Establish an intermunicipal expert working group	The task of the inter-municipal working group is to direct spatial planning considering water management in the river basin. Representatives of each local authority with the external help of requisite expert knowledge will be included in the working group. The position would last through the financial cycle of the river basin management plan.
2	Awareness campaign for water management experts	The objective of the awareness campaign for water management experts in the first place is to educate them on impacts of their work on hydromorphological pressures. The second objective is to educate them about more sustainable techniques in designing interventions on watercourses. The last objective is to collect existing good practices with suggestions for improvements and a complementing database of good practices.
4	Awareness campaign for local public	The objective is to inform the local public about the kind of impact on water management their actions have. The objective is also to prepare educational material for schools with the objective of presenting water-related challenges in Slovenia, focusing on Vipava river basin.
6	Upgrade and update the monitoring network	The objective is to review all of existing monitoring stations and their status and in the second phase to upgrade the network system with new stations where needed.
8	Construction of water reservoirs	The objective is to construct water reservoirs that are already part of the “Development Plan for Irrigation till 2020”. There are planned four new water reservoirs in Vipava river basin: • Koševec – in municipality Ajdovščina, volume 1.176 million m^3 • Vrnivec – in municipality Ajdovščina, volume 1 million m^3 • Svinjšček – in municipality Ajdovščina, volume 1 million m^3 • Pasji rep – in municipality Vipava, volume 2.5 million m^3
10	Reconstruction of water reservoir Vogršček	The objective is to reconstruct Vogršček water reservoir. The “Reconstruction of the Vogršček barrier” is already planned and now documentation is in preparation.
13	Restoration of Vipava river and its tributaries	The objective is to establish original state of the Vipava river and its tributaries with removal of transversal and longitudinal protection objects. It proposes 16 potential locations for the restoration of the Vipava river and seven locations of its tributaries in total length of 21,926 m.

14	Restoration of old meanders and oxbows	The objective is to establish original state of old meanders and oxbows with restoration of former connection of main watercourse with old meander and oxbow. It proposes restoration of old meanders on nine potential locations in total length of 2,721 m.
20	Preservation and introduction of shelterbelts	The objective is to preserve existing and introduce new shelterbelts. Implementation of shelterbelts includes seedling of trees (four seedlings per meter of approx. 50 cm high), with their marking and protection with poles.
22	Construction of municipal wastewater treatment plants	Agglomerations under 2,000 population equivalent (PE) – overall 21,225.44 PE is without existing public sewage system, 21.137,05 PE is without existing WWTP. Agglomerations above 2,000 PE – overall 4,767.36 PE is without existing public sewage system, 5,207.80 PE is without existing WWTP.

'adaptation pathway'

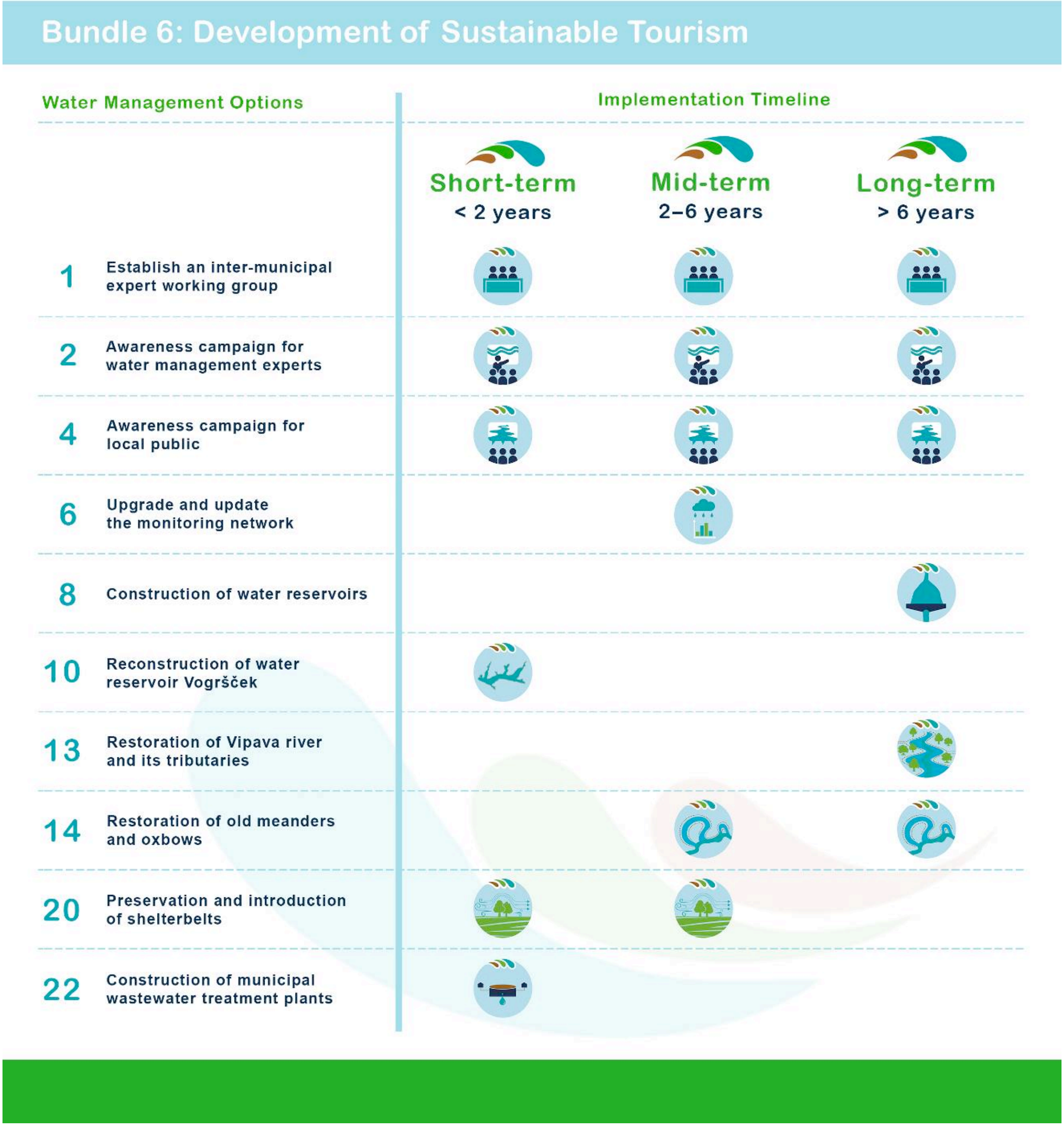
With the establishment of an inter-municipal expert working group (WMO 1), the much needed cooperation between municipalities and experts and the main objectives for developing tourism is first set. Together with WMO 2 and 4, they should be implemented first, in the first year (short term). Despite minor barriers due to limited financial capacities, they show many policy synergies. Activities planned in WMO 4 include the main elements of the educational tourism to be developed and should start being implemented in the first year. This also goes for WMO 2, the *awareness campaign focused on educating experts. By using more sustainable techniques in water management WMO 2 can achieve an attractive appearance and conditions of the aquatic and riparian ecosystems that can be integrated in the range of tourism services offered.*

Although minor barriers exist due to high costs, reconstruction of the existing Vogršček water reservoir (WMO 10) as such is already envisaged by the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and is consequently placed in the short term (first two years' time). Together with upgrading and updating the existing measurement network (WMO 6) they can serve as a tourist service linked to water environment.

Despite barriers due to high costs, constructing sewage and municipal wastewater treatment plants across the river basin (WMO 22) shows high policy synergies. WMO 22 can reduce burdening waters with pollutants (organic, nutrients, pathogens) and results in better water quality, especially in good quality for bathing waters. As such, WMO 22 should be implemented in parallel with WMO 10 and WMO 6.

Minor barriers due to high costs also accompany the next three proposed options, the restoration of old meanders and oxbows (WMO 14) and the preservation of the existing and introduction of new shelterbelts (WMO 20) could enrich the cultural landscape that plays an important role for the development of tourism. With that said, also the restoration of the Vipava river and its tributaries (WMO 13) could be implemented in the later stage. Both options show high co-benefits. If both applied, they improving the status of ecosystems in larger scale and give the variety of scenery that is a major attraction to visitors.

An additional option proposed by stakeholders (third workshop), namely multifunctional water reservoirs (WMO 8), can if planned from the beginning also function as a local tourist attraction. Although many synergies with policy objectives do exist, major barriers due to high implementation costs and varying acceptability of stakeholders have been identified and this option is consequently placed at the very end of the option list. This option shows high co-benefits with WMO 1 and 2, but shows conflicts with WMO 13 and 14, as water reservoirs on watercourses can affect structural water quality.



Way forward/implementation avenues

Water management options are show synergies with the draft river basin management plan, except options no. 10, 20, and 22. WMO 8 is in conflict with the river basin management plan due to the measure of restricting the granting of water rights, which is a precondition for the construction of water reservoirs. WMOs 8, 10, 13, and 14 are in synergy with the flood risk management plan. Except for WMOs no. 1, 2, and 22, other WMOs show synergy with the Natura 2000 management programme [70]. WMO 13 is in synergy with the programme for the management of fish in inland waters [76]. WMOs 1, 8, and 10 are in synergy with the national irrigation strategy in preparation [79]). WMO 1 is in synergy with the resolution on the national environmental action programme (2005–2012) [89] and others (e.g.: local self-government act [90]) that allow for the establishment of such associations. Option could help achieve objectives of the regional development programme of Northern Primorska (Goriška development region) 2014-2020 [91]. WMO 22 is in line with the operational programme for the discharge and treatment of urban waste water [69], which determines priority areas for the construction of sewerage systems and municipal wastewater treatment plants.

Funding of WMOs could be provided by the development programme of Northern Primorska [91], Horizon 2020, INTERREG MED Programme 2014-2020, the Common Agricultural Policy, the European Regional Development Fund, and the Cohesion Fund.

The main actor for the implementation of this bundle is the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) with its bodies the Direkcija Republike Slovenije za vode (Slovenian Water Agency) and the

Agencija Republike Slovenije za okolje (Slovenian Environmental Agency). The Inštitut za vode Republike Slovenije (Institute for Water of the Republic of Slovenia) and the Zavod za varstvo narave Republike Slovenije (Institute of the Republic of Slovenia for Nature Conservation) should be involved in WMO 13 and 14. Reconstructing and building new water reservoirs is an area where the Ministrstvo za kmetijstvo gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food) and the Ministrstvo za obrambo (Ministry of Defence) should actively cooperate and support the implementation. Important local actors are municipalities, Regional Development Agencies, and the Tourist Office.

During the third workshop (March, 2016) the municipalities, Regional Development Agencies, and the local Tourist Office indicated their willingness to take up the bundle or individual water management options with differing roles in the implementation process.

2.4.3.7 Implementation of nature protection management

Focus of the bundle

Water management in Slovenia is highly connected with nature protection management due to the fact that a lot of species and habitats are dependent on water. In the Natura 2000 management programme for 2015-2020 [70] there are a lot of species and habitats that have not achieved favourable conservation status and some extra options would be needed in order to restore the favourable conservation status of species and habitats. Options included in this bundle present the actual implementation of restoration options or options supporting the restoration of natural hydromorphology, which is an important element of nature conservation. This bundle addresses two identified challenges: water availability and appropriate water quality.

Proposed combination of options

Context

Water management options included indirectly address the objectives of nature protection by supporting the restoration of natural hydromorphology in the river basin, which is an essential part of nature protection.

The majority of WMOs are complement with each other and have scored co-benefits. 13 combinations out of 28 have scored no interlinkage as no co-benefit or conflict was assessed between them.

Low conflicts are shown for pairs WMO 13-17 and WMO 14-17 due to the effect on interrupted sediment transport. This is in contradiction to the objectives of WMOs 13 and 14 of restoring the natural hydromorphology.

Water Management Options

2	Awareness campaign for water management experts	The objective of the awareness campaign for water management experts in the first place is to educate them on impacts of their work on hydromorphological pressures. The second objective is to educate them about more sustainable techniques in designing interventions on watercourses. The last objective is to collect existing good practices with suggestions for improvements and a complementing database of good practices.
4	Awareness campaign for local public	The objective is to inform the local public as to the kind of impact on water management their actions have. The objective is also to prepare educational material for schools with the objective of presenting water-related challenges in Slovenia, focusing on the Vipava river basin.
13	Restoration of Vipava river and its tributaries	The objective is to establish the original state of the Vipava river and its tributaries with removal of transversal and longitudinal protection objects. It proposes 16 potential locations for the restoration of the Vipava river and seven locations of its tributaries in total length of 21,926 m.
14	Restoration of old meanders and oxbows	The objective is to establish original state of old meanders and oxbows with restoration of the former connection of the main watercourse with its old meander and oxbow. It proposes restoration of old meanders on nine potential locations in total length of 2,721 m.
17	Reconstruction of stabilizing and transverse constructions	The objective is to locate existing transversal and stabilizing construction in the tributaries of the Vipava river and set the priority for their reconstruction. Their function is to stabilize water bed and prevent erosion. Reconstruction is conceived with the use of all known sustainable techniques.
20	Preservation and introduction of shelterbelts	The objective is to preserve existing and introduce new shelterbelts. Implementation of shelterbelts includes seedling of trees (four seedlings per meter of approx. 50 cm high), with their marking and protection with poles.
21	Removal of invasive non-native species	The objective is to collect data on invasive non-native species in the Vipava river basin. It is also to determine the method of removal and disposal for each species and prepare a work programme for invasive non-native species.
23	Cultivation of climate change	The objective is the selection of new varieties and alternative crops that are more adapted to the climatic conditions influenced by global changes. It includes review

	resistant crops	and analysis of suitable crops and also a market analysis if there exists a market for those crops.

'adaptation pathway'

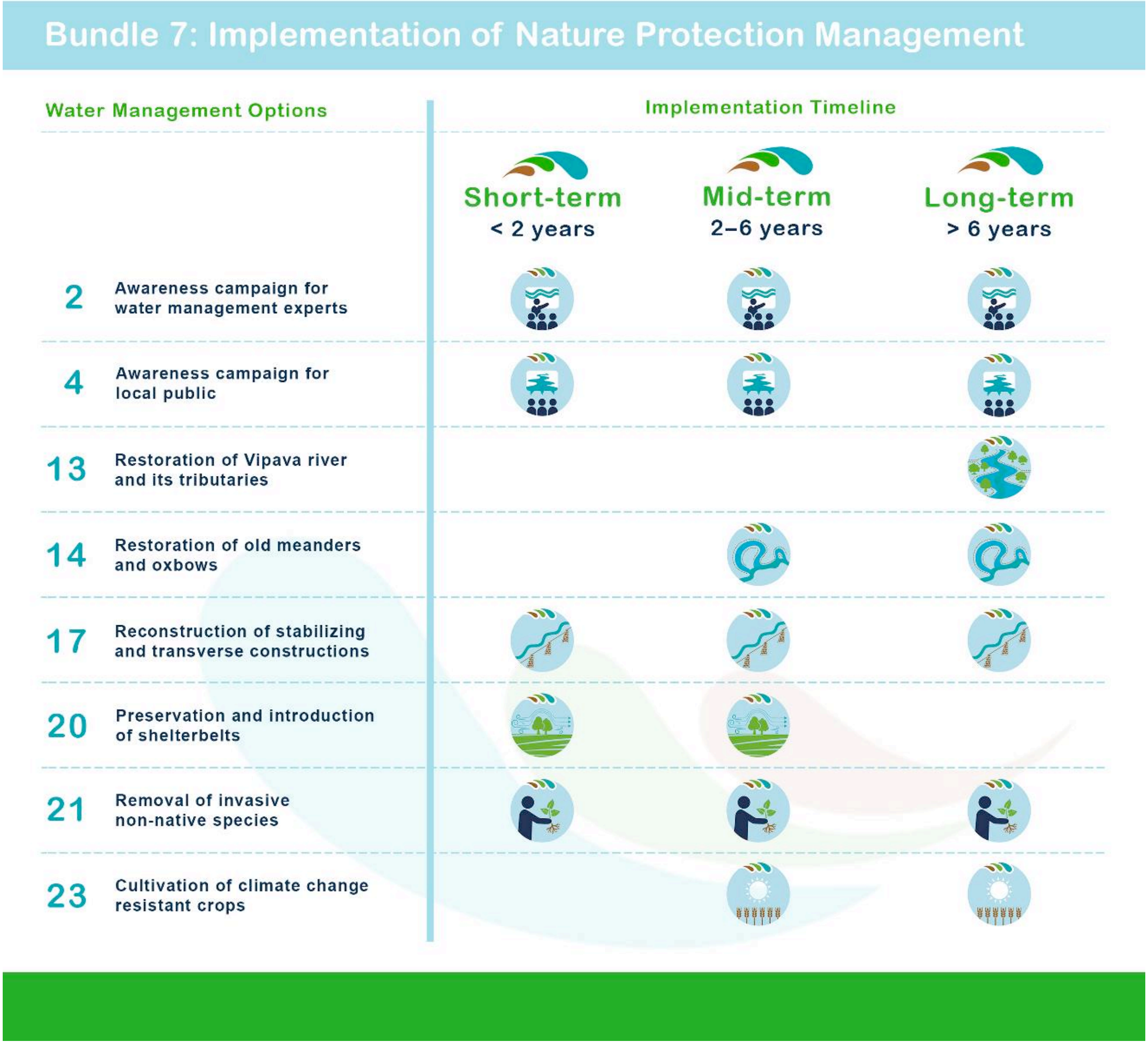
Raising awareness among experts (WMO 2) and local communities (WMO 4) about the positive effects of the proposed options with the aim of restoring natural elements is needed in the first year. In this sense nature protection management must be presented to society in a proper manner. Despite minor barriers due to limited financial capacities, WMO 4 shows many policy synergies.

Although minor barriers exist due to high costs, the preservation of existing and introduction of new shelterbelts (WMO 20) should begin to be implemented in the first year.

With low policy synergies (no National action plan of prevention and management of the introduction and spread of invasive alien species in Slovenia is in place) but low costs, removal of invasive non-native species (WMO 21) should also be implemented in the short term (first two years' time).

Restoration of old meanders and oxbows (WMO 14) and the restoration of the Vipava river and its tributaries (WMO 13) due to high costs or varying acceptability of stakeholders should be implemented in the next phase, with WMO 14 first in line. Both options would improve the ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization and provision of habitat for biodiversity). Both options show high co-benefits. If both applied, they would improve the status of ecosystems in a larger scale.

The cultivation of crops that are resistant to climate change (WMO 23) is a measure that can support the reduction of water consumption (irrigation) and supports the objectives of nature protection. However, high costs are involved. Therefore, the acceptability of stakeholders is not uniform. The implementation of the option should start in the mid-term, as some exotic or tropical crops are being already cultivated for research purposes. Therefore costs might decrease and acceptability increase.



Way forward/implementation avenues

Except WMOs 17 and 20, other WMOs are in synergy with the draft river basin management plan [29]. WMOs 13, 14, and 17 are in synergy with the flood risk management plan [63]. Except WMO 2, other WMOs are in synergy with the Natura 2000 management programme [70]. WMOs 13 and 21 are in synergy with the programme for the management of fish in inland waters [76].

Funding of options can be made through the development programme of Northern Primorska [91], Horizon 2020, INTERREG MED Programme 2014-2020, the Common Agricultural Policy, the European Regional Development Fund, LIFE, and the Cohesion Fund.

The main actor identified for this bundle is the Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) together with the Zavod za varstvo narave Republike Slovenije (Institute of the Republic of Slovenia for Nature Conservation) and other bodies such as the Direkcija Republike Slovenije za vode (Slovenian Water Agency) and the Agencija Republike Slovenije za okolje (Slovenian Environmental agency). By implementing WMOs 20, 21, and 23 the Ministrstvo za kmetijstvo gozdarstvo in prehrano (Ministry of Agriculture, Forestry and Food) and the Zavod za gozdove Slovenije (Slovenia Forest service) should be involved. At the local level municipalities and Regional Development Agencies could take the initiative.

According to third workshop (March, 2016) the Zavod za varstvo narave Republike Slovenije (Institute of the Republic of Slovenia for Nature Conservation), municipalities, and the local Tourist Office indicated their willingness to take up the bundle or individual water management options with differing roles in the implementation process.

2.4.4 Monitoring

Adaptive management assigns a strategic and central role to monitoring processes. An adaptive management approach means that plans are adjusted to future conditions as they unfold, taking account of uncertainty over future developments, and constantly updating the adaptation plan with new information from monitoring, evaluation, and learning [96]. Therefore, this section aims to outline the main elements that should be taken into account when monitoring the outcomes and impact of the proposed adaptation options.

Monitoring the environmental outcomes of implementing a particular water management option in a specific place and time is fraught with difficulties, as it is normally impossible to isolate the water system from the numerous external drivers and pressures affecting it alongside the implemented option. For instance, it is generally very hard to directly measure the impact of an option's generated water savings on the river flow, as the natural water availability in a system will depend on manifold factors such as recent meteorology, land use and its changes in the basin, the behaviour of other users, and so on. The same applies to measures addressing other goals, such as water quality. In view of the extreme complexity and the multiple causal chains impinging on single parameters, environmental programmes usually resort to monitoring the (degree of) implementation of a measure. In effect, they rely on scientific consensus about whether a measure delivers the desired effect on a certain parameter and about the expected range of this effect.

In addition to monitoring measures as described, monitoring in adaptive management often also addresses the overall system (the river basin in this context), so as to track its development over time and to enable reactions to unforeseen trends and developments.

Indicators for monitoring

Indicators for monitoring can assume various forms, each of which contributes to building a comprehensive overview of the option's or bundles' implementation. Types of monitoring indicators include [97]:

- *financial input indicators* that are used to monitor progress in terms of the annual payment of the funds available for any operation
- *output indicators* that measure activities directly realised within options (e.g. the number of training sessions organised)

When developing the water management options for this plan, a review of and comparison with existing management plans focusing on the river basin was undertaken (see Part 2). These existing plans, such as the River Basin Management Plans [27, 28, 29] developed in compliance with the European Water Framework Directive [21], have a monitoring and evaluation network in place in which the monitoring and evaluation of the presented water management options can be integrated. Such potential monitoring synergies exist, for example, with regards to the option of Reconstruction of the existing Vogršček water reservoir (WMO 10) and Reconstruction of the existing irrigation system (WMO 12).

Existing monitoring of the Vogršček water reservoir and its accompanying irrigation systems includes indicators showing water quantity and quality in the reservoir together with the quantity of water used for irrigation. Monitoring is under the responsibility of the operator of the facility and rules are laid down in the Operating Regulations. The existing practice is that the water reservoirs together with their monitoring are managed by concessionaires carrying out the Water Management Public Service. This is not the case in the existing irrigation systems, namely they are usually managed by agricultural cooperatives.

However, some water management options are unique to this river basin adaptation plan and therefore do not have specific links to existing monitoring efforts. For some of these options, opportunities exist for their implement within the frame of an ongoing project, such as those financed under the LIFE programme, which includes a budget for monitoring and evaluation activities and requires output monitoring for all projects. Within this river basin adaptation plan, monitoring for the following options could be funded via an external financing scheme: Preservation of existing and introduction of new shelterbelts (WMO 20) and Removal of invasive non-native species (WMO 21). More specifically, preserving and introducing new shelterbelts (WMO 20) or so-called green windbreaks could be funded within the LIFE sub-programme Climate Action. Based on expected changes in the climate of this region, the frequency of extreme events (including strong and gusty bora winds) will increase. As green windbreaks are a well verified measure for reducing damage from strong gusty winds by lowering wind speed, their installation could increase the resilience of the Vipava river basin against climate change. As the expected impact of green windbreaks is on reducing wind speed, measurements of wind speed would be the most appropriate output indicator. To monitor the actual effects of green windbreaks, measurement points should be adequately determined. The option on the removal of invasive non-native species (WMO 21) could also be funded within the LIFE programme. Namely, invasive alien species have multiple impacts (ecological, economic and human health), but are recognized first and foremost as a major threat to Europe's biodiversity and can cause the local extinction of indigenous species, for instance through competition for limited resources such as food and habitats, inter-breeding, or the spread of exotic diseases. The impact of invasive alien species may sometimes be so profound that they can alter the structure and functioning of entire ecosystems, compromising their ability to provide valuable ecosystem services, such as pollination, water regulation, or flood control [98]. As such, "invasive alien species (IAS) or other threats" (unit specimen/ha) or "species and number of non-native plant and animal (fish) species detected and removed" could be a potential indicator for the option on removal of invasive non-native species (WMO 21).

2.5 From planning to action: recommendations for implementation

The Vipava River Basin Adaptation Plan is based on a participatory approach, which was followed so as to develop a set of targeted water management options and, subsequently, bundles of these options. The outlined (bundles of) options serve to address the main challenges that were identified by the basin's stakeholders. This chapter provides guidance and recommendations for decision-makers, individuals, and entities that are in a position to implement bundles of synergistic water management options or individual options. The information provided throughout the plan is thus intended to serve as a tool to help to guide policy and decision makers in selecting appropriate options or sets of options to implement within the basin to address the basin's specific needs.

Implementation of all options within a given bundle

The bundles presented in chapter 2.4.3 are sets of options that have been grouped together on the basis of their foreseen abilities to collectively address the identified challenges within the Vipava river basin and react to additional local needs (e.g. increasing sustainable tourism in the area). Implementation of an entire bundle ensures a high occurrence of synergies between the options and the pursuit of one or more common objectives. Two water management options that are strongly aligned may decrease the implementation or maintenance costs if they are implemented together. Other combinations may lead to an increased impact with regards to addressing an existing threat.

In the bundle factsheets in chapter 2.4.3, extensive information is provided on the interaction of the water management options to support decision-making processes. This includes, for example, indications of the objectives that may be reached by choosing to implement a given bundle, the costs involved, the ideal phasing of the options in time, etc. If an entire bundle is to be implemented, the 'adaptation pathway' provides further information about which options are critical to implementation before other water management options in the bundle. For example, implementing the bundle Implementation of Sustainable Water Management would focus on achieving sustainable water management at the river basin level, and could be estimated at €63,798,691.00. Should sustainable water management at the river basin level be prioritised as a key objective and limited financing be a main consideration, the bundle Organisation of Sustainable Water Management would better suit the objective.

Implementation of individual water management options

The existence of very specific objectives, resource or capacity limitations or other considerations may make the implementation of an entire bundle unfeasible. In this case, deciding instead to implement one or more individual options will not necessarily have a negative impact on the performance of these options. While all of the water management options presented are suitable for implementation in the river basin, the decision to implement individual options on their own requires verifying that the option is not dependent on any other water management option. Information on the relationship between the options is outlined in the bundle factsheets in chapter 2.4 and should be consulted in order to reach such conclusions.

Here, particular focus should be given to prioritised water management options, which have been identified based on the wishes and needs of the stakeholders engaged in the process and by taking into account implementation-oriented factors, such as the multi-criteria analysis, performance with regards to the challenges, feasibility, acceptability, and policy synergies. As such, these options are strongly aligned with community interests and are foreseen to offer large potential in addressing the targeted challenges identified within the basin (see Table 4.2). In order to assess the best implementation timing, the adaptation pathways as presented in chapter 2.4

should be consulted. Following these criteria, the following water management options are recommended within the river basin:

- *Establishment of an inter-municipal expert working group* (WMO 1) addresses all three challenges, meaning water availability during droughts in the growing season (challenge A), flood risk reduction (challenge B) and appropriate water quality (challenge C). The option presents a path to a more coherent spatial development in the Vipava river basin, showing many co-benefits with other options. Hence, the option included in five out of seven bundles can help other options to be implemented easier and with the desired impact. The option represents a soft approach to adaptation, which was most preferred among stakeholders, having low implementation and operational costs and the most preferred outcome for all three identified challenges of Vipava river basin.
- *Awareness campaign for local publi*c (WMO 4) also addresses all three challenges, meaning water availability during droughts in growing season (challenge A), flood risk reduction (challenge B), and appropriate water quality (challenge C). The aim of the option would be to increase the awareness of the general public on the impacts of biological, chemical, hydrological and morphological pressures, biological pressures, the impacts of various pollution sources, etc. The option represents a soft approach to adaptation, which was most preferred among stakeholders, having low implementation and operational costs and the most preferred outcome for all three identified challenges of Vipava river basin.
- *Construction of water reservoirs* (WMO 8) addresses two challenges, meaning water availability during droughts in the growing season (challenge A) and flood risk reduction (challenge B). Water reservoirs would be used for two main purposes during droughts: 1) for irrigation of agricultural land and so avoiding agricultural drought and 2) as a water source in the function of enriching low waters by maintaining environmentally acceptable flow downstream and so avoiding hydrological drought. During short but heavy rainfall, water reservoirs would minimize floods downstream by retaining high waters. Although the option has most preferred evaluation outcome for the two identified challenges of the Vipava river basin, the option is a technical solution (grey approach to adaptation) with high implementation costs. As such it is also involved with low feasibility, but also with low co-benefits or even conflicts with other options and objectives of Water Framework Directive [21].
- *Awareness campaign for water management experts* (WMO 2) also addresses all three challenges, meaning water availability during droughts in the growing season (challenge A), flood risk reduction (challenge B), and appropriate water quality (challenge C). The aim of the option would be to increase the awareness of experts involved in water management (concessionaires for river management) so as to use more sustainable techniques when designing interventions on water bodies. The campaign would also increase the awareness of experts on the impacts of the effects of hydromorphological pressures (inadequate implementation of construction works). The option represents a soft approach to adaptation, which was most preferred among stakeholders, having low implementation and operational costs and the most preferred outcome for all three identified challenges of Vipava river basin.
- For many stakeholders the option *Improve the financing system for water infrastructure* (WMO 5) is one of the prerequisites for sustainable water management. The option addresses two challenges, meaning water availability during droughts in the growing season (challenge A) and flood risk reduction (challenge B). Through changes in legislation, this option aims to improve and optimize the system of financing water infrastructure from the national Water Fund; with the introduction of dedicated funding to finance measures to help achieve the objectives of water management and River Basin Management Plan. This option can result in the sustainability of water infrastructure, the prevention instead of recovery, sustainable flood protection and higher life quality, and reducing the damage caused by floods and droughts to different sectors (meaning also maintenance of the Vogršček water reservoir to help prevent damages to the agriculture in growing season). The option represents a soft approach to adaptation, which was most

preferred among stakeholders, having low implementation and operational costs and the most preferred outcome for all three identified challenges of Vipava river basin.

In order to assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial. Therefore, the suggestions made in section 2.4.4**Error! Reference source not found.** regarding the alignment of existing monitoring plans with the needs of the water management options specified in this plan should be considered. This includes finding synergies with existing monitoring schemes regarding the identification of suitable indicators for measuring the output.

PART 2

2.6 Detailed description of the water management options

WMO 1: Establish an inter-municipal expert working group for the Vipava river basin

Short explanation	A Vipava river basin working group (WG) would be established to have an active role in water management with objectives of optimizing water use in sectors dependent on water availability through active involvement in planning sustainable techniques (water saving equipment) and water sources (alternative, more suitable techniques). The WG would be also involved in spatial planning of all involved Municipalities and so coordinating existing and planned interventions that have impact on flood safety and scope of droughts. The WG would have a role of active, promptly resolving conflicts of interest in spatial and water use (tourism, fisheries, agriculture) and would consist of experts of various fields (spatial planning, hydrology, nature conservation, economy, agronomy, agro meteorology, etc.) connected with competent state authorities (Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and its bodies Direkcija Republike Slovenije za vode (Slovenian Water Agency), Agencija Republike Slovenije za okolje in prostor (Slovenian Environmental Agency)). Objectives of working group (WG) are: • determination of objectives and targets to guide the development plans of the planning authorities; • active in processes of Municipal Spatial Plan development with the aim to ensure sustainable water management (providing expert assistance in determining land and water use); • to promptly discuss about present issues on Vipava River (and tributaries) and solving potential disagreement (conflicts) between stakeholders (conducting confrontations and seeking solutions); • to propose new ideas, initiatives, projects that would encourage sustainable development in Vipava river basin; • to improve communication between Municipalities and experts (better flows of information) and so ensure needed support in finding the optimal solution at the river basin level; • to improve communication and collaboration between local and state authorities.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Local population (domestic), Tourism, Industry, Agriculture, Forestry, Energy, Water management, Fishery.
Benefits	Increased cooperation between municipalities and knowledge with involved experts can prevent inadequate water management and inadequate spatial planning. More coherent spatial development aims to resolve challenges of floods, water availability and water quality.
Potential negative impacts	Bigger workload of individual employees (managing various working areas and taking responsibility for the operation of the working group). Possible higher expenditures for water management can be balanced with reduced costs caused by inadequate water management and inadequate spatial planning (e.g. flood damages can be avoided if flood area and floodplains are taken into consideration when planning a development plan of a certain area).
Timeline of implementation	Should start in short (under 2 years' time) and continue till 2030.

Feasibility	Minor barriers with organizing a group (capacity of the group manager to make people in the group agree) and achieving agreements between different institutions.
Robustness	Yes
Flexibility	Yes
Costs/Actions	The total discounted cost towards year 2030: 138,506 euros (EUR 2018, discount rate: 5%) comprises of group organization that has maximum of 12 members (7 permanent and 5 external experts when needed) and animation of the group with 2 meeting per year.
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • River Basin Management Plan [29] – within measure: Information, awareness and education expert and general public on water management (label DUPPS1). • Resolution on the National Environmental Action Programme (2005–2012) (in short NEAP) [89] with giving support in Point 7.2 Public participation in decision-making and objective to open political arena to all civil society stakeholders. • Local Self-Government Act (Article 61. and 86.) [90] allows establishment of such associations [99]. • Municipal special plans encourage to prepare harmonized and coherent Municipal Spatial Plans that would help tackle identified challenges in Vipava river basin. • On regional level also Regional Development Programme of Northern Primorska (Goriška development region) 2014-2020 [91]. It could help achieve objectives of programme 5.1 A comprehensive spatial development of the region. *Funding of such an option could be through The INTERREG MED Programme 2014-2020 (priority axis 3: MED RESOURCES (Protecting and promoting Mediterranean natural and cultural resources - protection of natural and cultural heritage, biodiversity, the development of human activities in coherence with environmental change which represent enormous challenges to the MED area)) or Horizon 2020 (Societal challenges / 12. Climate action, environment, resource efficiency and raw materials / 14. Secure societies – Protecting freedom and security of Europe and its citizens Spreading excellence and widening participation (no. 15)).*
Acceptance	Medium to high. Some doubts were raised on October 2015 event regarding jurisdiction of municipalities. Also there are some barriers regarding individual (investors) interests.
Suggested stakeholder involvement	Municipalities (also in form of Association of Municipalities and Towns of Slovenia) together with their Regional development Agencies (e.g. Ra ROD Ajdovščina, RDA of Northern Primorska Ltd Nova Gorica) could achieve clear vision of development of the river basin, with clear vision for water management and support in achieving the objectives of EU directives (could be presented more an opportunity rather than burden). Regional development Agency would on the initiative of municipality representatives animate the WG and also decide when the group has to come to a meeting (session) - resources necessary for the purpose of guidance, management of WG could potentially be provided from involved Municipalities. Upon request of Municipalities, Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) would issue a decision on the nomination of inter-municipal WG for the Vipava river basin. Expert support should be ensured by following institutions: Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and its bodies Direkcija Republike Slovenije za vode (Slovenian Water Agency), Agencija Republike Slovenije za okolje in prostor (Slovenian Environmental Agency), Zavod Republike Slovenije za varstvo narave (The Institute of the Republic of Slovenia for Nature Conservation), Zavod za gozdove (Slovenian Forest Service), Inštitut za vode Republike Slovenije (Institute for Water of the Republic of Slovenia).
Preconditions for success	Willingness for cooperation of all Municipalities that share Vipava River but also that are part of Vipava river basin. Resources needed for implementation and operation of WG could potentially be provided from involved Municipalities.

	Political support in short. In detail a vertical communication with various ministries preparing strategic plans needs to be ensured. In that way the proposals and guidelines can be communicated. There should be a shown interest and true commitment of local and state authorities to promptly discuss about issues of water management.
Concrete examples where applied	Regional working groups for irrigation; Regional Development Agencies (RDA Ra ROD, RDA of Northern Primorska Ltd Nova Gorica, Regional Development Centre Koper); Skupnost Občin Slovenije (Association of Municipalities and Towns of Slovenia); “Svet za Vipavo” or Council for the Vipava River established in the end of year 2015. In past OVS = Regional Water Community (Primorska), 1975-1990.

WMO 2: Awareness campaign focused on educating experts involved in surface water management for sustainable water management

Short explanation	An awareness campaign would be launched to increase awareness of experts, involved in water management (concessionaires for river management) to use more sustainable techniques when designing interventions on water bodies. The campaign would also increase awareness of experts on impacts of the effects of hydromorphological pressures (inadequate implementation of construction works). Awareness campaign would be carried out in cooperation with experts in the field of ecology.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Water management.
Benefits	Increased knowledge exchange and cooperation among experts, involved in water management, aiming to resolve challenges of floods, water availability and water quality more efficiently.
Potential negative impacts	None.
Timeline of implementation	Should start in short (under 2 years' time) and continue till 2030.
Feasibility	Minor obstacles – willingness of experts to participate, also capacity of the person leading the awareness campaign to design a quality program/process that will persuade experts to actively participate.
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost towards year 2030: 226,277 euros (EUR 2018, discount rate: 5%) comprises of: • preparation and management of a communication strategy: prepare and disseminate publications, organize events, maintain a website, social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year; • creation the website and the database (first year); • collecting information and produce material for the first period (2.5 person-months); • organization of 1 workshop in the basin every year, stating from year 2; • review, analysis and synthesis of best management practices every 5 year, publishing them and preparing the content for the seminars (6 person-months and 1 publication, 100 copies)
Synergies and conflicts with policy objectives	Conflicts between the objectives of nature conservation policies (practices) and economic development (hydropower plants, water use). Synergies: • Water Framework Directive [21] - Article 14 – informing and consulting all interested parties in the implementation of the Water Framework Directive, in particular in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users. • River Basin Management Plan [29] – within measure: Information, awareness and education expert and general public on water management (label DUPPS1). • Floods directive 2007/60/EC [31] – within Article 9 option can contribute to take appropriate steps to coordinate the application of this Directive and that of WFD focusing on opportunities for improving efficiency, information exchange and for achieving common synergies and benefits having regard to the environmental objectives laid down in Article 4 of Water Framework Directive [21]. *Funding of such an option could be through Horizon 2020 for steps 2 and 3 of WMO (research on existing practices of watercourse management) as it represents a research to support measures/knowledge on any significant water management issues. Within group: Societal challenges / 12.*

	Climate action, environment, resource efficiency and raw materials / 14. Secure societies – Protecting freedom and security of Europe and its citizens OR Group: Spreading excellence and widening participation (no. 15).
Acceptance	High.
Suggested stakeholder involvement	Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) together with Direkcija Republike Slovenije za vode (Slovenian Water Agency) and Inštitutom za vode Republike Slovenije (Institute for Water of the Republic of Slovenia) as Institution leading the awareness campaign. Involved institutions: in the field of water management, nature conservation, ecology, and forestry and spatial planning. Also Water management companies who are with concessions responsible for maintenance of water infrastructure and aquatic and riparian land (concessionaires). Possible cooperation with existing associations in the field of water protection and management: e.g. Slovensko društvo za zaščito voda ((SDZV) Slovenian Association for Water Protection) to upgrade state-of-the-art knowledge on existing practices on watercourse management. Integrating the experience / knowledge of elderly inhabitants. Fakulteta za gradbeništvo in geodezijo (Faculty of Civil and Geodetic Engineering).
Preconditions for success	Funds available for implemention. Experts interested in cooperation/involvement in awareness campaign activities.
Concrete examples where applied	Slovenian River Restoration Centre (“Slovenski center za obnovo vodotokov”).

WMO 3: Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices

Short explanation	An awareness campaign would be launched to increase awareness among farmers to: 1) move towards a sustainable agricultural production, to optimize water use and reduce the use of fertilizers and plant protection products;2) irrigate agricultural land in more sustainable way with the help of decision support system (optimal, targeting the type of crop and soil type) that can result also in reducing pollution of surface and groundwater caused by washouts of nutrients, fertilizers and plant protection products; 3) use climate-smart agriculture practices and 4) to minimize the effects of hydromorphological pressures by avoiding or adjusting cultivating land near watercourses (in protected zones of watercourses).
Addressed challenges	Water availability during droughts (A), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Agriculture, water supply sector.
Benefits	Higher knowledge transfer aiming to decrease negative impacts of agriculture on water quality and quantity.
Potential negative impacts	Possible loss of agricultural production.
Timeline of implementation	Should start in short (under 2 years' time) and continue till 2030.
Feasibility	Minor obstacles – willingness of farmers to participate.
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost towards year 2030: 316,408 euros (EUR 2018, discount rate: 5%) comprises of: • preparation and management of a communication strategy: prepare and disseminate publications, organize events, maintain social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year; • review and preparation of a report on existing agricultural practices together with suggestions for improvements (first year, 4 person-months); • review, analysis and synthesis of best management practices (technical guidelines for proper agricultural practices) every 3 years from year 1 on (3 person-months, 1 publication, 500 copies); • organization of 1 workshop in the basin every year, stating from year 2; • collection and dissemination of best management practices on existing agriculture events like International Fair Of Agriculture and Food (AGRA), seminars, workshops, conferences, symposiums, demonstrations (demo-sites), study tours and promote active participation of farmers in Vipava river basin on existing events from year 2 (1.5 person-months, travel costs).
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • River Basin Management Plan [29] – within measure: Information, awareness and education expert and general public on water management (label DUPPS1). • Natura 2000 Management programme for Slovenia [70] – regarding the proper implementation of mowing meadows near watercourses, providing sufficient water flow. • Nitrates Directive [66] - Article 4: paragraph 1. (b) set up where necessary a programme, including the provision of training and information

	for farmers, promoting the application of the code(s) of good agricultural practice. • National Adaptation strategy for forestry and agriculture (2008) [94] and its implementation document (Action plan from 2011) [95] - Pillar II: Education, awareness and counselling. Measures that are already in place and are planned in future: 7. Raising awareness of farmers of the impact of climate change on agriculture with the program of Chamber of Agriculture and Forestry of Slovenia with Agricultural Advisory Service (KGZS), also various publications, brochures and leaflets as well as the media. *Funding of such an option could be through Horizon 2020 – within group: Societal challenges, 12. Climate action, environment, resource efficiency and raw materials and group: Spreading excellence and widening participation (no. 15). Also possible funding through Common Agriculture Policy/European Agricultural Fund for Rural Development (EAFRD) within sub measure M1.2 - support for demonstration activities and information activities.*
Acceptance	High.
Suggested stakeholder involvement	Leading the awareness campaign – proposing experts from University of Ljubljana, Biotechnical faculty, Department of Agronomy in close cooperation with Agricultural Institute of Slovenia and Ministry of Agriculture, Forestry and Food with Chamber of Agriculture and Forestry of Slovenia (CAFS) - Regional unit Nova Gorica, their agricultural advisory service. Experts from University are actively involved in irrigation projects already carried out and are part of so-called existing Working group for or the development of irrigation in Slovenia till 2020. Ministry of the Environment and Spatial Planning could help support agriculture to adapt to climate changes.
Preconditions for success	Farmers, who use mineral fertilizers, are obliged to make nutrient balances and farmers who participate in Agri-Environment Climate Measures. Active involvement of all local farmers. It is likely that farmers will need financial incentives - an incentive to voluntarily adopt less polluting technologies.
Concrete examples where applied	Chamber of Agriculture and Forestry of Slovenia with Agricultural Advisory Service (KGZS) are supportive towards measure. KGZS already organizes trainings and advisory through regional units. Farmers who apply for Agri-Environment Climate Measures must attend training.

WMO 4: Awareness campaign for local public on impact of their activities on the status of the Vipava river basin

Short explanation	An awareness campaign would be launched to increase awareness of the general public on the impacts of biological, chemical, hydrological and morphological pressures (due to legal and potential illegal water abstractions and impoundments of water, inadequate interventions in the riverbed), biological pressures (due to introduction of non-native (animal and plant) species into the environment), impacts of various pollution sources, etc. Topics that need to be considered: • water related challenges in Slovenia, focusing on Vipava river basin, including climate changes, o needs (different water users), conflicts (between users), constrains that need to be considered (floods, Natura2000 sites, waterprotection zones) in Vipava river basin. • couse/effect relation (different pressures or modifications in relation to their impacts; mitigation measures planning); o impact of the hydromorphological pressures on aquaric, riparian ecosystems, o impacts of non-native species on aquatic, riparian ecosystems, o impacts of various pollution sources on water quality.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Local population (domestic), Tourism
Benefits	Higher knowledge transfer aiming to decrease negative impacts of different pressures on water quality and quantity.
Potential negative impacts	None.
Timeline of implementation	Should start in short (under 2 years' time) and continue till 2030.
Feasibility	Minor obstacles – willingness of local public to participate.
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost towards year 2030: 187,052 euros (EUR 2018, discount rate: 5%) comprises of: • preparation and management of a communication strategy: prepare and disseminate publications, organize events, maintain social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year; • preparation of audio-visual material in form of documentary film with the objective to present water related challenges in Slovenia, focusing on Vipava river basin, including climate changes (approx. 20 to 30 minutes long film can cost about 5,000.00 to 10,000.00 euros); • participitation in existing events from year 2 on (2 events per year, travel cost for 2 persons, person months already included in communication strategy) and to be included in educational programs (3 schools, twice a year, travel cost for 2 persons, person months already included in communication strategy); • preparation of information panels on key points of Vipava river basin (9 information panels, in year 1, maintenance: 5% of implementation costs).
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Water Framework Directive [21] – Article 14 – informing and consulting all interested parties in the implementation of the WFD, in particular

	in the production, review and updating of the river basin management plans. Member States shall ensure that, for each river basin district, they publish and make available for comments to the public, including users • River Basin Management Plan [29] – within measure DUPPS1: Information, awareness and education expert and general public on water management. • Environmental protection Act [65]- Article 144. Eco Fund, Slovenian Environmental Public Fund - encourages promotion of various forms of education and public awareness. • Natura 2000 Management programme for Slovenia [70] – within measure of structured riverbed and riverbanks. *Funding of such an option could be through Horizon 2020 – within group: Societal challenges / 12. Climate action, environment, resource efficiency and raw materials / 14. Secure societies – Protecting freedom and security of Europe and its citizens / 15. Spreading excellence and widening participation. Also possible funding through The INTERREG MED Programme 2014-2020, priority axis 3: Med resources.*
Acceptance	High.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning together with Slovenian Water Agency and Institute for Water of the Republic of Slovenia as Institution leading the awareness campaign, some suggestions also that National Education Institute of the Republic of Slovenia would lead the awareness campaign. Help ensuring (expert) with support of Municipalities, The Institute of the Republic of Slovenia for Nature Conservation and Slovenian Environmental Agency. Involved institutions: in the field of water management, nature conservation, forestry and spatial planning. Teachers could help develop a programme for informing high schools, elementary schools, give support in preparing audio-visual material, to accept and follow programs in schools, help organize field trips.
Preconditions for success	Funds available for implementing the option. Local public, especially schools interested in active cooperation/involvement in awareness campaign activities.
Concrete examples where applied	Not available.

WMO 5: Improve the financing system for water infrastructure

Short explanation	Through changes in legislation, this option aims to improve and optimize the system of financing water infrastructure from the national Water fund; with the introduction of dedicated funding to finance measures to help achieve the objectives of water management and River Basin Management Plan. This option can result in the sustainability of water infrastructure, prevention instead of recovery, sustainable flood protection and higher life quality, reducing the damage caused by floods and droughts to different sectors (meaning also maintenance of Vogrščček water reservoir to help prevent damages to the agriculture in growing season).
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B)
Target locations and water uses	Location: River as a whole. Water uses: Water management.
Benefits	Improved status of water infrastructure serving its purpose (lower flood risk, higher water availability, etc.). Achieving the objectives of River Basin Management Plan (Water Framework Directive).
Potential negative impacts	None.
Timeline of implementation	Short (under 2 years' time).
Feasibility	Possible minor barriers with sectors that currently receive funds.
Robustness	Yes.
Flexibility	Yes.

Costs/Actions	The total discounted cost toward year 2030: 178,610 euros (EUR 2018, discount rate: 5%) comprises of four main approaches:
	• If other uses, different from the one that water infrastructure was designed and build for, are present, they must contribute financially to maintain59 the water infrastructure.
	  ○ Explaination - Reservoir Vogrščček is financed from two sources according to its specified primary (irrigation) and secondary use (flood protection). Other uses of water reservoir – e.g. tourism and fishery do not contribute to the financing scheme.
	  ○ Preparation of expert bases for the purpose of determination of contribution key. Good basis for information is measure label DDU19 [29] – 6 person months in year 1;
	  ○ Preparation of contracts with users of the water infrastructure (in accordance with article 48. of Waters Act – ZV-1 [59]). Pre-action is to identify this users! This information can be gained from measure label DDU19 [29] – 6 person months in year 1;
	  ○ Performance of the obligations determined in contracts – 1 person months from year 2 on.
	• Municipalities get annualy on average 60% of the funds contributed by the concession (water rights). The purpose of the use of these funds in municipal budget is not prescribed. The proposal is to prepare legal basis for eligible use of funds and that is for achieving the objectives of water management.
	  ○ Amendment of Financing of Municipalities Act [100] on the basis of expert analysis (Report for measure 4ED, 2013). The initiative must come from Ministry of the Environment and Spatial Planning but it is the Ministry of Finances that must amend the Act – 7 person months, year 1;
	  ○ Performance of amended Act [100] – Municipalities contribute funds for all the objectives of article 2. of Waters Act [59]; collaboration with Water Fund of the Ministry of the Environment and Spatial Planning to set priorities for measures needed for achieving the objectives of water management. No additional costs are expected for this action.
	• Improving the system of financing water infrastructure from the national Water fund; with the introduction of dedicated funding to finance

	measures to help achieve the objectives of water management and River Basin Management Plan, optimize use of resources, increase the realization the use of funds with respect to the eligible use of funds and an increase in personnel capacities. o Expert basis/analysis have been already prepared (Report for measure 4ED, 2013) to help analyse all relevant policy instruments that affect financing of Water Fund and propose proper changes to help achieve the objectives of water management and RBMP, optimize use of resources, increase the realization the use of funds with respect to the eligible use of funds and an increase in personnel capacities. No additional costs are expected for this action. o Amendments of policy instruments mentioned in Report 4ED. The initiative must come from Ministry of the Environment and Spatial Planning. Depending on proposition for amendments of different policy instruments, other ministries start the process on changing the legislation – 7 person months, year 1. o Performance of amended policy instruments in Annual Programme of the Water Fund. No additional costs are expected for this action as the programme is existing task of Water Fund. • Assessment of the possibility of co-financing of water infrastructure from the EU funds, Operational Programme Cohesion Policy (2014 - 2020) and the transnational and cross-border programs.Co-financing of water infrastructure: o To make an analysis of possible EU Funds, Operational Programme Cohesion Policy (2014 - 2020) and the transnational and cross-border programs. The analysis to be performed on regional level due to better knowledge on what issues need to ne addressed – 4 person months, year 1, year 4.
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • River Basin Management Plan – within measures “Ensuring reimbursement of environmental costs and the cost of water as a natural resource” (label 3ED) and “Alignment of the funds collected from taxes on water pollution in water management (label 4ED). • Flood Risk Management Plan [63] - Achieving compliance with objective of reducing flood risks, and in synergy with measures U13 - Providing financial resources for the implementation of the public utilities of water management and U20 - Systemic, regulatory, financial and other measures. • Financing of Municipalities Act [100] - Municipalities would contribute funds for all the objectives of article 2. of Waters Act; collaboration with Water Fund of the Ministry of the Environment and Spatial Planning to set priorities for measures needed for achieving the objectives of water management. • Waters Act [59] - In accordance with the Act it is necessary to conclude an agreement and arrange relations in respect of mutual rights and obligations, use and maintenance of water infrastructure (Article 48). Water fund (Article 162 of Waters Act [59]) finances the modernization of water reservoirs intended for irrigation of agricultural land, which are government water infrastructure.
Acceptance	Not known – on October event (2015) no concrete answers on this question – possible low acceptance with Municipalities – this WMO would prescribe exactly for what funds should be envisaged. Also due to past experience when the energy sector got most of these funds to build hydropower plants.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning together with users of water infrastructure; Ministry of Finances – an initiative must come from Ministry of the Environment and Spatial Planning; in cooperation also with Municipalities. Ministry of the Environment and Spatial Planning (Water Sector) together with other ministries responsible for amending proposed policy instruments Local – regional development agencies together with Municipalities

Preconditions for success	In the options amendment of Financing of Municipalities Act [102] on the basis of expert analysis (Report for measure 4ED, 2013) is proposed. The initiative must come from Ministry of the Environment and Spatial Planning but it is the Ministry of Finances that must amend the Act.
Concrete examples where applied	Not available.

WMO 6: Upgrade and update the existing network for monitoring the status of water environment

Short explanation	Option aims to upgrade the monitoring network for the state of the water environment as there is a need for a good and representative monitoring of hydrological, biological and water quality-based parameters, possible meteorological and agro-meteorological parameters. This option aims to upgrade also the existing monitoring stations together with establishment of additional ones for water quality and hydrological, meteorological measurements. More representative data can help to better understand the current situation in the Vipava river basin and so improve planning measures to improve the river basin management.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Water management, water supply sector, agriculture
Benefits	Improved hydrological data, data on, biological and water quality aimed at better understanding the current situation in the Vipava river basin and so improve planning measures to improve the river basin management.
Potential negative impacts	None.
Timeline of implementation	Short (under 2 years' time).
Feasibility	Minor barriers due to limited financial capacities.
Robustness	Yes.
Flexibility	No, as the measure will only have an impact if implemented entirely.

Costs/Actions	The total discounted cost toward year 2030: 491,330 euros (EUR 2018, discount rate: 5%) comprises the costs of the planning process, implementation of 1 hydrological station (Vrtojbica), 8 monitoring stations for water quality (4 for ecological state and 4 for chemical state on Vrtojbica, Vogršček, Branica and Močilnik).
	Investor must follow next step when implementing new monitoring stations:
	• Planning of monitoring stations (Review of all existing monitoring stations and their status, review of BOBER outcomes and what still needs to be covered. Determination of priority areas and existing monitoring stations that need to be implemented/upgraded. Also need to check if implementation of monitoring stations is allowed in Municipal spatial plans) – 1 person month/station.
	  ○ (Investor) plans monitoring stations in following steps ("plan"):
	    ▪ searching of plots,
	    ▪ searching for servitudes and consents (a consent of the owner in the form of easement agreements (slo: "služnostna pogodba")) with surveying snapshot,
	    ▪ Designing (dimensioning) and determine fixed boundary conditions (designing engineering base) with the help of hydraulic calculations (for monitoring stations on watercourses).
	• Preparation of project documentation – 0.5 person months/station.

Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Water Framework Directive [21] – To know the status of watercourses and to determine precise measures for improving status of water environment. • River Basin Management Plan [29] – similarity to the measure "The establishment and implementation of monitoring of sediment (and

	debris) transport, construction of the sediment management plan and preparation of regulations on the manner and conditions of debris and sediment removal" (label DDU16). • Flood Risk Management Plan [63] – measure "Implementation of hydrological and meteorological monitoring" (label U4) where it is stated that rationality of establishing new locations of automatic hydrological stations on two of the areas of significant impact of floods (Podnanos and Vrtojba-Šempeter) need to be verified. U4 is somehow also connected to the measure Flood Forecasting (label U15). • Natura 2000 Management programme for Slovenia [70] – within measure of adapted water quality to the ecological requirements of the species. *Funding of such an option could be through Horizon 2020 – Research to support measures/knowledge on any significant water management issues and from Cohesion Funds.*
Acceptance	High with local public, local community and Municipalities. Slovenian Environmental Agency has low acceptance for additional monitoring stations (beside already planned/implemented in BOBER project) due to high operational costs of existing monitoring stations. Their objective is only to comply monitoring with WFD requirements.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning and its body Slovenian Water Agency and Slovenian Environmental Agency. Ministry is responsible for establishment of the measure. All of the above are actively involved in processes of site selection, implementation of monitoring stations and monitoring. Slovenian Environmental Agency must include the data from new monitoring stations in existing database (data processing) for forecasting extreme weather events like droughts and floods. Possible involvement of the Municipalities and local communities, also The National Laboratory of Health, Environment and Food. They are supportive towards measure as this data will support them in finding out the status of watercourses – for possible development of new activities on the watercourses (bathing sites).
Preconditions for success	Funds available for implementing WMO and later for operational costs (most important).
Concrete examples where applied	In the 2009-2015 period, the Slovenian Environmental Agency of the Republic of Slovenia is carrying out a project called BOBER, which is an acronym for Better Observation for Better Environmental Response (Boljše Opazovanje za Boljše Ekološke Rešitve). (part of a measure in River Basin Management Plan, NUV I [29]) [101] and PUBLICATION from 2010 (also text in English): [102]. Municipality Nova Gorica already monitors the water in Vogrščék water reservoir (microbiology).

WMO 7: Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage

Short explanation	This option aims to set up monitoring of hydromorphological pressures on aquatic ecosystems to ensure appropriate water management. With this option, more comprehensive data supporting water management regarding pressures will be obtained, meaning legal and potential illegal water abstractions and impoundments of surface water. Verifying actual water consumption at holders of water rights during a period of low natural flows. Verifying of possible illegal abstractions and impoundments.
Addressed challenges	Water availability during droughts (A), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Local population, Tourism, Industry, Agriculture, Forestry, Water management
Benefits	Decrease of hydromorphological pressures on aquatic ecosystems.
Potential negative impacts	Possible negative social impact – no more possible illegal abstractions - increase in costs of water use and crop reduction due to less irrigation.
Timeline of implementation	Should start in short (under 2 years' time) and continue till 2030.
Feasibility	Minor social barriers due to restriction of water use and limited financial capacities.
Robustness	Yes. Water use is limited with ecological acceptable flow.
Flexibility	No, as the measure will only have an impact if implemented entirely.
Costs/Actions	The total discounted cost toward year 2030: 65,507 euros (EUR 2018, discount rate: 5%) comprises the costs of: • Verifying existing water rights in Vipava river basin – 0.25 person month; • Verifying actual water consumption at holders of water rights during a period of low natural flows. Verifying of possible illegal abstractions, impoundments during a period of low natural flows – 1 person month (woth field trip); • Measurements on selected locations, analysis of the results and the written report – 4 person month; • If needed, proposal of measures to the Government: for example - adjustment of already acquired water rights in order to reduce negative impacts on the aquatic ecosystems / penalties for possible illegal water abstractions – 0.5 person month. These actions (1 to 4) are repeated every 5 years, starting year 1. verification of existing water rights, actual water consumption and possible illegal abstractions, costs of measurements and analysis of the results together with preparation of the proposal of measurements for the Government.
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Water Framework Directive [21] – To set up monitoring of hydromorphological pressures on aquatic ecosystems to ensure appropriate water management and to contribute achieving objectives (Annex V, 1.3.2. Design of operational monitoring); • River Basin Management Plan [29]; Ecological flows in the implementation of the Water Framework Directive [21] and within the measures "Monitoring the withdrawn the quantity of water" (label DDU18.3) and "Decision support system on water use" (label DDU26). *Funding of such an option could be through Horizon 2020 – within group: Societal challenges / 12. Climate action, environment, resource efficiency and raw materials.*

Acceptance	Low acceptance by water users (potential illegal users). High acceptance by political and environmental sector.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning should start implementing this option with help of the supporting services, Slovenian Water Agency, Slovenian Environmental Agency, Institute for Water of the Republic of Slovenia, The Institute of the Republic of Slovenia for Nature Conservation and Slovenian Forest Service. On local level the municipalities, Mandatory Municipal Public Utility Services (Drinking water), holders of water rights (hydropower plants – Company called SENG, farmers, etc.) and general public (possible illegal abstractors) should be actively involved in such monitoring providing data and support in implementation.
Preconditions for success	Funds need to be available for implementing the option. When option in place, a reference measuring site is needed to easily know the cause of lower water flows. This option would be ideally combined with raising awareness among farmers (WMO 3) and local population (WMO 4).
Concrete examples where applied	Similar project was part of a yearly programme of IzVRS in previous years: Measurements of the quantity of abstracted water, river flow and determination of Ecological flow in Vipava river basin (“Meritve količin odvzema in pretokov vode v Vipavi, določitev Qes-a.”).

WMO 8: Construction of water reservoirs on the watercourses in the upper part of the river basin

Short explanation	With construction of water reservoirs, high waters can be retained and accumulated in the colder part of the year (e.g. autumn peak of precipitations) in the upper part of the Vipava river basin. When high waters occur due to short but heavy rainfall, water retention in the upper part of river basin can minimize floods downstream. In the warmer part of the year (spring, summer) accumulated water can represent a water resource for two main purposes: 1) for irrigation of agricultural land and so avoiding agricultural drought and 2) water source in the function of enriching low waters by maintaining environmentally acceptable flow downstream and so avoiding hydrological drought. If not in conflict they can be planned as multifunctional reservoirs with possibility of e.g. developing tourism activities.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B)
Target locations and water uses	Location: Upper part of river basin. Water uses: Local population, Tourism, Agriculture, Water management, Fishery.
Benefits	Water available for irrigation during droughts, enrichment of low flows, reducing floods downstream.
Potential negative impacts	Effect on water quality (affecting structural water quality), fragmentation of river (aquatic and riparian) ecosystem, sediment continuum.
Timeline of implementation	Long (after 6 years) although stakeholders on third workshop suggested to start implementing the option in the short-term as it needs to start planning as soon as possible, but the actual implementation can be postponed to medium and long-term.
Feasibility	Serious barriers – long processes of placing water reservoirs in spatial plans of involved Municipalities; hard to economically justify the projects of building water reservoirs (e.g. Koširec – already assessed costs at 4.6 mio € without mitigation measures); negative opinion of The Institute of the Republic of Slovenia for Nature Conservation;
Robustness	No.
Flexibility	No.
Costs/Actions	The total discounted cost toward year 2030: 18,292,910 euros (EUR 2018, discount rate: 5%). In “Development Plan for Irrigation till 2020” following water reservoirs are planned in Vipava river basin (priorities till year 2020): • Koširec – in municipality Ajdovščina, volume 1.176 million m3 (is also object of land use changes in municipal spatial plan), • Vrnivec – in municipality Ajdovščina, volume 1 million m3, • Svinjšček – in municipality Ajdovščina, volume 1 million m3, • Pasji rep – in municipality Vipava, volume 2.5 million m3. Main costs have been determined with the help of last known implementation costs of water reservoir Koširec. The costs consist of: • Purchase of land (separately for each location); • Preparation of project documentation (separately for each location) (8 % of investment costs); • Implementation of water reservoirs (all 4 reservoirs separately implemented, year 2, year 4, year 6, year 8); • Maintenance (2 % of investment costs).
Synergies and conflicts with policy objectives	Conflicts: • Water Framework Directive [21] and River Basin Management Plan [29]: The construction of water reservoirs on watercourses will affect structural water quality. Although WMO is in conflict with the objectives of WFD [21] there are some exceptions included in Article 4.7 of Water Framework Directive [21]. There are several conditions that need to be met if the reservoirs will be built.

	• Natura 2000 Management programme for Slovenia [70]: Possible conflict with the protection objectives relating to the provision of passability (transitivity) of watercourses for aquatic organisms and reducing the hydromorphological pressures. • Ordinance of the municipal spatial plan of the Renče-Vogrsko Municipality [103] Synergies: • Rural Development Plan 2014-2020 [74], • Floods directive 2007/60/EC [31] - help achieving compliance with objective of reducing flood risks. • Flood Risk Management Plan [63] – similarity to measure –“ Design and construction of building flood protection measures” (label U7). • Natura 2000 Management programme for Slovenia [70] – within measure of providing a sufficient volume of water. • Resolution on the strategic orientations of development of Slovenian agriculture and food industry by 2020 - "Securing you food for tomorrow" (Official Gazette of RS, no. 25/2011) [104] - Special attention will be given to investments that will enable the development of innovative technologies and adaptation to climate change. • Regional Development Programme of Northern Primorska (Goriška development region) 2014-2020, measure A1P2 (page 237) [91] and measure A2P1 (page 264) - selection of the optimal project solutions of flood safety measures, which will allow multipurpose use and integration of financial resources across sectors and, consequently, best solutions from a technical, environmental and economic point of view. Measure A1P2 has some limitations - Before investing resources in the preparation of documentation for the construction of new water reservoirs it is reasonable to verify functionality and optimal utilization of existing irrigation infrastructure (e.g. Vogršček water reservoir in the Vipava Valley). • not yet confirmed Plan for development of Irrigation until 2020 (Irrigation Plan) [79], • Spatial Plan of Municipality Ajdovščina and its amendments (Official Gazette of the Municipality of Ajdovščina, no. 7/1997) [92] - already planning two water reservoirs, Koševec and Vrnivec. Ordinance of the municipal spatial plan of the Renče-Vogrsko Municipality in Article 34 [103]. Paragraph 11 determines the construction of reservoirs for irrigation of agricultural land. They must be designed locally in order to minimize the impacts on hydrological system, taking into account the conservation of biodiversity and protection of natural features. Designing area of reservoirs should allow ingrowth of the natural ecosystem and allowing the use of other activities.
Acceptance	High acceptance by agricultural sector (farmers and their advisors). Low or no acceptance by environmental sector (The Institute of the Republic of Slovenia for Nature Conservation).
Suggested stakeholder involvement	Ministry of Agriculture, Forestry and Food together with Municipalities and their development agencies, Ministry advisory service Chamber of Agriculture and Forestry of Slovenia (CAFS) (Regional units) should prepare proposals for implementation together with farmers – land owners and potential users of reservoirs. Planning must be in close cooperation of Ministry of the Environment and Spatial Planning who leads SEA process (also Ministry of Defense) and other institutions that are involved in the process of obtaining needed permits (also EIA processes), meaning ensuring expert support in the implementation process (for each intervention into the watercourse it is necessary to obtain requirements or guidelines of the Institute; guidelines must be considered in project documentation) (e.g. Slovenian Water Agency, Slovenian Environmental Agency, The Institute of the Republic of Slovenia for Nature Conservation, The Fisheries Research Institute of Slovenia).
Preconditions for success	A precondition for the option to be implementable is the cooperation of landowners as they have to agree with giving up plots in order to create such reservoirs. Precondition is acceptance of planned reservoirs by all Spatial Planning Authorities (Slo.: “Nosilci urejanja prostora”), especially Environmental sector (Water, Nature conservation) within SEA and EIA processes! Precondition is also assured funding – determination of financial structure – it is suggested that this reservoirs are multifunctional, not just for irrigation and flood protection, but also for developing eco-tourism, recreation sites, etc. That said, all secondary functions of water reservoirs must ensure water for low flow in dry period of year. The regulation of operation must be prepared in a way that ensuring low flow in dry period of year

	has priority before other uses.
Concrete examples where applied	Vogrščček water reservoir in the mid-/lower part of Vipava river basin in 1980s.

WMO 9: Construction of dry reservoirs

Short explanation	With construction of dry reservoirs, high waters in the colder part of the year (e.g. autumn peak of precipitations) can be retained till the water flow normalises. Water retention in the upper and lower part of the river basin would solve problems with floods downstream. If dry reservoirs would be built along watercourses, this option would represent a more sustainable solution then building dry reservoirs on watercourses.
Addressed challenges	Flood risk reduction (B)
Target locations and water uses	Location: River as a whole. Water uses: Local population, Water management
Benefits	Reducing floods downstream.
Potential negative impacts	Reducing agriculture production where reservoirs would be build (if placed on agricultural land). Depending the location of the dry reservoir – on or along watercourses – possible alteration of morphology of the watercourse.
Timeline of implementation	Med-term (between 2 and 6 years).
Feasibility	Minor barriers (placement of the reservoirs in spatial plans, cooperation of landowners, land users and farmers) - more acceptable for environmental sector (The Institute of the Republic of Slovenia for Nature Conservation). Limited financial capacities.
Robustness	Yes.
Flexibility	No.
Costs/Actions	The total discounted cost toward year 2030: 5,637,741 euros (EUR 2018, discount rate: 5%) comprises the: • Integrated analysis for potential location for dry reservoirs (year 1); • Purchase of land (separately for each location, land must be purchased where the barrier will stand); • Preparation of project documentation (separately for each location) (8 % of investment costs); • Implementation of dry reservoirs/barriers (4 dry reservoirs, year 2, year 4, year 6, year 8); • Maintenance (2 % of investment costs).
Synergies and conflicts with policy objectives	Conflicts: • possible with Water Framework Directive [21] (possible alteration of morphology of the watercourse). This depends on the location of the dry reservoir and construction technique – on or along watercourses – possible alteration of morphology of the watercourses. Possible conflict with fundamental measure HM8 of RBMP relating to the provision of good hydromorphological water status (in Slovene: “omejevanje novih ureditev vodotokov” (former DUPPS 21)). • Habitats Directive [72] - Possible negative impact on protective forests and forests with a special purpose and possible negative impact on nature conservation areas (Natura2000 sites, valuable natural features, ecologically significant area, designated nature protected areas). Synergies: • Floods Directive [31], and in comparison with water reservoirs the dry reservoirs present more suitable solution for Natura2000. • Flood Risk Management Plan [63] – similarity to measure “Design and construction of building flood protection measures” (label U7).
Acceptance	Higher acceptance by environmental sector (The Institute of the Republic of Slovenia for Nature Conservation), lower acceptance by agricultural sector (if arable land will be affected).
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning and its bodies, which are involved in SEA procedure (e.g. The Institute of the Republic of Slovenia for Nature Conservation) should check the possibility of implementing such an option. Slovenian Environmental Agency is involved in

	SEA procedure, but also leading EIA procedure. Slovenian Water Agency is the one bearing responsibility in the field of water management - maintenance of the dry reservoirs and monitoring (data acquisition for water management). Cooperation of Ministry of Defense (Administration of the Republic of Slovenia for Civil Protection and Disaster Relief), Ministry of Agriculture, Forestry and Food together with Slovenian forest service (ZGS, OE Tolmin, KE Ajdovščina), Municipalities (local community) and landowners must be assured. Farmers (or landowners) would need financial initiative (compensation for the loss of income) – usually investor proposes three options: purchase of the land, compensation for the loss of harvest or can get substitution of agricultural land with a suitable one.
Preconditions for success	A precondition for successful implementation is a good analysis if and where this dry reservoirs are needed to achieve desired results (reducing floods downstream). A proper analysis must be conducted of most suitable locations of the reservoirs. Also in the process of searching for proper location, the measure can be implementable only if there is a common agreement and cooperation of landowners (farmers, land users, Mandatory Municipal Public Utility Services) as they have to agree on giving up plots in order to create such reservoirs. Last but not least there must be funds available for implementation.
Concrete examples where applied	Dry reservoirs Pikol and Pikolud in the Municipality Nova Gorica. Also a local dry reservoir in municipality Renče-Vogrsko (Arčoni pri Renčah) – the Municipality itself manages the reservoir.

WMO 10: Reconstruction of existing water reservoir Vogrš□ek

Short explanation	With reconstruction of exsisting water reservoir Vogrščєk in the lower part of Vipava river basin, this options aims to improve the operation of reservoir Vogrščєk and its associated facilities. Good status of water reservoir Vogrščєk is the precondition for a well-functioning and optimal utilization of the irrigation system. The impact of this option will be more efficient irrigation of agricultural land in lower part of the river basin that can prevent agricultural drought, enable cleaner water for irrigation and healthier local food production.
Addressed challenges	Water availability during droughts (A)
Target locations and water uses	Location: Lower part of river basin. Water uses: Local population, Tourism, Agriculture
Benefits	More efficient irrigation with minimizing negative impact of drought on agriculture, appropriate water quality for irrigation.
Potential negative impacts	Economically this is an expensive option, but is already planned.
Timeline of implementation	Short (under 2 years' time).
Feasibility	Minor barriers (economical). WMO costs a lot of money – due to limited financial capacities reconstruction has been delayed.
Robustness	No.
Flexibility	No.
Costs/Actions	The total discounted cost toward year 2030: 4,428,486 euros (EUR 2018, discount rate: 5%). Ministry of the Environment and Spatial Planning is with "Conceptual plan" (slo: "projektna naloga" of terms of reference) already in process of public procurement for Reconstruction of barrier Vogrščєk and its accompanying facilities. In conceptual plan, project and investment documentation for obtaining a building permit must be prepared (construction works carried by a contractor). We used last known estimated cost of restoration works of the reservoir from year 2013. The costs consist of: • Preparation of project documentation (8 % of investment costs); • Implementation of reconstruction works; • Maintenance (2 % of investment costs) – here we also took into account existing costs of maintaining the reservoir Vogrščєk (100,000 Eur/year).
Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Flood Risk Management Plan [63] – similarity to measure –"Design and construction of building flood protection measures" (label U7). • Natura 2000 Management programme for Slovenia [70] – with measure of ensuring a sufficient volume of water. • Rural Development Plan 2014-2020 [74] - Funds available for construction of large irrigation systems (reservoir Vogrščєk is a part of a large irrigation system and reconstruction of extraction facility is a precondition to develop new irrigation systems from reservoir Vogrščєk), • Water fund (Article 162 of Waters Act [59]) finances the modernization of water reservoirs intended for irrigation of agricultural land, that are government water infrastructure. • Resolution on the strategic orientations of development of Slovenian agriculture and food industry by 2020 - "Securing you food for tomorrow" (Official Gazette of RS, no. 25/2011) [104],

	• Regional Development Programme of Northern Primorska (Goriška development region) 2014-2020 plans within measure A1P2 (page 237) [91]; • not yet confirmed Plan for development of Irrigation until 2020 (Irrigation Plan) [79].
Acceptance	High acceptance with agriculture sector, also with water sector.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning as an owner of the reservoir is with "Conceptual plan" (slo: "projektna naloga" of terms of reference) already in process of public procurement for Reconstruction of barrier Vogrščček and its accompanying facilities. In conceptual plan, project and investment documentation for obtaining a building permit must be prepared (construction works carried by a contractor). Involved should be also Ministry of Agriculture, Forestry and Food, Ministry of Defense (Administration of the Republic of Slovenia for Civil Protection and Disaster Relief) and Municipalities (local community).
Preconditions for success	Funds available for implementing WMO. The main problem is unclarified ownership of the reservoir and its infrastructure between government and the private sector, which, in the past 20 years, has resulted in poor management, improper functioning, lack of operation and maintenance funding. Although formally the owner of the entire system Vogrščček (reservoir and irrigation systems) is one (government), we can see that shared ownership between the Ministry of Agriculture, Forestry and Food (irrigation systems) and Ministry of the Environment and Spatial Planning (reservoir) represent the main problem (disagreements) for proper functioning (maintenance) [105]. So the precondition for success would be improved legal framework concerning the ownership, management and financing for maintaining the system (not just reservoir). Reservoir needs to be seen as a part of the whole system.
Concrete examples where applied	In 2013 some refurbishment works (first phase) took place on the reservoir Vogrščček with the objective to ensure the safe operation of the dam.

WMO 11: Development of new irrigation systems

Short explanation	This option develops/implements new irrigation systems, derived from the existing water reservoir Vogršček or from other planned water reservoirs (e.g. Košivec, Vrnivec, Svinjšček, Pasji rep). This measure can prevent agricultural drought and consequently reduce the damage caused in the agriculture and consequently, also increase self-sufficiency in food. Also cleaner and more appropriate water for irrigation means reducing the risk of contamination and consequently healthier local food production. The establishment of proper irrigation systems, new technologically more efficient and equipped with proper agrometeorological support with sensors for optimal irrigation, targeting the type of crop and soil, and also reducing water consumption caused by inappropriate irrigation techniques.
Addressed challenges	Water availability during droughts (A)
Target locations and water uses	Location: Upper part of river basin. Water uses: Agriculture
Benefits	Increased irrigated crop production and self-sufficiency in food.
Potential negative impacts	More intensive agricultural production can lead to deterioration of water quality.
Timeline of implementation	Long-term (> 6 years' time). According to stakeholder comments also short-term (under 2 years' time) for irrigation systems that are linked to existing water reservoir Vogršček.
Feasibility	Serious barriers – involvement of different stakeholders must be assured to implement this option (farmers, landowners, and spatial planning stakeholders), also relatively big financial burden.
Robustness	No. This option only functions if there is sufficient water for irrigation. Therefore, if the future is extremely dry, or wet, the option does not have a great effect anymore.
Flexibility	Yes.

Costs/Actions	The total discounted cost toward year 2030: 22,500,811 euros (EUR 2018, discount rate: 5%) comprises the costs of project documentation, implementation and maintenance costs of new irrigation systems with total area of 3,797 ha.
	Steps that need to be considered:
	• Preparation of project documentation (8 % of investment costs);
	• Implementation of new irrigation systems (For cost assessment we decided to take into account data from "Action plan for the development of irrigation in the RS until 2020"[71] on planned new irrigation systems for 2,700.00 ha of net agricultural land. Action plan also financially evaluated the measure based on information on funds of rural development program (2007 - 2013) intended for the construction of new irrigation systems. It has been estimated that 6,046.00 €/ha is the cost of new irrigation system.);
	• Maintenance (2 % of investment costs) starting from the year following the implementation.
	Plan for implementation of new irrigation systems (according to Action plan and information based on one of our stakeholders in the field of agricultural consultancy):
	• Irrigation system from water reservoir Vogršček with area 1,080 ha:
	    ○ project documentation in year 1,
	    ○ implementation in year 2.
	• Irrigation system from water reservoir Košivec with area 600 ha:

	o project documentation in year 3, o implementation in year 4. • Irrigation system from water reservoir Vrnivec with area 1,107 ha: o project documentation in year 5, o implementation in year 6. • Irrigation system from water reservoir Svinjšček with area 188 ha: o project documentation in year 7, o implementation in year 8. • Irrigation system from water reservoir Pasji rep with area 822 ha: o project documentation in year 9, o implementation in year 10.
Synergies and conflicts with policy objectives	Conflicts: • Possible overexploitation of water resources – conflicts with Water Framework Directive [21] – River Basin Management Plan [27, 28]. Synergies: • Development Programme of Northern Primorska (Gorizia development regions) 2014-2020, measure A1P2 (page 237) [91]; • not yet confirmed Plan for development of Irrigation until 2020 (Irrigation Plan) [79] has included new irrigation system in the area of Vipava river basin; • Rural Development Plan 2014-2020 has funds available for construction of large irrigation systems (Measure M4.3)[74].
Acceptance	Medium (high acceptance with agriculture sector and low with water sector).
Suggested stakeholder involvement	Ministry of Agriculture, Forestry and Food on the basis of a proposal given by the applicant (proposer) issues and enforces regulation or decision on the introduction of an irrigation system according to the Agricultural Land Act. Proposers for the introduction of the irrigation system can be melioration communities or legal person on behalf of the owners of agricultural land on the planned irrigated area or individual owners of agricultural land that is planned to be irrigated. Ministries supporting services Chamber of Agriculture and Forestry of Slovenia (CAFS) (Regional units) could support farmers in the planning and implementation processes, but an initiative must come from farmers with interest of using water for irrigation. Municipalities can be initiators for future planning of irrigation systems and possibly help with management issues (as part of their public service). Within implementation process there are other institutions involved: Ministry of the Environment and Spatial Planning leads the SEA process (spatial plans), Slovenian Environmental Agency leads EIA process (if irrigation system needs a building permit, it is necessary to do an environmental impact assessment. On the basis of EIA assessment environmental consent is issued.), and Slovenian Water Agency that issues water permit. Due to amendments of Agricultural Land Act (Official Gazette of RS, no. 27/16) [106] there is the possibility that the local community (Municipalities or/and irrigation communities) can have a bigger role in management and maintenance of national (state) irrigation systems. Namely, if the interest is expressed, with conducted contract between the Ministry of Agriculture, Forestry and Food landowners and local community the ownership of national irrigation systems is transferred to the local community. At the same time the management and maintenance of the system is transferred as well (except for the management and maintenance of irrigation equipment as it is already owned and managed by the users) and so the national irrigation system becomes a local irrigation system.
Preconditions for success	The selected water source must have sufficient water quantities (issued water permit). Cooperation and agreement of land owners who own more than 80% of agricultural land where irrigation systems are planned. There must be clear interest of farmers (cultivating land that would be irrigated) to use irrigation systems and to pay for its usage.

	Operator of irrigation systems needs to be determined! Last but not least funds must be available for implementing the option. Within the document *Development Programme of Northern Primorska [91]* is stated one major conditions and that is: Before investing resources in the preparation of documentation for the construction of new irrigation systems it is reasonable to verify functionality and optimal utilization of existing irrigation infrastructure (eg. water reservoir Vogršček in the Vipava Valley).
Concrete examples where applied	Not available.

WMO 12: Reconstruction of existing irrigation systems

Short explanation	This option aims to replace the current irrigation network from water reservoir Vogršček to arable land. The existing irrigation systems are outdated, inappropriately managed and this results in unsustainable use of water for irrigation (pipes are leaking - loss of water, the lack of pressure in the system, etc.). This measure can prevent agricultural drought and consequently reduce the damage caused in the agriculture and consequently, also increase self-sufficiency in food. Also cleaner and more appropriate water for irrigation means healthier local food production. The establishment of proper irrigation systems, new technologically more efficient and equipped with proper agrometeorological support or modernization of existing irrigation systems with sensors for optimal irrigation, targeting the type of crop and soil, and also reducing water consumption caused by inappropriate irrigation techniques (sprinklers vs drip irrigation).
Addressed challenges	Water availability during droughts (A)
Target locations and water uses	Location: Upper and lower part of river basin. Water uses: Agriculture
Benefits	Increased irrigated crop production and self-sufficiency in food. Proper irrigation can reduce water consumption and pollution of groundwater caused by washouts of nutrients, fertilizers and plant protection products.
Potential negative impacts	Possible overexploitation of water resources (known as rebound effect (or take-back effect) that means the reduction in expected gains from new technologies that increase the efficiency of resource use). If irrigation properly in place farmers could choose to cultivate crops that need more water (are usually economically speaking, more profitable).
Timeline of implementation	Short-term (under 2 years' time)
Feasibility	Minor barriers – existing irrigation systems need to be reconstructed and this can represent a financial burden for some farmers already struggling with the loss of income due to market situation.
Robustness	No. This option only functions if there is sufficient water for irrigation. Therefore, if the future is extremely dry, or wet, the option does not have a great effect anymore.
Flexibility	Yes.
Costs/Actions	The total discounted cost toward year 2030: 2,864,605 euros (EUR 2018, discount rate: 5%) comprises: • to review status of existing irrigation systems, needs and scope of the needed reconstruction works – 3 person month, year 1; • Preparation of project documentation (8 % of investment costs), year 1; • Reconstruction works in year 2 - for cost estimation we decided to take into account cost assessment of planned reconstruction of existing irrigation systems in Action plan for the development of irrigation in the RS until 2020 [79]. Action plan financially evaluated the measure with help of data based on information on funds of rural development program (2007 - 2013) intended for the reconstruction of existing irrigation systems. It has been estimated that 2,395.00 €/ha is the cost of reconstruction of existing irrigation system.). As no data is available on the status of existing irrigation systems we assumed that all 1,000 ha of existing irrigation systems need to be reconstructed due to the fact that most systems are 20 to 30-years old; • Maintenance (2 % of investment costs) starting from the year following the implementation.
Synergies and conflicts with policy objectives	No known conflicts. Synergies:

	• Development Programme of Northern Primorska (Gorizia development regions) 2014-2020, measure A1P2 (page 237) [91]; • not yet confirmed Plan for development of Irrigation until 2020 (Irrigation Plan) [79] promotes renovations of existing irrigation systems; • Rural Development Plan 2014-2020 has funds available for reconstruction of irrigation systems (Measure M4.3) [74]. *Possible funding through CAP/European Agricultural Fund for Rural Development (EAFRD) within sub measure M1.2 - support for demonstration activities and information activities but most importantly within art. 17 Investments, linked to irrigation (1: efficient, responsible and sustainable use of water resources in agriculture: only indirect links to Significant Water management Issues (SWMIs); cooperation and irrigation/water savings possible).*
Acceptance	High acceptance by the agriculture sector.
Suggested stakeholder involvement	Stakeholders involved in the process of reconstruction of existing irrigation systems are common to those that are involved in construction of new irrigation systems (look above at the WMO 11: Construction of new irrigation systems).
Preconditions for success	Funds must be available for implementing WMO. Farmers (users of the system) would likely need financial initiatives. Namely they have limited financial capacities (also due to the current situation on the market). It is also the case that farmers are not well connected between each other although agricultural cooperative association (KZ Vipava) exist. There is incoherent organization of the existing irrigation fields and so we believe that this issue needs to be solved first by establishment of proper operator - active operator of irrigation system that has also expert knowledge on irrigation (requires formal legal arrangement) together with proper system of financing the operation of irrigation systems (possible introduction of counters for water consumption). Commitment of farmers using irrigation systems and paying usage must be achieved.
Concrete examples where applied	Not available.

WMO 13: Restoration of Vipava river and its tributaries

Short explanation	This option aims to restore the functionality of natural aquatic and also riparian ecosystems on Vipava river and its tributaries. Aim of this option is also to start implementation procedures for improvement of ecological status of Vipava River and all the other benefits that comes together with this option such as improvement of hydromorphological elements of river body quality.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole (excluding settlement areas). Water uses: Local population, Tourism, Agriculture, Water management.
Benefits	With restoration of regulated watercourses, the stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems. With retaining flood waves and prolonging the runoff, flood magnitudes can be reduced downstream. With natural self-cleansing capability, based essentially on the action of microorganisms and plants that can survive in polluted water or soil, and either absorb, break down or neutralize harmful waste substances, water quality is improved or preserved. With capacity of retaining water, this results in natural enrichment of groundwater (raising the level of ground water) and also results in natural humidification of the soil. Providing a suitable habitat for animal and plant species that are tied to occasional flooding and so maintain a favourable status of protected and endangered plant and animal species (Natura 2000 management) and creating conditions for preserving biodiversity of aquatic, riparian and wetland ecosystems. If buffer zones or water margins along watercourses are established they can also slow down the wind and locally prevent wind erosion. Giving the Vipava River and its tributaries more needed space, natural river processes and link between water and terrestrial ecosystems can be restored. In the areas where agriculture prevails, improving habitat and biodiversity, and thus connectivity of ecosystems is important. Increased self-cleaning capacity of the watercourse eases the effects of chemicals (pesticides, insecticides) on aquatic and riparian ecosystems and the quality of water is preserved. Increased retention function of aquatic and riparian ecosystems results in natural humidification of the soil and raised groundwater level.).
Potential negative impacts	Restoration of riparian ecosystems and natural flow needs a lot of space at the expense of agricultural land. Furthermore, when restoring the natural water flow conditions, it can affect hydropower. Contradiction with the WMOs on reservoirs (#8, #9).
Timeline of implementation	Long-term (> 6 years' time).
Feasibility	Minor barriers – low acceptance by farmers that cultivate land near watercourses.
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost toward year 2030: 5,868,377 euros (EUR 2018, discount rate: 5%). For the purpose of cost estimation, few options for restoration are prepared by IzVRS expert. On Vipava river and its tributaries all together 23 locations potentially suitable for restoration have been determined. On Vipava river, 16 potential locations have been determined with a total of 11 km (11,016 metres) and 74 ha (40 m protected zone on each side). On tributaries, 7 potential locations have been determined with a total of 11 km (10,910 metres) and 11 ha (5 m protected zone on each side). For calculations of the area of restoration, one- or two-sides of riverbank was taken into account. Main costs have been determined with the help of IzVRS expert. The costs consist of: • Preparation works to examine potential locations for restoration, preparation of "restoration plan" by expert 0.25 person month/location, 23 locations would mean 6 person months in year 1;

	• Purchase of land (separately for each location); • Preparation of project documentation (separately for each location) (8 % of investment costs); • Implementation of measures (Removal of lateral walls / hard lateral structures (allowing for morphologic development) and planting riparian reed vegetation) (separately for each location, not for all locations planting riparian reed vegetation is planned); • Maintenance (2 % of investment costs).
Synergies and conflicts with policy objectives	Possible conflicts: • Natura 2000 Management Programme for Slovenia for the period 2015-2020 [70] – some species (slo: “močvirska sklednica” or *Emys orbicularis*) need to have riverbank covered with grass and not trees, bushes (need to be trimmed) – here different maintenance techniques must be adopted (species specifics). • There are known sections where the river continuity must not be enabled (small hydropower plant in Prvačina). This is due to the fact that there are Natura 2000 fish species (*Barbus plebejus*) whose living area is upstream of the hydropower plant dam (in Prvačina). The predatory fish species (*Silurus glanis*) live downstream of the dam where this Natura 2000 species (*Barbus plebejus*) are no longer present. Synergies: • Habitat Directive [72] – within Natura 2000 Management Programme for Slovenia for the period 2015-2020 [70], Vipava Valley (SI3000226) is proposed for restoration. • Water Framework Directive f21] – Article 4: Member States shall protect, enhance and restore all surface water bodies, for artificial and heavily modified water bodies with the aim of achieving good ecologic status/potential. • River Basin Management Plan [29] – within measure –“Sustainable regulation of the watercourse and flood control reservoir (dry reservoirs)” (label DUDDS5.2). • Waters Act [59] determines in Article 14 a 15 m (40 m) width buffer stripes for Rivers of first order (Vipava) of width and 5 m width buffer stripes for Rivers of second order (its tributaries). Within Article 16 it determines that local community can in order to facilitate the overall water use, decide that the status of natural public water good is established on the part of coastal land of inland waters. • Flood Risk Management Plan [63]– measure U2 or so called “Identification, establishment and maintenance of the retention areas for high waters”. • Programme for the Management of Fish in Inland Waters of the Republic of Slovenia, 2015 [76] – The program for the management of fish in inland waters 2010-2021 has already proposed Vipava river (section Vipava – Kasovlje) for restoration. *Possible funding through CAP/European Agricultural Fund for Rural Development (EAFRD) within Art. 18 ("restoring agricultural production potential damaged by natural disasters and catastrophic events and introduction of appropriate prevention actions"), Art. 24 ("prevention and restoration of damage to forests from forest fires and natural disasters and catastrophic events) and Art. 17 (investments in non-productive physical assets, such as achieving biodiversity conservation status of species and habitat as well as enhancing the public amenity value of a Natura 2000 area or other high nature value systems). Also through The INTERREG MED Programme 2014-2020 within priority axis 3, European Regional Development Fund (ERDF) within TO 5 (climate change adaptation, risk prevention): ecosystem-based approaches for hydromorphological alterations (reconnection of wetlands/floodplains), possibly nutrient pollution (diffuse pollution from agriculture) and TO 6 (protecting the environment and promoting resource efficiency): organic pollution (UWWTP, industrial point sources), nutrient pollution (UWWTP, industrial point sources), hazardous substances pollution (UWWTP industrial point sources), hydromorphological alterations (reconnection of wetlands/floodplains). Also possible funding through Cohesion Fund (CF) within Climate change adaptation and risk prevention: hydromorphological alterations (reconnection of wetlands/floodplains).*

Acceptance	High acceptance by environmental sector (The Institute of the Republic of Slovenia for Nature Conservation) although on third workshop concern was raised that during construction works negative impact on the river ecosystem can emerge. Low acceptance by farmers that cultivate land near watercourses. On first workshop they commented that in past money was spent for regulating the Vipava River and its tributaries. Now it would be the opposite and does not make sense.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning could give financial support by directing funds from Water fund for implementation of this measure. The ministry is with its bodies (e.g. , Slovenian Environmental Agency, The Institute of the Republic of Slovenia for Nature Conservation and Slovenian Forest Service) involved in SEA procedures – obtaining permits for implementations of the option. This option has support from Municipalities that are already involved in some projects within Council for Vipava (Svet za Vipavo, projektna skupina). Local population – inhabitants with their knowledge and valuable experience need to be involved in planning of restoration.
Preconditions for success	Funds available for implementing WMO (buying land, implementation). Acceptance of farmers to relinquish their farm plots and land owners to sell their land near watercourses. Also spatial planning authorities must give consent for implementation of the option.
Concrete examples where applied	LIFE project Ljubljanica Connects (“Ljubljanica povezuje”). Project Kučnica/ Kutscheniza (European Territorial Cooperation, the Operational Programme Slovenia–Austria 2007-2013). Publication on all restored watercourses [107]

WMO 14: Restoration of old meanders and oxbows of Vipava river and its tributaries

Short explanation	This option aims to restore functionality of abandoned (non-functional) natural aquatic ecosystems called meanders and oxbows on Vipava river and its tributaries. The stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems.
Addressed challenges	Water availability during droughts (A), Flood risk reduction (B), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole (focusing on locations of abandoned meanders that sometimes functioned on the Vipava River). Water uses: Local population, Tourism, Agriculture, Water management.
Benefits	The stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems. With retaining flood waves and prolonging the runoffs, floods can be reduced downstream. With natural self-cleansing capability, based essentially on the action of microorganisms and plants that can survive in polluted water or soil, and either absorb, break down or neutralize harmful waste substances, water quality is improved. With capacity of retaining water, this results in natural enrichment of groundwater (raising the level of ground water) and also results in natural humidification of the soil. Providing a suitable habitat for animal and plant species that are tied to occasional flooding and so maintain a favorable status of protected and endangered plant and animal species (Natura 2000 management) and creating conditions for preserving biodiversity of aquatic, riparian and wetland ecosystems.
Potential negative impacts	When restoring the natural water flow, it can affect hydropower. Contradiction with the WMOs on reservoirs (#8, #9).
Timeline of implementation	Medium (2 to 6 years).
Feasibility	Minor barriers – low acceptance by farmers that cultivate land near watercourses (still this will not affect their land – all potential areas are covered with forest and landowner is the government.
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost toward year 2030: 1,276,262 euros (EUR 2018, discount rate: 5%). For the purpose of cost estimation, few options for restoration are prepared by IzVRS expert. On Vipava river and its tributaries all together 9 locations potentially suitable for restoration have been determined with a total of 2 km (2,721 metres). Main costs have been determined with the help of IzVRS expert. The costs consist of: • Preparation works to examine potential locations for restoration, preparation of “restoration plan” by expert 0.25 person month/location, 9 locations * 0.25 month = 2.5 person months; • Implementation of measures (restoration of meander or oxbow) together with preparation of project documentation; • Maintenance (2 % of investment cost).
Synergies and conflicts with policy objectives	Possible conflicts: • Natura 2000 Management Programme for Slovenia for the period 2015-2020 [70] – some species (slo: “močvirska sklednica” or *Emys orbicularis*) need to have riverbank covered with grass and not trees, bushes (need to be trimmed) – here different maintenance techniques must be adopted (species specifics).

	• There are known sections where the river continuity must not be enabled (small hydropower plant in Prvačina). This is due to the fact that there are Natura 2000 fish species (*Barbus plebejus*) whose living area is upstream of the hydropower plant dam (in Prvačina). The predatory fish species (*Silurus glanis*) live downstream of the dam where this Natura 2000 species (*Barbus plebejus*) are no longer present. Synergies: • Habitat Directive [72] – within Natura 2000 Management Programme for Slovenia for the period 2015-2020 [70], Vipava Valley (SI3000226) is proposed for restoration. • Water Framework Directive [21] – Article 4: Member States shall protect, enhance and restore all surface water bodies, for artificial and heavily modified water bodies with the aim of achieving good ecologic status/potential. • River Basin Management Plan [29] – within measure –"Sustainable regulation of the watercourse and flood control reservoir (dry reservoirs)" (label DUDDS5.2). • The program for the management of fish in inland waters 2010-2021 [76] has already proposed Vipava river (section Vipava – Kasovlje) for restoration. • Waters Act [59] determines in Article 14 a 15 m (40 m) width buffer stripes for Rivers of first order (Vipava) of width and 5 m width buffer stripes for Rivers of second order (its tributaries). Within Article 16 it determines that local community can in order to facilitate the overall water use, decide that the status of natural public water good is established on the part of coastal land of inland waters. • Flood Risk Management Plan [63]– measure "Identification, establishment and maintenance of the retention areas for high waters" (label U2). *Possible funding same as with WMO 13.*
Acceptance	High acceptance by environmental sector (The Institute of the Republic of Slovenia for Nature Conservation) although on third workshop concern was raised that during construction works negative impact on the river ecosystem can emerge.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning could give financial support by directing funds from Water fund for implementation of this measure. The ministry is with its bodies (e.g. , Slovenian Environmental Agency, The Institute of the Republic of Slovenia for Nature Conservation and Slovenian Forest Service) involved in SEA procedures – obtaining permits for implementations of the option. This option has support from Municipalities that are already involved in some projects within Council for Vipava (Svet za Vipavo, projektna skupina). Local population – inhabitants with their knowledge and valuable experience need to be involved in planning of restoration.
Preconditions for success	Funds available for implementation of the option. Money for buying land is not needed as the potential areas for restoration are all in owned by the government.
Concrete examples where applied	LIFE project Ljubljanica Connects ("Ljubljanica povezuje"). Publication on all restored watercourses. BioMura project (LIFE06NAT/SLO/00006) establishing of old canal distributaries.

WMO 17: Reconstruction of stabilizing and transverse constructions from natural stone in the smaller tributaries of Vipava river

Short explanation	This option aims to reconstruct stabilizing and transverse constructions from natural stone in the smaller tributaries of the Vipava River. These barriers would be in function of slowing down the flow and retention of sediment and woody debris.
Addressed challenges	Flood risk reduction (B)
Target locations and water uses	Location: River Basin as a whole. Water uses: Water management.
Benefits	Reducing floods and flood damages downstream.
Potential negative impacts	Depending on the material and technical solution (height) - if constructions would be passable for water organisms, material as rocks not concrete is used, then no negative impacts.
Timeline of implementation	Short-term (under 2 years' time), and as stakeholders commented on third workshop the option must be implemented continuously through mid- (2 to 6 years) and long-term (> 6 years' time) as it is considered as much needed maintenance.
Feasibility	No major barriers.
Robustness	No.
Flexibility	No.
Costs/Actions	The total discounted cost toward year 2030: 173,934 euros (EUR 2018, discount rate: 5%). No data on the state of stabilizing and transverse constructions for Vipava river basin exist. There are some data on web portal "e-Vode"73 on where water infrastructure in located, but the state and needed reconstruction works are not known. For this option steps are proposed: • Analysis of all stabilizing and transverse constructions (weirs) on the smaller tributaries on steep slopes needs and review of activities that are already carried out (through concessions) intended mainly to reduce flood risk. Afterwards priority areas of reconstruction need to be determined, taking into account the objectives of the Water and Floods directive and also existing iniciatives from involved Municipalities – 6 person month • Preparation of the reconstruction project (8 % of investment costs). • Implementation of the measure – cost estimation of reconstruction/implementation of one transverse construction for stabilizing river bed was prepared by IzVRS expert – for 5 meter wide watercourse (5 meters into the bottom level of 0.5 meters, 0.5 meters deep): 11,500.00 €/location; • Maintenance (2 % of investment costs) starting from the year following the implementation.
Synergies and conflicts with policy objectives	Conflicts: It depends. If torrents, where migratory fish do not live, river continuity is not obligatory and is not reasonable. Also somewhere this existing constructions will need to be reconstructed to achieve flood safety, for some that would not have this function, could be removed (WMO #13). At this point we do not know locations and best solutions. Synergies: • Flood Risk Management Plan [63]– measure "Regular maintenance of watercourses, water facilities and aquatic and inshore land" (label U10). • Natura 2000 Management programme for Slovenia [70] - transversal structures in a way can imitate natural conditions in upper parts of torrent tributaries in Vipava river basin. With use of sustainable techniques and material we believe that some co-benefits could be achieved. One of positive things would be increased aeration. • Draft Spatial plan of the Municipality of Ajdovščina, June 2014 [108] within Article 104 determines: Arrangements on watercourses and torrents

	must be made primarily from natural materials. The natural dynamics of watercourses must be maintained, except for regulations needed for protection against floods and torrential waters. • Ordinance on Municipal Spatial Plan of the Municipality of Vipava [109]within Article 116 determines: Arrangements on watercourses and torrents must be made primarily from natural materials.
Acceptance	High acceptance with water sector and municipalities.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning could give financial support by directing funds from Water fund for implementation of this measure. In cooperation with its bodies like Slovenian Water Agency and Slovenian Environmental Agency (together with the concessionaires) they could implement the option. Slovenian Water Agency is responsible for water (regulation) management. This option can contribute to other objectives of water management (flood safety). Support would be given from municipalities (local communities), hydrologists, and planners, possible in the scope of proposed inter-municipal working group. The Fisheries Research Institute of Slovenia can ensure expert support in the process of the implementation. Namely the Institute performs public service activities in the fields of Freshwater fisheries. For each intervention into the watercourse it is necessary to obtain requirements or guidelines of the Institute. Guidelines must be considered in project documentation. The Institute also carries out fish monitoring and holds information on fish species and communities within the area of intervention. These data are the basis for the preparation of the guidelines.
Preconditions for success	Funds need to be available for implementing the option. There is a clear need for an analysis which barriers need reconstruction or are no longer needed and can be removed (as part of restoration option). Need to combine this measure with other measures aiming at reducing floods.
Concrete examples where applied	Not available.

WMO 19: Improving the system of payment for water used for irrigation

Short explanation	This option aims to improve the system of payment for water used for irrigation. Water availability would be reflected in the payments that need to be made to allow water being used for irrigation purposes. Two options are proposed: 1. To lower the limit of yearly consumption (from 5.000 m3 to 2.500 m3) when farmers do not need to pay for actual water use by changing the provisions of the *Decree on the water fee* [110]. 2. To increase the level of water reimbursement fee for the use of water for irrigation of agricultural land to the value specified for the irrigation of non-agricultural land (in year 2013 that was 0.0015 €/m3 for agricultural land compared to non-agricultural land 0.0919 €/m3) by changing the provisions of the *Decision determining the amount of water charge basis for the use of water, alluvial deposits and water areas* [111].
Addressed challenges	Water availability during droughts (A), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Local population, Agriculture, Water management.
Benefits	By reflecting water availability in pricing, this measure would result in reducing water consumption (from water reservoirs Vogršček, groundwater, surface water), and can also result in providing incentives for more efficient water use, all potentially resulting in reducing impact on aquatic ecosystems (more sufficient quantities of water mean better water quality and ecological status).
Potential negative impacts	Potential conflicts with users of water for irrigation (farmers, inhabitants).
Timeline of implementation	Short-term (under 2 years' time).
Feasibility	Minor barriers – low acceptance of agricultural sector.
Robustness	Yes.
Flexibility	No, as the measure will only have an impact if implemented entirely.

Costs/Actions	The total discounted cost toward year 2030: 83,895 euros (EUR 2018, discount rate: 5%).
	There are two possible ways to improve system of payment for water used for irrigation. Both options need to be further analysed if feasible:
	• Overall analysis of both proposed options, their effectiveness, and on farmers willigness to pay more for irrigation – 6 person month in year 1;
	• To lower the limit of yearly consumption (from 5.000 m3 to 2.500 m3) when farmers do not need to pay for actual water use.
	  ○ Amendments of Decree on the water fee (http://www.pisrs.si/Pis.web/pregledPredpisa?id=URED2657). Here it is important to know, if any analysis is needed to determine boundaries of yearly consumption showing also result of such an action! – 7 person month in year 2;
	• To increase the level of water reimbursement fee for the use of water for irrigation of agricultural land to the value specified for the irrigation of non-agricultural land (in year 2013 that was 0.0015 €/m3 for agricultural land compared to non-agricultural land 0.0919 €/m3).
	  ○ Amendments of Decision determining the amount of water charge basis for the use of water, alluvial deposits and water areas [111] – 4 person month in year 2.

Synergies and conflicts with policy objectives	No known conflicts. Synergies with River Basin Management Plan [29], within measure –" The provision of compensation of environmental costs and the cost of water as a natural resource" (label 3ED).

Acceptance	Low acceptance by farmers as they do not believe this will not solve the problems with water quality and quantity. High acceptance by water sector and environmental sector.
Suggested stakeholder involvement	Ministry of Agriculture, Forestry and Food with supporting services of Chamber of Agriculture and Forestry of Slovenia (CAFS) (Regional units), an initiative must come from Ministry of the Environment and Spatial Planning and its supportive bodies Slovenian Water Agency and Slovenian Environmental Agency.
Preconditions for success	Strong political support/back-up would be needed. Review of good practices of the system of payment for water used for irrigation around the world. Also analysis to definite exact figure on (1) changing the limit of yearly consumption (from 5.000 m^3 to 2.500 m^3) when farmers do not need to pay for actual water use with assessed impacts of the option and (2) increasing the level of water reimbursement fee for the use of water for irrigation of agricultural land (in year 2013 that was 0.0015 €/m^3 for agricultural land compared to non-agricultural land 0.0919 €/m^3). Within the payments for the usage of irrigation systems the costs of operation and maintenance in addition to water reimbursement fee should be taken into consideration. An appropriate professional manager (operator) of irrigation systems needs to be assigned (determined).
Concrete examples where applied	Not available.

WMO 20: Preservation of existing and introduction of new shelterbelts

Short explanation	This option aims to protect the land against the effects of wind. Shelterbelts would reduce velocity of the strong winds (Bora), and would reduce damage in agriculture caused by this strong bora wind and also would be in function of reducing evaporation and the impact of summer winds on soils (drying, loss of water in soil). Also this vegetation belts represent a habitat for animal species that feed on insects (biodiversity, pest management) - lower consumption of plant protection products and related water pollution (sustainable agriculture). It is important to use native trees species - probably deciduous trees.
Addressed challenges	Water availability during droughts (A), Appropriate water quality (C)
Target locations and water uses	Location: Upper part of the river basin. Water uses: Agriculture.
Benefits	Reducing wind damages, reducing evaporation and impact of summer winds on soil. Increasing habitat for animal species – can result in lower consumption of plant protection products and related water pollution (sustainable agriculture). Option can help create a rich cultural landscape that is a good basis for development of sustainable tourism.
Potential negative impacts	None.
Timeline of implementation	Short- (under 2 years' time) to mid-term (2 to 6 years' time) – Shelterbelts can fully function only when trees grow to a certain height.
Feasibility	Minor barriers due to low awareness of farmers, also not available funds for implementation and operation of the option. The land where shelterbelts are planned was already reserved within Republican Green Plan and excluded at the time of land readjustment and is treated as common good (slo: "javno dobro").
Robustness	Yes.
Flexibility	Yes.
Costs/Actions	The total discounted cost toward year 2030: 1,018,971 euros (EUR 2018, discount rate: 5%). Potential locations and length of shelterbelts in upper part of Vipava river basin (last information from March 2015): • Ajdovsko polje: 6,500 meters, • Lokavec: 8,850 meters, • Log-Zemono: 14,506 meters, • Vipavski Križ: 10,370 meters. Steps for successful implementation of shelterbelts: • Preparation of implementing regulation or amending existing Forest Act of its implementing regulations, with the objective to regulate the system of financing for the implementation and maintenance of shelterbelts – 4 person month in year 1; • Already mentioned new implementation regulation or amendments of the existing ones, proper control of shelterbelts must be ensured – 12 person month from year 2 on; • Implementation of shelterbelts (all together 40,226 meters) - 11.70 Eur/m; • Maintenance - 3.70 Eur/m (cost in 4 years).

Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Habitat and Bird Directive [38, 39] – within Natura 2000 Management Programme for Slovenia for the period 2015-2020 [70], Vipava Valley (SI3000226) is proposed for restoration. • Water Framework Directive [21] – Article 4: Member States shall protect, enhance and restore all surface water bodies, for artificial and heavily modified water bodies with the aim of achieving good ecologic status/potential. • Common Agricultural Policy (CAP) – RDP 2014 – 2020. *Possible funding through CAP/European Agricultural Fund for Rural Development (EAFRD) within Art. 18 ("restoring agricultural production potential damaged by natural disasters and catastrophic events and introduction of appropriate prevention actions"), and Art. 17 (investments in non-productive physical assets, such as achieving biodiversity conservation status of species and habitat as well as enhancing the public amenity value of a Natura 2000 area or other high nature value systems). Also through The INTERREG MED Programme 2014-2020 within priority axis 3 and LIFE (Climate Change Adaptation)..*
Acceptance	High acceptance by environmental sector (Slovenian Forest Service, The Institute of the Republic of Slovenia for Nature Conservation).
Suggested stakeholder involvement	Ministry of Agriculture, Forestry and Food together with Municipalities and Ministry advisory service Chamber of Agriculture and Forestry of Slovenia (CAFS) (Regional units) and Farmland and Forest Fund of the Republic of Slovenia. Implementation and maintenance with the help of the experts – ZGS – Slovenian Forest Service. Farmers, local inhabitants.
Preconditions for success	It is essential to determine the operator of shelterbelts and to make funds available for implementation and later on for operation of the option. It is essential to raise awareness among local inhabitants (WMO 4) and farmers (WMO 3) of the positive effects of shelterbelts and involve them actively in their implementation.
Concrete examples where applied	In the frame of Republic Green plan (1970-1980), shelterbelts (wind barriers) were planted to minimize the impact of bora wind on agriculture. Most of them were illegally removed by farmers (lack of awareness), only few were left till today (Lokavec).

WMO 21: Removal of invasive non-native species

Short explanation	Non-native plant and animal species have a direct impact on the biodiversity of aquatic environment, changing and threating the natural balance of aquatic ecosystems (their functional and structural features). With changing the composition of riparian and aquatic habitats, they degrade ecosystems and so have indirect impact on water quality. Introduction of fish in aquatic systems can affect trophic relationships and set off "trophic cascades" with resulting declines in native species and degradation of water quality [114] (e.g. Common Carp (Cyprinus carpio) feeds by searching through underwater vegetation. This feeding habit uproots plants which muddies the water. This makes it hard for other fish to see and destroys the food and cover for other fish. Also they compete with native species or are their predators, can be vectors of disease to native species). This can be also the case of plant species (e.g. Japanese knotweed threatens native plants and animals by forming dense thickets, blocking routes used by wildlife to disperse). More exactly there are problems with non-native fish species that were introduced by fishermen (fish farming) - for Vipava river it means a biological pressure - 9 non-native fish species were recorded in the project Analysis of biological pressures With measure identification, data collection and removal of invasive non-native species is planned. This measure would be addition to measure of restoration of watercourses in river basin to maintain a favorable status of protected and endangered plant and animal species.
Addressed challenges	Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Water management, Nature conservation, Fishery
Benefits	Obtaining data on all invasive non-native species. Reducing number of invasive non-native species and biological pressures.
Potential negative impacts	None.
Timeline of implementation	Short- (under 2 years' time) to long-term (> 6 years' time) till year 2030.
Feasibility	Minor barriers – low acceptance with fishery (posing restrictions with fish introduction), understaffing and limited financial capacities of institutions that should implement this option. Limited success of removal of invasive fish species.
Robustness	Yes.
Flexibility	No - The measure will only have an impact if implemented entirely. Otherwise, the species might come back. (Note: Depending on species – which species, their prevalence, etc.)
Costs/Actions	The total discounted cost toward year 2030: 175,921 euros (EUR 2018, discount rate: 5%). Not enough data on the species, number and prevalence is available (available only for fish species in Vipava river). Hence next steps are needed to implement this WMO: • Identification and data collection of invasive non-native species in Vipava river basin – 2 person month, year 1. 4. 7. 10, 13; • Determination for which species, the area and the method of removal and disposal is possible – 1 person month, year 1. 4. 7. 10, 13; • Preparing work program of removal of invasive non-native species – 0.5 person month, year 1. 4. 7. 10, 13; • Choosing the location of the disposal of invasive non-native species – 0.5 person month, year 1. 4. 7. 10, 13; • Preparing and execution of monitoring programme – 1 person month, year 1. 4. 7. 10, 13; • Execution of removal of non-native species (priority: Vipava river; duration of the removal approx. 5 years) – 2 person month, year 1. 4. 7. 10, 13.
Synergies and conflicts	No known conflicts. Still Slovenian legislation does not use the terminology/definition of invasive non-native species [113]. A legal void is also in the

with policy objectives	protocol of removing invasive non-native plant or animal species that threaten native species, since implementing regulations envisaged by the Nature Conservation Act has not yet been adopted. Synergies: • Water Framework Directive [21] - Establishing monitoring systems for the purpose of estimating the values of the biological quality elements specified for each surface water category or for heavily modified and artificial bodies of surface water. In applying the procedure set out below to heavily modified or artificial water bodies, references to ecological status should be construed as references to ecological potential. Such systems may utilise particular species or groups of species which are representative of the quality element as a whole. • River Basin Management Plan - within measures “Direct removal of invasive non-native species” (label DUPPS3), “Systematic data collection and processing of invasive non-native species” (label DDU9), “Preventing the spread of invasive non-native species” (label DDU33) and “Amendments of legislation in the field of non-native species” (label DDU34). • Habitats Directive [39] –promoting measures that help establish natural watercourse biocoenosis. • Natura 2000 Management programme for Slovenia [70] - without exotic species of turtles, the stock of native fish that does not threaten amphibians, excluding non-native species in streams, without the propagation of non-native species (crayfish), excluding non-native species in the ponds, biocoenosisof natural watercourse, without the propagation of non-native species of catfish over a dam in Prvačina. • Nature Conservation Act [34] - Terminology/definition for non-native species can be adopted/used from receptive Europe-wide lists. • EU Biodiversity Strategy to 2020 [114] - Protecting species and their habitats, help us combat climate change and adapt to its impacts and contribute to meeting the goals of the EU's resource-efficient Europe initiative. One of 6 priority targets that aim to combat invasive alien species. • Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species [115]- Sets out rules to prevent, minimise and mitigate the adverse impact on biodiversity of the introduction and spread within the Union, both intentional and unintentional, of invasive alien species. • Programme for the Management of Fish in Inland Waters of the Republic of Slovenia [76]: The program for the management of fish in inland waters 2010-2021 has already proposed that in Vipava river population of *Silurus glanis* needs to be reduced by classifying it as an invasive species. *Possible funding through The INTERREG MED Programme 2014-2020 within priority axis 3 and LIFE Nature & Biodiversity (sub-programme for Environment) - Within the LIFE Nature and Biodiversity strand, specific funding is targeted at Biodiversity, a LIFE project category for innovative or demonstration projects that tackle wider biodiversity issues. These can range from the creation of green infrastructure, such as species corridors, to climate change adaptation measures and the removal of invasive species.*
Acceptance	Highly acceptable by environmental sector. Low acceptable by fishermen.
Suggested stakeholder involvement	Ministry of the Environment and Spatial Planning with the support of Slovenian Water Agency, Slovenian Environmental Agency and The Institute of the Republic of Slovenia for Nature Conservation could with the implementation of the option achieve objectives defined in national and EU legislation and obtain information in-situ. This institutions need to cooperate with the Ministry of Agriculture, Forestry and Food and their supporting bodies (Fisheries department - fish species), Agricultural Institute of Slovenia (KIS, for plant species)) by raising awareness among farmers and owners of fish farms. Some of them could help organize the removal. On third workshop local Biotechnical School is already involved in raising awareness and educating high school students. They would need support in a form of materials for awareness campaign for different publics (kindergarten, primary school…). They are willing also to actively participate in the implementation of the option.
Preconditions for success	Knowing the ecology of all species so that removal is successful, still it is known that removal of these species (especially fish) has limited success

	[116]. Raising awareness among local people, also including them in the removal of invasive species. Local Slovenian Environmental Agency and The Institute of the Republic of Slovenia for Nature Conservation need to be more involved. Slovenia should adopt National action plan according to Regulation (EU) No 1143/2014 [115].
Concrete examples where applied	LIFE project – removing Japanese knotweed on Ljubljansko barje [117]

WMO 22: Construction of municipal wastewater treatment plants and sewage systems

Short explanation	Problem of small and dispersed settlements and insufficient sewage systems and municipal wastewater treatment causing pollution (organic, pollution with nutrients and pathogens) of surface and ground water. All municipal wastewater treatment plants (WWTP), also can be implemented as biological WWTP, constructed wetlands for wastewater treatment, etc., depending on the analysis of most suitable treatment technology. Construction of small wastewater treatment plants Lozice, Črnice and other small WWTP in dispersed settlements. Also additional treatment of municipal wastewaters in the areas of bathing waters (in the case of the establishment of eco-bathing).
Addressed challenges	Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Local population, Water management.
Benefits	Reducing burdening waters with pollutants (organic, nutrients, pathogens) and so would result in better water quality (achieving objectives of WFD). Also result in good quality for bathing waters.
Potential negative impacts	None.
Timeline of implementation	Short-term (under 2 years' time).
Feasibility	Minor barriers – lack of funds available for the implementation. Municipalities have problems with limited financial capacities (there are EU funds available but VAT is not eligible cost). They have also problems with acquisition of easements.
Robustness	No - often, WWTP are planned for a certain throughput. If, due to water scarcity in the future, this is not given, the WWTP might not be effective.
Flexibility	No.

Costs/Actions	The total discounted cost toward year 2030: 55,461,147 euros (EUR 2018, discount rate: 5%) comprises the costs of the preparation of the project documentation and implementation with maintenance costs of sewage system for about 26,000 person equivalent and wastewater treatment plants for about 26,300 person equivalent.
	The overall results have been prepared on the basis of the number of PE in each agglomeration:
	• Agglomerations under 2,000 PE (no. of person equivalent):
	    ○ 21,225.44 PE is without existing public sewage system – cost of implementation of sewage system for agglomerations under 2,000 PE is 1,500 €/PE;
	    ○ 21,137.05 PE is without existing (municipal) WWTP - cost of implementation of WWTP for agglomerations under 2,000 PE is 800.00 €/PE;
	    ○ Project documentation (8% of implementation costs);
	    ○ Maintenance (2 % of implementation costs).
	• Agglomerations above 2,000 PE (no. of person equivalent):
	    ○ 4,767.36 PE is without existing public sewage system – cost of implementation of sewage system for agglomerations above 2,000 PE is 1,000 €/PE;
	    ○ 5,207.80 PE is without existing (municipal) WWTP - cost of implementation of WWTP for agglomerations above 2,000 PE is 500 €/PE;
	• Project documentation (8% of implementation costs);
	• Maintenance (2 % of implementation costs).

Synergies and conflicts with policy objectives	No known conflicts. Synergies: • Council Directive 91/271/EEC [47]- Determination of priority areas for the construction of sewerage systems and municipal wastewater treatment plants. • National legislation regulating water quality (Waters Act [59] and its statutory instruments) and wastewater treatment (Operational programme for the discharge and treatment of urban waste water [69], etc.). - Determination of priority areas for the construction of sewerage systems and municipal wastewater treatment plants. *Possible funding through European Regional Development Fund (ERDF)(within TO 6 (protecting the environment and promoting resource efficiency): organic pollution (UWWTP, industrial point sources), nutrient pollution (UWWTP, industrial point sources), hazardous substances pollution (UWWTP industrial point sources), hydromorphological alterations (reconnection of wetlands/floodplains)) and Cohesion Fund (CF) (Investment in the water and waste sectors, and the urban environment: organic pollution (UWWTP, industrial point sources), nutrient pollution (UWWTP, industrial point sources, urban run-off), hazardous substances pollution (UWWTP, industrial point sources, urban run-off).*
Acceptance	High acceptance by local population, water sector.
Suggested stakeholder involvement	Municipalities (and local communities) and Operators of public service of collection and treatment of wastewater are already involved in accordance with their financial capacity. Planning process in cooperation with Ministry of the Environment and Spatial Planning and its bodies (SEA and EIA processes). Individuals (where public sewage system is not planned). Ministry has also the role of setting priorities for agglomerations that urgently need sewage system and WWTP (in phase of preparation of new Operational programme).
Preconditions for success	Funds available for implementing the option need to assured. Explore the options of convincing people to replace inappropriate septic tanks (slo: “nepretočnih”) with suitable WWTP. To raise awareness among inhabitants to replace inappropriate septic tanks (slo: “nepretočnih”) with suitable WWTP.
Concrete examples where applied	WWTP Vipava (central WWTP - trial operation). Still in construction WWTP Vrtojba.

WMO 23: The cultivation of crops that are resistant to climate changes (drought, pests and diseases)

Short explanation	To cultivate crops resistant to droughts, pests and diseases. Problem of agriculture is that it is not adapted to climate changes. This measure can reduce water use (irrigation), water pollution (reducing the use of plant protection products) and increase self-sufficiency in food.
Addressed challenges	Water availability during droughts (A), Appropriate water quality (C)
Target locations and water uses	Location: River as a whole. Water uses: Agriculture.
Benefits	Increase self-sufficiency in food. Decrease of negative impact of droughts on agriculture. Reducing impact of unsustainable agricultural practices on water quality. Using old varieties of crops, also new ones, but not using genetically modified organisms.
Potential negative impacts	Possible decrease in profitability of crop production.
Timeline of implementation	Mid-term (2 to 6 years' time) as suggested by stakeholders on third workshop to long-term (>6 years' time).
Feasibility	No major barriers – some farmers and their advisors believe that better solution for them is crop production that uses water for irrigation (comments from stakeholders on second workshop).
Robustness	Yes.
Flexibility	Yes.

Costs/Actions	The total discounted cost toward year 2030: 452,957 euros (EUR 2018, discount rate: 5%).
	Review and analysis of existing data, studies, projects on the best selection of crop type regarding water requirements, growth phases (when and how long) and soil type - 6 person months;
	• Formation of an experimental center (test area - can be an active or abandoned agricultural land, part of a farm, where the municipality, agricultural cooperative or an individual farmer is owner and is willing to sell/rent the farm for experimental cultivation of these crops and to put theory into practice.
	  ○ Purchase of the farm, and purchase of agricultural land of about 20 ha (some of existing equipment and basic infrastructure – e.g. tractor within the farm, warehouse);
	    ▪ Some expert assume 200,000 to 300,000 € cost for buying a farm; we used 250,000.00 €;
	    ▪ For buying an agricultural land we used data where 1 ha is estimated at 24,000 €77
	  ○ Preparation of project documentation (8%) – new equipment – one greenhouse (10x63 meter)78, cold storage (cost is part of the warehouse) and warehouse (around 1,000 m2);
	  ○ Implementation;
	  ○ Maintenance (2%) of implementation works plus running costs:
	    ▪ 24 person month from year 3 on,
	    ▪ 6 person month from year 3 on.
	• Replacement of maize with sorghum crops from year 8 on (80 ha/year). In year 12 area of 400 ha will be replaced with sorghum.

Synergies and conflicts with policy objectives	No known conflicts. The use of genetically modified organism (GMO) is not planned. Also there is a National Restriction or Prohibition of the Cultivation of Genetically Modified Plants Act (Official gazette, no. 69/15) [118] in place that prohibits the use of GMO. Synergies:

	• National Adaptation strategy for forestry and agriculture (2008) [94] and its implementation document (Action plan from 2011) [95] - Pillar I: Building capacity to handle the adaptation of agriculture and forestry. Measures that are already in place and are planned in future: 5. The functioning of experimental-demonstration centres for crop and livestock production that are already in place and where research work is carried out with the aim of searching and introducing new technologies production, creating new varieties of crops and production monitoring in various conditions. • and with policies aiming at water resource conservation (Water Framework Directive [21] – River Basin Management Plan [29]). • Natura 2000 Management programme for Slovenia [70] – similarity with the measure of extensive meadows. • Flood Risk Management Plan [73] – some similarity with measure –“Aadaptation of land use” (label U3). *Possible funding through CAP/European Agricultural Fund for Rural Development (EAFRD) within Axis 2: improving the environment and the countryside and Rural development plan (2014-2020) within sub measure M1.2 - support for demonstration activities and information activities. Also through The INTERREG MED Programme 2014-2020 within priority axis 3 and Horizon 2020 within Societal challenges (9. Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bio economy/ 12. Climate action, environment, resource efficiency and raw materials / 13. Europe in a changing world – inclusive, innovative and reflective Societies).*
Acceptance	Low acceptance by farmers due to lower profitability.
Suggested stakeholder involvement	With the support of the Ministry of Agriculture, Forestry and Food together with their professional services (Chamber of Agriculture and Forestry of Slovenia (CAFS) (Regional units)) and in close cooperation with local farmers and agricultural cooperative, researchers from agro-meteorological field (ARSO, UNI BF and KIS) could be the leading partners in the implementation of the option.
Preconditions for success	Raising awareness of farmers regarding the benefits of cultivating drought resistant agricultural crops. Farmers would likely need some compensation for loss of income, hence funds available for implementing the option need to be assured (not just for compensation but also for implementation of the option itself). This option should be implemented in combination with agro-environmental and technological measures. Cross compliance must be assured. One of the preconditions that stakeholders pointed out at third workshop is the availability of such crops for cultivation. Nevertheless important for this measure is also to make market analysis - verify the interest of the market for such crops and farmers interest in growing new crops…here it would be preferable also to check the interest of private sector to commit on marketing such crops in their supply chains (to make clear commitments).
Concrete examples where applied	Agricultural Experimental Centre Jable [119] and Gene bank of Crops [120].

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Annex I: List of engagement activities held in Vipava River Basin

Engagement activity	Objective	Target group	Dates
First stakeholder workshop	Identification of challenges regarding water management in the Vipava river basin, drawing an outline for future WMOs in the Vipava river basin.	A wide group of local, regional and national stakeholders.	6th June 2014
Stakeholder interviews	Collection of information from policy-makers on the current situation of adaptation to climate changes on national and river basin level, their experience with public participation in the design of policies and potential conflicts that may appear. Discussion on current water use problems and desired state for the Vipava river basin.	Policy-makers and other relevant stakeholders not able to attend the first workshop in June.	September – November 2014
Stakeholder consultations (I)	Validation and harmonization of FCM as a result of the first stakeholder workshop and stakeholder interviews.	A group of local, regional and national stakeholders actively engaged in the BeWater project.	February 2015
Second stakeholder workshop	Evaluation of WMOs as a result of the first stakeholder workshop.	A group of local, regional and national stakeholders actively engaged in the BeWater project.	27th May 2015
Expert/stakeholder consultations	Supplementation of information on implementation steps and costs of WMOs.	Selected experts and stakeholder actively engaged in the BeWater project from national instutites, agencies, university and companies.	August – October 2015
Stakeholder consultations (II)	Presentation and discussion of final list of WMOs.	A wide group of local, regional and national stakeholders.	12th October 2015
Third stakeholder workshop	Validation of draft adaptation plan for the Vipava river basin.	To be decided.	23rd March 2016
Fourth stakeholder worshop	Presentation of adaptation plan for the Vipava river basin.	A group of national stakeholders. / To be decided.	February 2017

Annex II: List of dissemination activities held in Vipava River Basin

Parallel to the stakeholder engagement, other dissemination activities are taking place in the Vipava river basin with the aim to forward results of the BeWater project, to expand the list of stakeholders, to raise social awareness and to encourage capacity building, empowerment and social formation in water management challenges and adaptation.

Dissemination activity	Content	Target group	Dates
GEP/BeWater meeting	Presentation of results of GEP Project, focusing on hydrogeological and spatial surveys on the Slovenian border area.	GEP and BeWater project team.	26th September 2014
Awareness Campaign	A mobile exhibition comprising of seven roll-up posters on display at key venues in critical communities throughout the Vipava river basin and in Ljubljana.	Venues: Development Agency ROD in Ajdoščina, Ministry of Agriculture, Forestry and Food (in cooperation with Ministry of the Environment and Spatial Planning) in Ljubljana, Municipalities Ajdovščina, Vipava, Miren-Kostanjevica and Šempeter-Vrtojba,Nova Gorica, Renče-Vogrsko, Central public library called "Lavričeva knjižnica Ajdovščina" in Ajdovščina and Vipava, Lanthieri mansion in Vipava.	27th November 2014 - ongoing
Event called „Water days of Primorska"	Presentation of BeWater project on 12th February in the session on ongoing projects and plans for the region.	A wide group of local, regional and national stakeholders.	11th – 12th February 2015
Awareness Campaign for Highschool Students	Presentation of BeWater project and organization of field trip to the Vipava river basin.	Students of Biotechnical Secondary School Nova Gorica.	15th April 2015
International workshop in the frame of 7FP Cropsustain	Presention of the objectives and results of BeWater Project, especially the participatory approach.	A wide group of international experts in the field of agriculture and environment.	24th November 2015

3 Pedieos River Basin, Cyprus

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Preface

Climate change projections for the Mediterranean region estimate an increase in water scarcity and drought episodes, as well as other extreme events. There is a high likelihood that these events will evoke substantial socio-economic losses and a range of other environmental impacts if no action is taken to support territories' adaptation efforts. Furthermore, changes in population and land use, such as urban expansion or the abandonment or intensification of agriculture, also affect the response of territories to these events. In this context, sustainable water management strategies are urgently needed.

Sustainable water management strategies are key to enhancing the resilience of socio-ecological systems as they address both society and the environment's abilities to absorb disturbances while retaining their same structure, way of functioning and capacity to adapt to stress and change. Current water management practices focus on the river basin level as the natural geographical and hydrological unit, which fosters appropriate responses to pressures within this spatial scale while also minimizing disruptions to the socio-ecological systems.

The BeWater Project ('Making Society an Active Participant in Water Adaptation to Global Change') is an EU-funded project that aims to respond to the above challenges by promoting dialogue and collaboration between science and society for sustainable water management and adaptation to the impacts of global change. The project, taking place from October 2013 to February 2017, focuses on the design of adaptive water management approaches at a river basin scale in the Mediterranean region. More specifically, the project aimed to develop a River Basin Adaptation Plan for each of four pilot case studies, namely for the Tordera (Spain), Pedieos (Cyprus), Rmel (Tunisia) and Vipava (Slovenia) River Basins. These basins are representative of various Mediterranean conditions with regards to climate, topography, environment, socio-economic and political conditions, land use and water demands.

The adaptation plans were developed in a collaborative process according to a common methodology developed within BeWater, and utilising existing information on the local dynamics of global change. Over the course of the three and a half-year project, the subsequent plan and the plans of the other three pilot cases were co-produced by experts and stakeholders in the respective river basins as well as with scientists and experts from within the BeWater consortium, with guidance from the project's advisory board.

The four River Basin Adaptation Plans (RBAPs) aim at fostering adaptation to climate change within the four basins, and serve as a reference for other basins within the Mediterranean region and beyond, that wish to increase their resilience and undertake such a participatory development process. To facilitate the transferability potential, the BeWater Project is also producing a handbook presenting lessons learned throughout the development process.

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Executive Summary

The Pedieos River Basin Adaptation Plan, which has been developed over the course of the BeWater Project, is the result of intense team effort, wide stakeholder integration, targeted information gathering, critical analysis and thoughtful planning. The main emphasis of the adaptation plan is on river basin management under climate change. The stakeholder-driven approach adopted in the formulation of the plan allowed a common understanding of the major challenges and their interlinkages in the Pedieos River Basin. The adaptation plan is based on the outcomes of the co-design and evaluation of adaptation responses by stakeholders and scientists. The following six bundles of adaptation options were formulated to address the multiple outcomes of climate change in the river basin and maximise the co-benefits among the adaptation options:

- *Sustainable Irrigation Water Management*
- *Good governance*
- *Sustainable urban drainage and flood management*
- *Hydrological management*
- *Domestic water supply*
- *Environmental engagement*

The implementation of these complementary bundles of adaptation options enhance synergistic benefits and reduce trade-offs. Adaptation pathways within the bundles of the options were indicated by the stakeholders based on their effectiveness over time and local preferences. A description of the 30 adaptation options that make up these bundles is presented in the Part 2. The bundles of adaptation options can assist stakeholders and decision makers in planning water resources management and can improve governance for adaptation to climate change. The Pedieos River Basin Adaptation Plan increases the awareness of local actors and citizens on climate change challenges and strengthens the adaptive capacity of the river basin.

The Pedieos River Adaptation Plan will be presented in a policy forum in Nicosia with local and national representatives to provide policy recommendations and highlight potential paths forward.

Περίληψη

Το Σχέδιο Προσαρμογής στην Κλιματική Αλλαγή της Λεκάνης Απορροής του Πεδιαίου Ποταμού, το οποίο εκπονήθηκε κατά τη διάρκεια του Ευρωπαϊκού Προγράμματος BeWater, είναι το αποτέλεσμα μιας ομαδικής προσπάθειας και ευρείας συμμετοχής όλων των εμπλεκομένων φορέων, βασισμένο στην στοχευμένη συλλογή πληροφοριών, στην κριτική ανάλυση και στον προσεγμένο σχεδιασμό. Η κύρια έμφαση του προγράμματος προσαρμογής εστιάζει σε θέματα διαχείρισης λεκάνης απορροής κάτω από τις κλιματικές αλλαγές. Η υιοθέτηση μιας εκ των κάτω προς τα άνω προσέγγισης στο πλάνο προσαρμογής με τη συμμετοχή των εμπλεκομένων φορέων, επέφερε την συναντίληψη και κατανόηση των πιο σημαντικών προκλήσεων καθώς και των αλληλεξαρτήσεων τους στην Λεκάνη Απορροής του Πεδιαίου Ποταμού. Το σχέδιο προσαρμογής βασίζεται στα ευρήματα μιας από κοινού προσπάθειας σχεδιασμού και αξιολόγησης επιλογών προσαρμογής μεταξύ εμπλεκόμενων φορέων και επιστημονικών εταίρων. Οι ακόλουθες έξι δέσμες επιλογών προσαρμογής διαμορφώθηκαν για την αντιμετώπιση των πολλαπλών επιπτώσεων της κλιματικής αλλαγής στη λεκάνη απορροής και τη μεγιστοποίηση των συνεργειών μεταξύ τους:

- *Βιώσιμη διαχείριση νερού άρδευσης*
- *Σωστή διακυβέρνηση*
- *Βιώσιμη αστική απορροή όμβριων υδάτων και διαχείριση πλημμυρών*
- *Υδρολογική διαχείριση*
- *Ύδρευση*
- *Περιβαλλοντική ευαισθητοποίηση*

Η εφαρμογή αυτών των συμπληρωματικών δεσμών επιλογών προσαρμογής ενισχύει τις συνέργειες και τα οφέλη. Οι εμπλεκόμενοι φορείς υπέδειξαν τον χρονικό ορίζοντα εφαρμογής των επιλογών προσαρμογής στις επιμέρους δέσμες με βάση την αποτελεσματικότητα τους στο χρόνο και τις τοπικές προτιμήσεις. Στο δεύτερο μέρος του σχεδίου επεξηγούνται αναλυτικά οι 30 επιλογές προσαρμογής που απαρτίζουν τις παραπάνω δέσμες. Οι δέσμες επιλογών προσαρμογής μπορούν να βοηθήσουν τους εμπλεκομένους φορείς και τους λήπτες αποφάσεων στον σχεδιασμό της διαχείρισης των υδάτινων πόρων και μπορούν να βελτιώσουν τη διακυβέρνηση για τη προσαρμογή στην κλιματική αλλαγή. Το Σχέδιο Προσαρμογής της Λεκάνης Απορροής του Πεδιαίου Ποταμού βελτιώνει την ευαισθητοποίηση των τοπικών φορέων και πολιτών για τις προκλήσεις της κλιματικής αλλαγής και ενισχύει την προσαρμοστική ικανότητα της λεκάνης απορροής του ποταμού.

Το Σχέδιο Προσαρμογής της Λεκάνης Απορροής του Πεδιαίου Ποταμού θα παρουσιαστεί σε ένα φόρουμ πολιτικής στη Λευκωσία με τη συμμετοχή τοπικών και εθνικών αντιπροσώπων για την παροχή συστάσεων πολιτικής και την ανάδειξη μελλοντικών κατευθύνσεων.

Glossary of key terms

- **Acceptability (as criteria for water management options) -** an option is considered as acceptable if there is not significant reason a priori for actors in the basin to reject the option, e.g. because of its design[(i)]
- **Adaptation pathway -** portrays a sequence of actions and their implementation prioritisation over the short, medium and long-term, with regards to achieving a set of pre-specified objectives under uncertain changing conditions[(ii)]
- **Adaptive management -** an approach to reduce ecological uncertainty and increase resilience by emphasising that management regimes should be regularly adjusted to changes in the ecological system being managed and to managers' evolving understanding of this system
- **Bottom-up approach -** entails the participation of local actors in decision-making about the selection of the priorities and actions to be pursued in their local area; the approach can interact and be combined with top-down approaches from national and/or regional authorities in order to achieve better overall results[(iii)]
- **Carrying capacity** - the maximum capacity of the natural environment in a certain area to provide ecosystem services (e.g. water, fertile soil for the production of crops, growth of natural vegetation or a healthy interplay between species that controls pests and diseases) to sustain the development of human activities; overriding the carrying capacity of a territory means disrupting its functionality
- **Citizen participation** - a process in which ordinary people take part – whether on a voluntary or obligatory basis and whether acting alone or as part of a group – with the goal of influencing a decision that will affect their community; this can take place within an institutional framework, and may be organized either by members of civil society or by decision makers[(iv)]
- **Challenge -** something that by its nature or character serves as a call to a special effort; the RBAP focuses on the challenges related to the impacts of global change in the river basin - now and in the years to come
- **Climate change -** any long-term change in climate over time, whether due to natural processes or as a result of human activity[(v)]
- **Climate change adaptation -** appropriate action to prevent or minimise the damage that climate change impacts can cause, or taking advantage of opportunities that may arise due to climate change[(vi)]
- **Climate change scenario -** the difference between a climate scenario (i.e. a plausible and often simplified representation of the future climate) and the current climate[(vii)]
- **Co-benefits (as criteria for water management options) –** options are considered to have co-benefits when their combined implementation amplifies the total impact-related benefits, as compared to the benefits which would arise from implementing each option individually
- **Environmental flow regime** - describes the amount of water that is needed by the river ecosystem to sustain its natural functioning
- **Extreme climate and weather event -** The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. Both extreme weather events and extreme climate events are referred to collectively as 'climate extremes. Definitions of thresholds vary, but values with less than 10, 5, 1%, or even lower chance of occurrence, for a given time of the year, during a specified reference period (generally 1961-1990) are often used. Absolute thresholds can also be used to identify extreme events (e.g., specific critical temperatures for health impacts). Extreme events include floods and droughts[(viii)]

- **Feasibility (as criteria for water management options) -** an option is considered as feasible if physical, technical, regulatory or organizational obstacles are not existing or can be easily overcome during option's implementation(i)
- **Flexibility (as criteria for water management options) -** an option is considered flexible when it can be adjusted/ complemented or reversed when it turns out to be inadequate or inappropriate in practice(i)
- **Fuzzy cognitive map -** a tool to graphically represent the knowledge about or the perception of a given system; can be converted into simple mathematical models to run simulations and calculate outcomes of possible scenarios to facilitate the discussion and exploration of complex issues(ix)
- **Global change** - changes in the global environment that may alter the capacity of the Earth to sustain life, encompassing climate change as well as other critical drivers of environmental change that may interact with climate change, such as land use change, population trends, the alteration of the water cycle and changes in ecosystem functionality(x)
- **Good status (of a water body)** – a term to describe a condition under which water bodies have the biological and chemical characteristics expected under sustainable conditions(xi)
- **Governance -** the way rules, norms and actions are produced, sustained, regulated and held accountable; it refers to the processes of interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions(xii)
- **(Invasive) alien species –** plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health(xiii)
- **Impact assessment –** a method to identify the environmental, social and economic impacts of an action or project prior to decision-making
- **Implementation barrier or opportunity -** elements deriving from the implementation context influencing the foreseen or ideal development of an action
- **Knowledge transfer –** the process of engaging with researchers, decision-makers or the community and decision-makers to generate, acquire, apply and make accessible the knowledge necessary to successfully develop and enhance evidence-based initiatives which enhance human, material, social and/or environmental wellbeing(xiv)
- **Multi-criteria analysis -** a tool for supporting complex decision-making situations with multiple and often conflicting objectives (e.g. economic, ecological and social) that stakeholder groups and/or decision-makers value differently(xv)
- **Mutual learning -** a learning process experienced and shared by different actors developed through direct interactions; the process is conducive to adaptive water management and includes the exchange of information on technical features of river basin management, scientific findings, as well as political aspects, so as to arrive at a shared understanding of issues and possible solutions
- **Non-conventional water resources -** in the context of this plan, non-conventional water resources refer to the desalination of brackish and seawater, and treated sewage water, which present potential options to balance current and future water demands and available supplies(xvi),(xvii)
- **Participatory co-creation -** an approach which integrates all stakeholders in the entire design process of an action, i.e. problem definition, solution generation, evaluation of proposed solutions during development, and implementation of solutions, to help ensure the result meets user needs and increase acceptability
- **Policy framework -** a broad set of laws, regulations, or processes that structure political, social, cultural or economic activities in a society; these policies form an interacting web and

therewith impact the functioning of existing policies as well as new policy developments and policy amendments[(xviii)]

- **Pressure -** anthropogenic factors inducing environmental change (impacts), including for example the release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities[(xix)]
- **Resilience -** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change[(xx)]
- **River basin -** the area of land from which all surface water runs off through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta[(xxi)]. It is a natural geographical and hydrological unit that is used e.g. by the European legislation to manage a single drainage area[(xxii)]
- **River Basin Adaptation Plan -** management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.
- **River Basin Management Plan -** document including the objectives for a given river basin district and the programme of actions required to meet these objectives; the aim is to protect, improve and sustainably use the water environment; these plans are a requirement of the European Water Framework Directive
- **Robustness (as criteria for water management options) -** an option is considered robust to uncertainties if it can maintain its effectiveness under different climatic and socio-economic development scenarios[(i)]
- **Sediment management -** organized and coordinated actions to reduce the impact of human activities or natural changes on the quantity and quality conditions of solid material that is or can be transported by or deposited from the river's water[(xxiii)]
- **Socio-ecological system –** consists of 'a bio-geophysical' unit and its associated social actors and institutions; delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context[(xxiv)]
- **Stakeholder** - any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome; the term is usually reserved for well-organised and active groups and organisations, thus making a distinction from the general public
- **Terrace -** a permanent berm and channel arrangement either constructed along the face of a slope at regular intervals or constructed as a continuous series of horizontal steps on the face of a slope in order to reduce erosion damage by capturing or slowing down surface runoff and directing it to a stable outlet at a velocity that minimizes erosion[(xxv)]
- **Water management option –** activity developed within the scope of the BeWater Project which aims to impact the interactions between water uses and the water body; can be characterised as nature-based approaches (enhancing natural regulation of ecosystem functionality), soft approaches (acting on management or policy norms and regulations) or technical approaches (developed through engineering)
- **Water scarcity –** a lack of sufficient available or safe water resources to meet water needs within a region; this can involve water stress, water shortage or deficits, and water crisis as a result of climate change, increased pollution, or increased human demand and overuse of water[(xxvi)]
- **Watershed -** the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater; this area is typically smaller than a river basin, meaning that several watersheds may comprise a single river basin[(xxvii)]

PART 1

3.1 Introduction

3.1.1 *Contextualization of the plan*

The Pedieos River Basin is a dynamic basin that currently faces significant water management challenges. Regional climate models project a drier and warmer Pedieos watershed in the near future that can aggravate the already high pressures on water resources for domestic use, agriculture, and the environment. The BeWater Project aims to test innovative bottom-up approaches to integrate adaptation to global change in river basin management. A key objective of the project is to move away from expert-dominated adaptation planning towards a process that will support the co-design of adaptation responses by stakeholders and experts.

Box 1.1. Definition of River Basin Adaptation Plan

The BeWater River Basin Adaptation Plans (RBAPs) are management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.

In other words, the Pedieos River Basin Adaptation Plan aims to start a transition from a technologically-focused river basin management approach to a stakeholder-driven planning and management process that allows a pro-active response to emerging climatic changes and related pressures. Many initiatives across the world have started to integrate climate change in water management at multiple scales. However, few attempts have been made to integrate adaptation to global change in river basin management, in a participatory manner, as proposed by the BeWater Project.

3.1.2 *Objectives and Vision*

Sustainable water management under global change is an urgent challenge for the Euro-Mediterranean region. Future climate change projections estimate an increase in water scarcity and droughts in the region, causing substantial socioeconomic losses and environmental impacts [(xxviii,xxix)]. Within this context, efforts are needed to strengthen public participation and embed a sense of responsibility within the society concerning water management and adaptation towards these threats.

The Pedieos River Basin Adaptation plan has been created on the basis of the vision that the combination of improved awareness, mutual learning processes and shared responsibility of the civil society and stakeholders are keys to ensuring successful adaptation strategies and their implementation, leading to increased resilience of the social-ecological system of the river basin. BeWater recognizes the crucial role of participation and engagement of a wide group of stakeholders, including civil society, scientists, public administrators (policy makers and implementers, institutional administrations and local governments), water sector actors (e.g. service providers) and other related sectors (e.g. energy). Therefore the participatory approach used envisions direct interaction between stakeholders and science partners for formulating water management options and, subsequently, the adaptation plan for the river basin.

The objectives of the Pedieos River Basin Adaptation Plan are:

(a) to identify the main climate change challenges for the water resources in the Pedieos River Basin
(b) to identify, analyse and evaluate adaptation options for the river basin based on a bottom-up participatory approach
(c) to provide recommendations for strengthening the resilience of the river basin to climate change and improving governance for adaptation.

The Pedieos River Basin Adaptation Plan takes into account the knowledge and the preferences of local stakeholders and identifies adaptation strategies that can increase the resilience of the river basin to climate change challenges.

3.1.3 *Overview of Contents*

After this introductory section, the structure of the River Basin Adaptation Plan is as follows. The next chapter, Chapter 2, provides the background to the river basin, the impacts of global change and the policy context. Chapter 3 outlines the framework for the participatory development of the River Basin Adaptation Plan with specific emphasis put on stakeholder engagement. Chapter 4 presents the bundles of the adaptation options suggested by the stakeholders. The adaptation plan concludes with recommendations for the Pedieos River Basin.

The characteristics of the water management options are described in Part 2.

3.2 The Pedieos River Basin

Chapter 2 describes the Pedieos River Basin systems, portrays the current state of the river basin as well as the potential impact in the future considering global change scenarios.

3.2.1 *Current state and dynamics*

3.2.1.1 Current state of the basin

The Pedieos River, similar to the majority of rivers in Cyprus, is a non-perennial river, of ephemeral nature that only flows during the rainy winter months or after heavy rainfall events. The river originates in the north-eastern hillslopes of the Troodos mountain complex (Figure 2.1), where it has its highest elevation at 1,400 m above sea level. The Pedieos River Basin receives an average annual precipitation (1980-2010) ranging between 670 mm upstream to 320 mm downstream [(xxx)]. The river basin covers approximately 120 km^2 at the green line in Nicosia, where it flows into the occupied areas of northern Cyprus. There are ten communities in the upstream and midstream areas (i.e., Lazanias, Kampia, Politiko, Pera, Episkopeio, Psimolofou, Ergates, Anageia, Pano Deftera, Kato Deftera) and five municipalities downstream (i.e., Lakatameia, Egkomi, Agios Dometios, Strovolos and Lefkosia). The basin has a population of approximately 192,000 inhabitants [(xxxi)] according to the 2011 census of population.

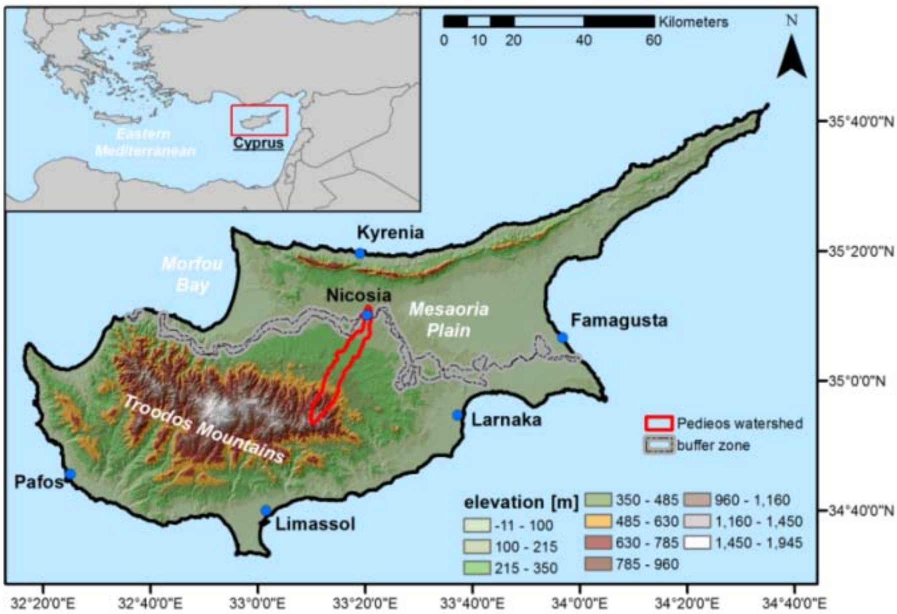


Figure 2.1. Location of the Pedieos River Basin in Cyprus.

The steeply sloping forested upstream area hosts beautiful picnic sites and nature trails and forms an important Natura 2000 site[(xxxii)]. The fractured volcanic formations in the upstream area are mainly covered by conifers, with smaller areas of sclerophyllous and shrub woodlands and few plots of rainfed cereals, irrigated fruit trees, greenhouses and livestock farms.

At the bottom of the foothills, the Tamassos dam, which was completed in 2002, captures and stores the runoff of the 45-km^2 upstream river basin in a 2.8-million m^3 reservoir[(xxxiii)] (see Figure 2.2). The dam provides flood protection, groundwater recharge through the release of water to the downstream alluvial aquifer, and water supply for nearby communities.

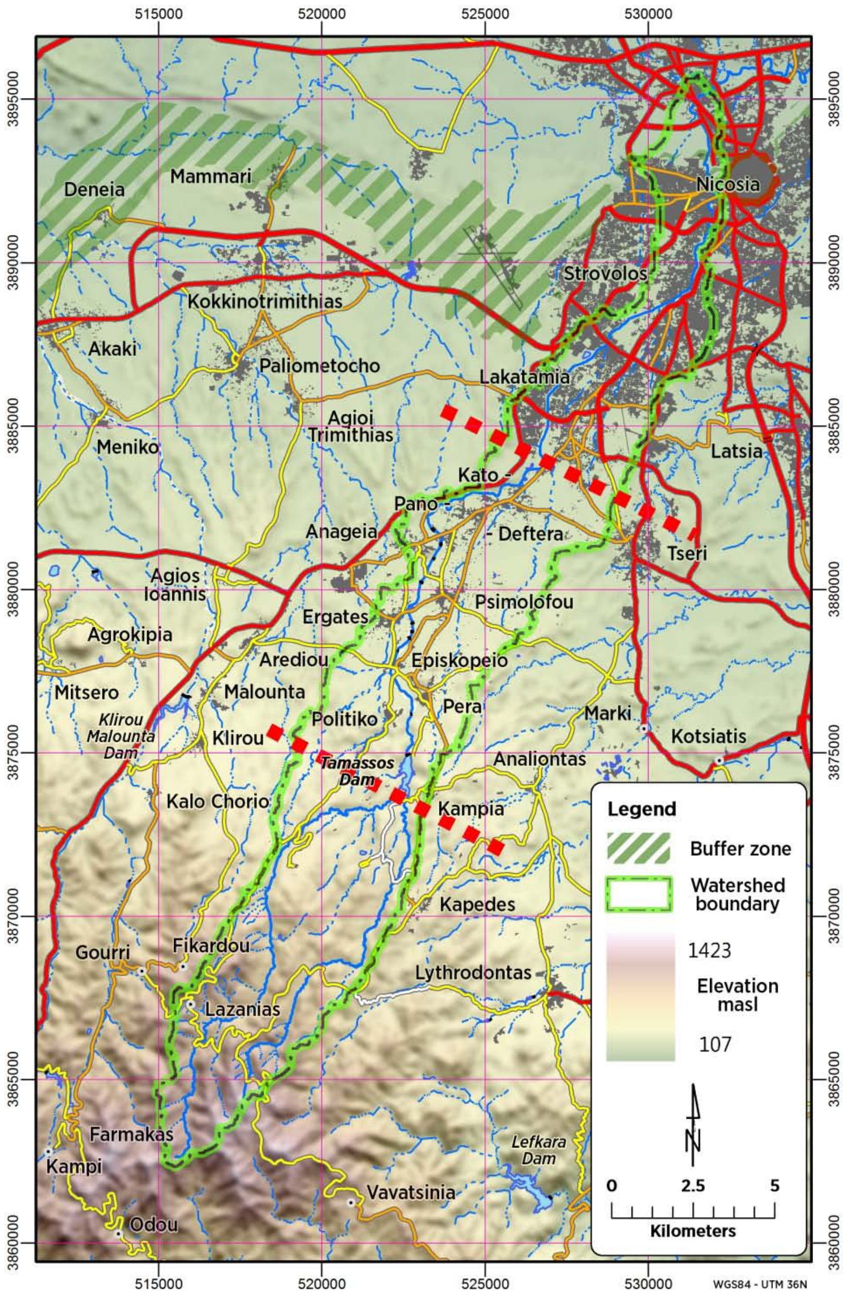


Figure 2.2. The Pedieos river basin; the build-up areas are shown in dark-grey; the red dotted lines indicate upstream, midstream and downstream (North) areas

Streamflow data just upstream from the dam, collected by the Cyprus Water Development Department, showed that the largest rainfall event in the past 40 years produced the enormous amount of 3.1 million m^3 runoff in one day. This event occurred on 9 January 1989 and resulted from 57 mm rain over the upstream catchment on the preceding day and 108 mm on the day itself. Considering that there is always water in the reservoir in winter time, an enormous volume of water would have flown through the spillway of the dam.

Downstream from the dam, the river basin crosses about half a dozen rural communities, which grow rainfed and groundwater-irrigated crops. Barley, fresh vegetables and olives are the most common crops. Agricultural irrigation is the largest user of water in the rural areas of Pedieos consuming on average 4.5 Mm^3/year (82%)[xxxiv].

The river then flows into the urban agglomeration of the capital Nicosia and its adjacent municipalities. The Pedieos River in the urban areas of Nicosia is dry most of the year. However, during heavy rainfall events runoff from the surrounding paved areas flows to the river. A total of 38 floods were recorded in urban Nicosia, from 1960 to 2012, of which three were caused by flooding from the river ([xxxv]). Natural vegetation that grows in the dry river bed impedes the flow of the water. Garbage and branches that are dragged along by the flood get trapped at the low road crossings over the river, causing water to spill over the road. The Water Development Department has identified the urban area along the Pedieos as an area of potentially significant flood risk[xxxvi], for the European Flood Directive (2007/60/EC).

Along the river, a linear park with cycling path offers a quiet green corridor in the hectic urban environment of Nicosia. Many people visit the park in the early mornings and evenings during summer. Daily maximum temperatures in Nicosia average 37 degrees in July and August. A survey of the park visitors, conducted by intern students of the Cyprus Institute, showed that most people come for exercise or to enjoy nature ([xxxvii]). The majority of the people indicated that they were happy with the services of the park. The park contributes to environmental awareness and creates an understanding of the functioning of ephemeral streams.

Historical sources indicate that Pedieos River was important for the foundation and growth of Nicosia ([xxxviii]). The river used to replenish the groundwater reserves that served the historical town and its nearby agricultural communities. However, floods occurred in the past too. The most well-known historical flood of 1330 caused the death of 3000 people. Around 1570, the river was diverted northwards around the town. The reasons for this diversion, under debate by various authors, could have been the protection of the city against flood or the supply of water to the moat around the walls [(xxxviii)].

3.2.1.2 Future climate change impacts and water demand

Regional climate models indicate a drier and warmer Pedieos watershed in the near future (2020-2050) (Figures 2.3 & 2.4 [(xxxix)]). In particular, it is projected that maximum and minimum temperatures may increase by an annual average of 1.5 ºC, indicating mainly hotter summers, while winter precipitation may decrease by an annual average of 7% [(ii)]. Changes in the number of hot days (Tmax ≥ 35 ºC) and tropical nights (Tmin ≥ 22.5 ºC) are also foreseen [(xxxixxxxix)]. The number of extreme precipitation events is also expected to increase in a warmer future [(xl)]. No increases in precipitation extremes were found for Cyprus for three downscaled Regional Climate Models under the IPCC A1B scenario for 2020-2050, relative to 1980-2010 [(xli)]. However, these 30-year periods may be too short to identify changes in precipitation extremes. These adverse changes can exert sizeable pressure on water supply and agriculture, thus creating negative impacts on the local economy and the living standards of the residents.

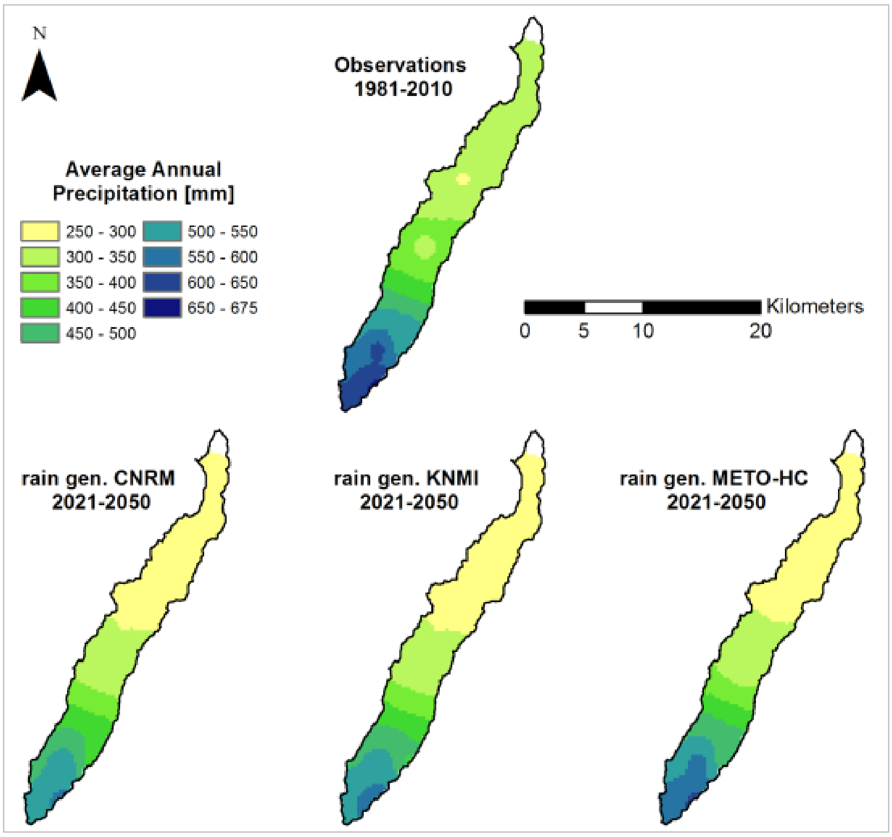


Figure 2.3. Precipitation projections for the period 2021-2050 indicate a drier Pedieos Watershed in the future (xli).

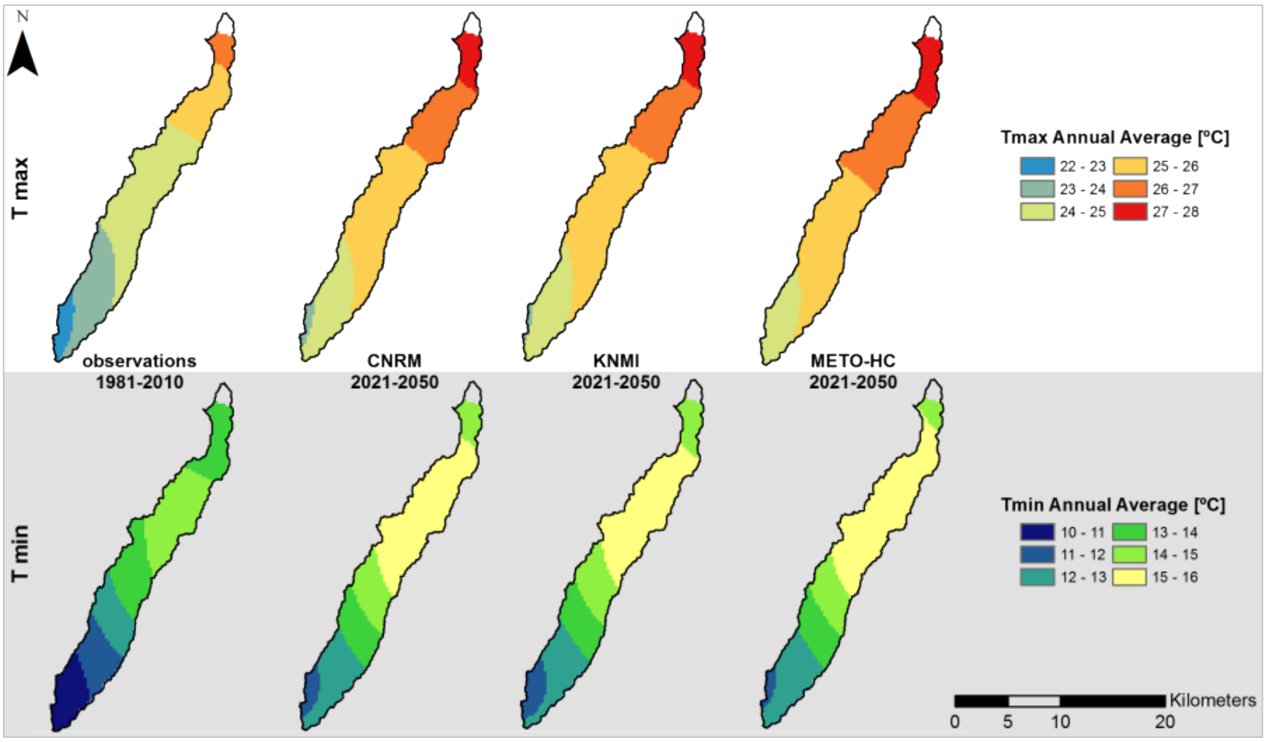


Figure 2.4. Average maximum and minimum temperature projections for the period 2021-2050 show a warmer future for Pedieos Watershed (xxxix).

Population trends and the associated water demand are additional parameters that deserve attention. The population of both urban and rural communities of the Pedieos River Basin follow an increasing trend over the past 30 years as shown in Figure 2.5. The population includes the rural communities Lazanias, Kampia, Politiko, Pera, Episkopio, Anageia, Ergates, Psimolofou, and Pano and Kato Deftera, which have their population centers in the basin. The urban Pedieos communities (municipalities) are Lakatameia with Anthopouli, Strovolos, Nicosia, Engomi and Agios Dometios. Some 94% of the total watershed population is located in urban communities, according to the 2011 Census [xxxi]. Note that the total population of these communities and municipalities is shown. However, the administrative boundaries do not always coincide with the hydrological boundaries. Thus, part of the reported population lives outside the pictured boundaries of the watershed.

According to the UN [xlii] medium variant projection, the urban population of Cyprus will continue to grow over the next 35 years, while the rural population will follow a diminishing trend over the period 2015-2050 (Figure 2.6). Based on the annual population rate of change of these projections, the gross domestic water demand for the two population categories was estimated (Figures 2.7 and 2.8). It was assumed that people in urban communities consume 215 l/d per capita and people in rural communities 180 l/d per capita, following the assumptions of the WDD [xliii]. Currently, the annual domestic water demand in urban communities is 15 Mm^3/year and by 2050 is expected to increase by 28%. On the contrary, a 23% decrease by 2050 is expected in rural communities, from the current 0.85 Mm^3/year domestic water demand. It should be noted domestic water supply in urban communities relies on seawater desalination (supplied from outside the watershed), while groundwater and water from the Tamassos dam are the predominant water supply sources for rural communities.

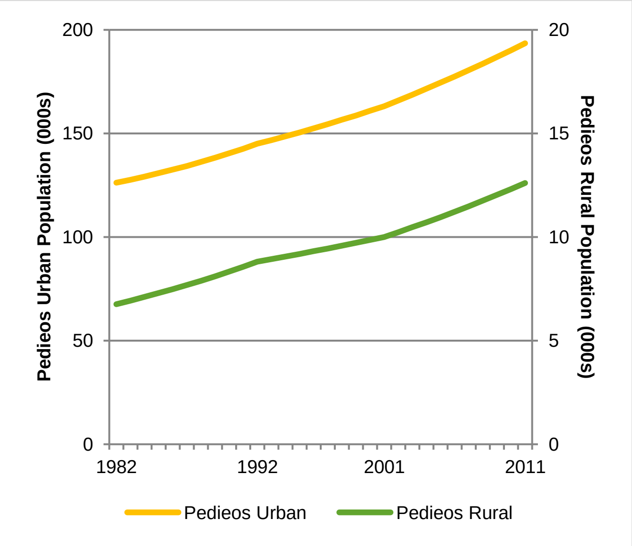


Figure 2.5. Urban and rural population in Pedieos watershed, 1982-2011 [xxxi]

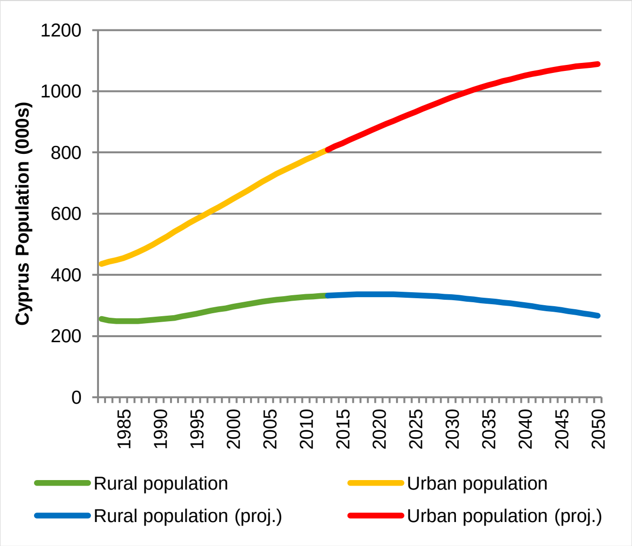


Figure 2.6. Past and projected total urban and rural population in Cyprus [xlii]

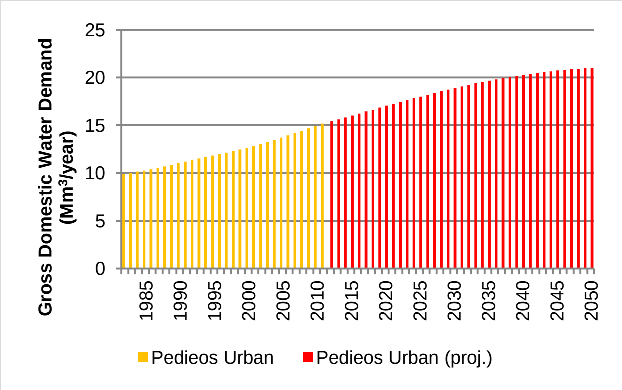


Figure 2.7. Estimated gross domestic water demand in the urban communities of Pedieos watershed (computed by authors, based on (xlii, xliii)).

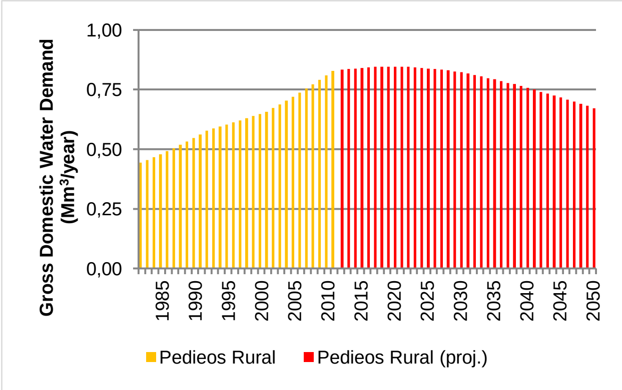


Figure 2.8. Estimated gross domestic water demand in the rural communities of Pedieos watershed (computed by authors, based on (xlii, xliii)).

3.2.2 *Policy Context*

The EU strategy on adaptation to climate change has set out a framework to facilitate the climate proofing of the main policies, e.g. Common Agricultural Policy (CAP), Cohesion Policy and Common Fisheries Policy (xliv). Strengthening the synergies of the related policies could increase the resilience of territories to the impacts of climate change. In this section, the main policies relevant to the identified adaptation options for the Pedieos River Basin are outlined.

The Water Development Department of the Ministry of Agriculture, Rural Development and Environment is authorized to design and implement water policy and water management in Cyprus. The Republic of Cyprus has completely transposed the Water Framework Directive (WFD) to national legislation through the "Water Protection and Management Law of 2004" (xlv). The Water Development Department implements the necessary measures to prevent the quantitative and qualitative degradation of water resources from uncontrolled exploitation, contamination and pollution. In order to meet the increasing water demand, the strategy of the Water Development Department focuses on the maximum potential exploitation of non-conventional resources such as desalination and recycled water. The Floods Directive 2007/60/EC was also harmonized in the Cypriot legislative framework with the Law 70(I) 2010 on the Flood Risk Assessment, Management and Preparedness. The Water Development Department, in conformity with the EU guidelines, has also elaborated a Drought Management Plan in 2010 (xliii).

Several measures are implemented in the Pedieos River Basin (being identical at national, regional and river basin level) and contribute directly and/or indirectly towards the adaptation to climate change impacts on the water resources. These measures include:

(a) *water demand measures*: water allocation mechanisms, installation of water supply meters, irrigation water pricing; subsidies for water-saving measures, awareness campaigns (xlvi, xlvii, xlviii)

(b) *water supply measures*: control groundwater exploitation; increase storage capacity; repair and improvement of water distribution networks; use of non-conventional water resources (xlvii, xlix).

(c) *water quality measures*: the Cyprus River Basin Management Plan includes the regulations and the basic measures that should be implemented in order to attain good ecological and chemical status of fresh and coastal waters by 2015 [(xliii)].

(d) *flood protection measures*: integration of flood risk assessment results in spatial and urban planning, development of interactive hazard maps to improve understanding of flood risk, establishment of protection zones across the rivers, construction of flood protection works [(l)].

(e) *drought protection measures*: computation of drought indicators, including wet period runoff index and dam storage capacity indicator, and alert levels to trigger action. According to the level of alert (mild, moderate, high, extremely high), drought management actions include notification of users for consumption reduction, increase of water supply served from desalination plants, intensive controls for restrictions of uncontrollable abstractions and pumping [(li)].

The Department of Agriculture of the Ministry of Agriculture, Rural Development and Environment is responsible for the implementation of the Common Agricultural Policy. The current Rural Development Programme (RDP) 2014-2020 provides several incentives for farmers to adapt to challenges stemming from climate change and adopt climate change mitigation and adaption actions. The measures that provide incentives to farmers for climate change mitigation and adaptation include [(lii)]:

(a) Art. 14 *Knowledge transfer and information actions*: soil management; training activities on energy efficiency; reducing greenhouse gas (GHG) emissions; climate change impacts and adaptation

(b) Art. 17 *Investments*: irrigation water use efficiency; green infrastructure; infrastructure for using renewable energy (e.g. biogas); manure storage facilities; energy-efficient equipment and buildings

(c) Art. 20 *Basic services and village renewal*: climate proofing of local development plans

(d) Art. 21 *Investments in forest area development and improvement of the viability of forests*: afforestation; investments

(e) Art. 28 *Agri-environmental measures*: input intensity reduction; manure management; soil management practices; diversified crop rotations; climate-resilient crops

(f) Art. 29 *Organic farming:* reducing energy-intensive production inputs and N_2O emissions from soils

(g) Art. 42-44 *Leader*: climate change mitigation and adaptation as integral element of Local Development Strategies

The Department of Environment of the Ministry of Agriculture, Rural Development and Environment is responsible for implementing and enforcing the environmental legislation in Cyprus. The Department has a legally-binding long-term framework to reduce greenhouse gas emissions and a framework for building Cyprus' ability to adapt to a changing climate. A draft National Adaptation Plan has been developed based on a multi-sectoral climate change vulnerability analysis after an extensive consultation process with the relevant stakeholders [(liii)]. The harmonisation of the European environmental acquis, namely, the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, and the Council Directive 79/409/EEC on the conservation of wild birds, through the Republic of Cyprus' Protection and Management of Nature and Wildlife Law 153(I)/2003 and the Republic of Cyprus' Protection and Management of Wild Birds and Game Law 152(I)/2003 ([liv, lv]), forms the cornerstone of Cyprus' environmental policy.

3.2.3 *Main Challenges*

Water scarcity and drought are major challenges in Cyprus and in particular in Pedieos River Basin. Agricultural and natural ecosystems are strongly affected by the high annual and inter-annual rainfall variability. The driest September-October hydrologic years in the past 35 years were 1990-1991 and 2007-2008, when the rainfall at the Athalassa station in the downstream area was just 132 and 133 mm, respectively (Fig 2.9). Average reference evapotranspiration for this station, computed with the FAO Penman-Monteith equation[lvi], was 1520 mm (1980-2010). This gives the downstream area an aridity index (Precipitation/Evapotranspiration) of 0.21, which classifies it on the driest edge of the semi-arid climate zone[lvii]. On the other hand, the most extreme daily rainfall event in the past 30 years was 92.6 mm at Athalassa station (27.11.2000) downstream and 196 mm at Kionia (2.12.2001) on the upstream end of the watershed.

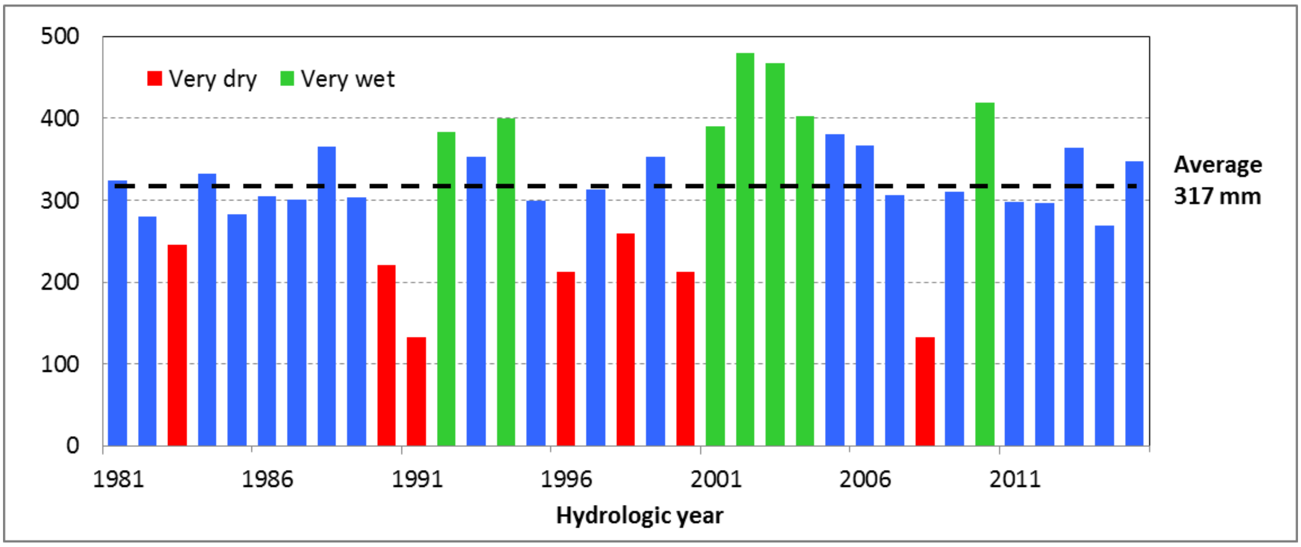


Fig 2.9. Annual rainfall for the past 35 hydrologic years (October 1980 to September 2015) at Athalassa station in the downstream area.

Future climate projections indicate higher temperatures, reduced precipitation volumes and more extreme precipitation events [xxxix]. These projections imply increased water demand for irrigation and domestic water use, potential deterioration of water quality and more severe and frequent flooding events in Pedieos River Basin. Stakeholders identified a wide range of challenges for the Pedieos River Basin. For more details see Section 3.2.2.

3.3 Participatory Development of Pedieos River Basin Adaptation Plan

3.3.1 *Development process*

Stakeholder engagement has gained prominence in the water sector as a principle of good governance in the last years [(lviii)]. The formulation of the Pedieos River Adaptation Plan is the result of a public participation process. The stakeholder engagement process used comprises several steps of a participatory process, where stakeholders actively participated and provide concrete input in the formulation of the adaptation plan (Figure 3.1).

More precisely, various stakeholders representing several sectors (agriculture, infrastructure, water, environment, energy, forest) and organizational affiliations (business, government authorities, civil society, environmental management practitioners, media, youth and education) were involved through workshops, expert-consultations and face-to-face interviews to: (a) exchange ideas and identify the major challenges for the Pedieos River Basin; (b) identify, formulate and evaluate adaptation options to tackle these challenges. The methodological framework of the adaptation plan is based on the active engagement of stakeholders throughout the different steps of the adaptation plan development (see Figure 3.2).

In parallel to the stakeholder engagement, a comprehensive review of existing river basin adaptation plans and strategies was conducted [(lix)]. The description of best practice examples provided valuable input for the design of the Pedieos River Basin Adaptation Plan. Figure 3.1 analytically presents the preparatory steps for developing the Pedieos River Basin Adaptation Plan, with indications of when the main events took place. The list of all engagement activities held in Pedieos River Basin is presented in the Annex I.

Figure 3.1. Development process of Pedieos River Basin Adaptation Plan


adaptation plan
BeWater
Society Adapting to Global Change
July–September
Stakeholder interviews on the river basin context and challenges
October–December
2nd general project meeting in Nicosia
July–September
Finalisation of water management options
Impact assessment, multi-criteria analysis and economic assessment of water management options
October–December
Stakeholder consultation event to present and gather opinions on final water management options
3rd general project meeting in Barcelona
Finalisation of impact assessment, multi-criteria analysis and economic assessment
July–September
Completion of River Basin Adaptation Plan
Next steps
Development of policy recommendations to support river basin adaptation
Compilation of lessons learned during the River Basin Adaptation Plan development process
Local policy forum to present river basin adaptation plan and highlight potential paths forward
European policy workshop in Brussels to highlight BeWater outcomes and key messages for policy makers
River basin adaptation conference and final project meeting in Nova Gorica, Slovenia

3.3.2 *Methodological steps followed*

This section presents the main methodological steps followed for the development of the Pedieos River Basin Plan (Figure 3.2). Further information on the methodology and results introduced within this adaptation plan, as well as the BeWater Project in general, can be found on the project website (www.bewaterproject.eu).

3.3.2.1 Identifying and inviting stakeholders

The first step in the formulation of the adaptation plan was to identify the relevant stakeholders within key sectors: (a) water, (b) agriculture, (c) environment, (d) ecology, (e) urban planning and management, (f) forest and (g) education. For the invitation of stakeholders to participatory workshops, a balanced representation across various criteria (e.g. gender, age, organisational affiliation and sector) was aimed for.

3.3.2.2 Identifying challenges and water management options with stakeholders

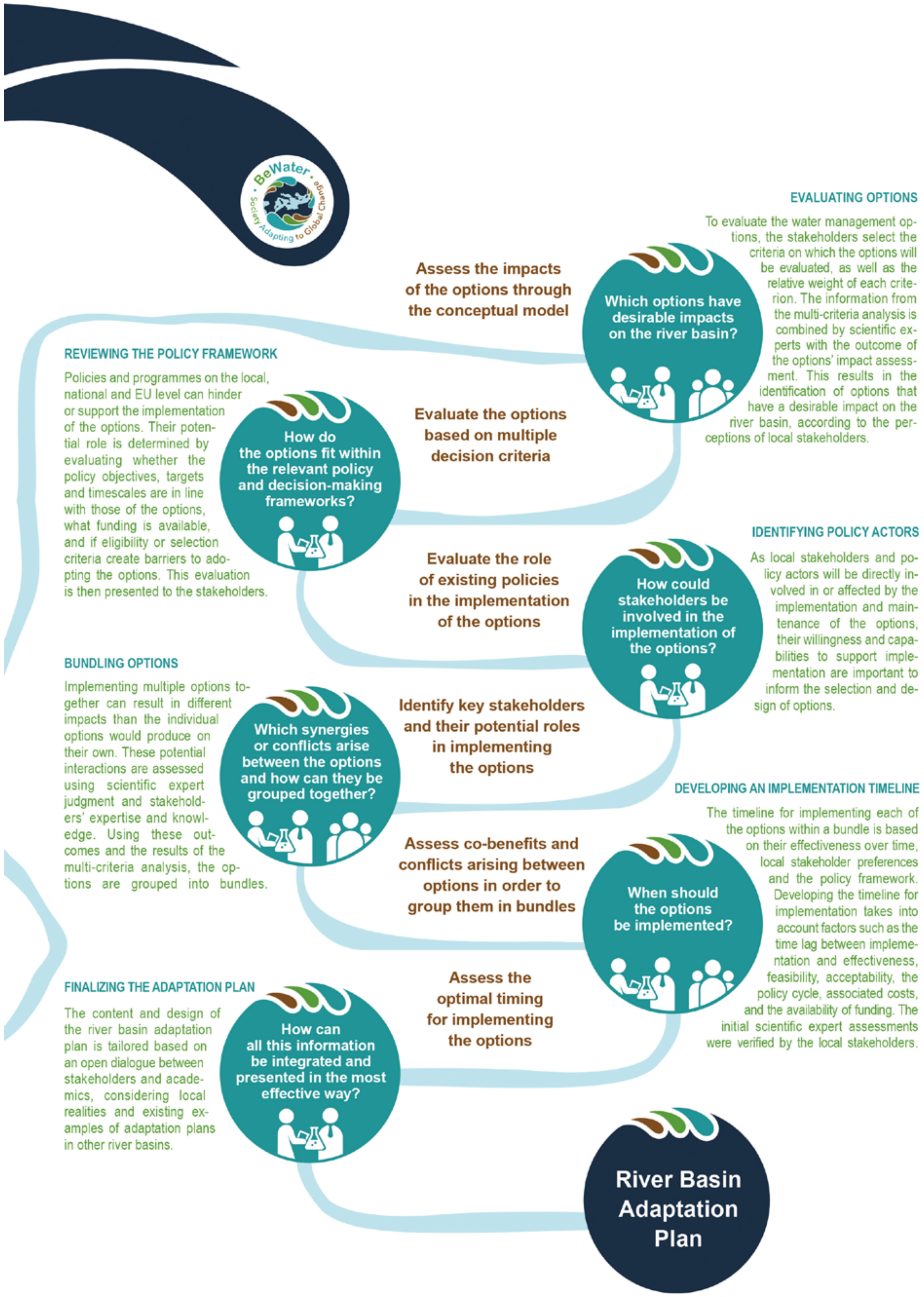
During the first stakeholder workshop (July 2014), the participants identified a wide range of medium-to-long term challenges for the Pedieos River Basin and proposed several options to address these challenges. The information from the first workshop was further explored and complemented with 10 additional face-to-face interviews with policy officials. The interviews revealed additional river basin-relevant considerations, such as the current status of adaptation in the region, their experience with public participation in the design of policies and potential conflicts that may appear. The challenges identified by the stakeholders during the first Pedieos stakeholder workshop and the subsequent interviews were consolidated into three overarching challenges (Box 3.1). In order to tackle these challenges, 30 water management options were formulated (see Section 4.1 & Part 2).

Box 3.1. Identified main challenges for the Pedieos River Basin

	**Challenge A: Quantitative and qualitative status of groundwater** A major challenge identified in the Pedieos River Basin is groundwater quantity and quality. The high temperatures and the increased variability of precipitation leads to increased irrigation water demand that will exacerbate the already high pressures on groundwater resources. A reduction in groundwater quantities will affect irrigated crop production and livestock farms, as well as some of the communities in the midstream area of the Basin that pump groundwater for domestic supply. Over-pumping of groundwater lowers the water table and alters how water moves between the aquifers and the stream. Furthermore, over-pumping of groundwater can also affect the groundwater quality. The completion of the Tamassos dam at the foothills of the forested Troodos mountains in 2004, has reduced the recharge of the downstream river aquifer. The results of monitoring activities for the European Water Framework Directive have been summarized in the Cyprus River Basin Management Plan and its Annexes [xliii]. The Central and Western Mesaoria groundwater body, which includes the alluvial Pedieos Riverbed aquifer, has been qualified as having a bad quantitative status for the European Water Framework Directive, with dropping groundwater levels [xliii]. Non-point source pollution from agriculture could affect groundwater quality, especially in the rural midstream area of river basin. Croplands are a primary non-point source of contamination to groundwater due to the applications of agricultural chemicals such as

	fertilizers, pesticides and manure. Excess irrigation water applications may also leach agricultural chemicals into groundwater. As a whole, the chemical status of the Central and Western Mesaoria groundwater body has been qualified as good, even though high concentrations of ammonium (NH4) have been found [xliii].
	Challenge B: Quantitative and qualitative status of surface water The adverse climatic conditions (increase of temperature & precipitation decrease) will result in diminished surface water supplies. These changes affect the services and the functions of the Tamassos dam water body. The Tamassos dam provides water supply for the nearby rural communities, but has also created a new aquatic ecosystem and recreational area. Surface water flows downstream from the dam are controlled by the release of water from the dam for downstream groundwater recharge. During wet years water flows over the dam spillway and continue downstream. A few small recharge checkdams and diversion structures have been constructed in the midstream area to increase groundwater recharge or divert surface water for irrigation. The reduction in surface water quantities will affect the riparian vegetation and biodiversity habitats of the streams as well as irrigated farming. Similarly to groundwater qualitative status, during peak precipitation events, agro-chemicals from irrigated agriculture and livestock manure are carried away to the river. Urban development has led to the degradation of the riverbed and riparian area. Solid and liquid waste dumping has detrimental effects on the quality of the surface water. Urban sprawl also results in soil sealing in suburban areas of Pedieos River Basin. Pollutants from paved areas can degrade river water quality when washed into the stream.
	Challenge C: Flooding The urban area along the Pedieos River has been identified as an area of potentially significant flood risk. Although the Pedieos River in its downstream part is dry most of the year, heavy rainfall events may lead to significant floods, as indicated by the latest flood risk assessment [lx]. Natural vegetation across the riverbed impedes the flow of the water, while illegal dumping of garbage is often blocking waterways and causes localised floods and spill overs of water in the roads. The restoration and maintenance of the riverbed was emphasized by the stakeholders [lxi]. The forests in the upstream area of the River Basin help to regulate relatively minor floods although they are not able to prevent major floods. Crop fields in good state have also a positive contribution to flood prevention in the midstream parts of the river basin. Tamassos dam provides significant flood protection to the midstream and downstream areas of the river basin. The dam modifies the volume of water flowing downstream and alters the natural rates at which river rise and fall during extreme runoff events. The high urban sprawl intensifies soil sealing, which increases the risk of flooding. Flooding is also caused by problems in the rainwater drainage systems in the urban area. Sustainable urban drainage systems are necessary to capture and store surface water runoff and control its release into Pedieos River.

Figure 3.2. Methodological framework of the Pedieos River Basin Adaptation Plan


BeWater
Society Adapting to Global Change
EVALUATING OPTIONS
To evaluate the water management options, the stakeholders select the criteria on which the options will be evaluated, as well as the relative weight of each criterion. The information from the multi-criteria analysis is combined by scientific experts with the outcome of the options' impact assessment. This results in the identification of options that have a desirable impact on the river basin, according to the perceptions of local stakeholders.
Assess the impacts of the options through the conceptual model
Which options have desirable impacts on the river basin?
REVIEWING THE POLICY FRAMEWORK
Policies and programmes on the local, national and EU level can hinder or support the implementation of the options. Their potential role is determined by evaluating whether the policy objectives, targets and timescales are in line with those of the options, what funding is available, and if eligibility or selection criteria create barriers to adopting the options. This evaluation is then presented to the stakeholders.
How do the options fit within the relevant policy and decision-making frameworks?
Evaluate the options based on multiple decision criteria
IDENTIFYING POLICY ACTORS
As local stakeholders and policy actors will be directly involved in or affected by the implementation and maintenance of the options, their willingness and capabilities to support implementation are important to inform the selection and design of options.
Evaluate the role of existing policies in the implementation of the options
How could stakeholders be involved in the implementation of the options?
BUNDLING OPTIONS
Implementing multiple options together can result in different impacts than the individual options would produce on their own. These potential interactions are assessed using scientific expert judgment and stakeholders' expertise and knowledge. Using these outcomes and the results of the multi-criteria analysis, the options are grouped into bundles.
Which synergies or conflicts arise between the options and how can they be grouped together?
Identify key stakeholders and their potential roles in implementing the options
DEVELOPING AN IMPLEMENTATION TIMELINE
The timeline for implementing each of the options within a bundle is based on their effectiveness over time, local stakeholder preferences and the policy framework. Developing the timeline for implementation takes into account factors such as the time lag between implementation and effectiveness, feasibility, acceptability, the policy cycle, associated costs, and the availability of funding. The initial scientific expert assessments were verified by the local stakeholders.
Assess co-benefits and conflicts arising between options in order to group them in bundles
When should the options be implemented?
FINALIZING THE ADAPTATION PLAN
The content and design of the river basin adaptation plan is tailored based on an open dialogue between stakeholders and academics, considering local realities and existing examples of adaptation plans in other river basins.
Assess the optimal timing for implementing the options
How can all this information be integrated and presented in the most effective way?
River Basin Adaptation Plan

3.3.2.3 *Developing a conceptual model for the basin*

The information on challenges was used in a next step to develop a conceptual model (fuzzy cognitive map) for the river basin (Box 3.2; Figure 3.3).

Box 3.2. Description of fuzzy cognitive map

A fuzzy cognitive map is a graphical representation of a system - in this case a river basin - where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the sign and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system based on the understanding of individuals. Fuzzy cognitive map allows all the information available on the basin to be organized in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them and their relationships in the system. The map was constructed with inputs from a group of expert stakeholders with different environmental and water management expertise.

The conceptual model was used to qualitatively assess the impact of the 30 water management options on the Pedieos River Basin. The impact of changes in drivers on the dynamics of the river basin was estimated by iteratively multiplying the initial values of all factors with the strength of the relationships. A sigmoid function was used to normalize all factors within the 0-1 range for each multiplication. The impact assessment results were used as input to a multi-criteria analysis that was conducted during the second stakeholder workshop (Section 3.2.4).

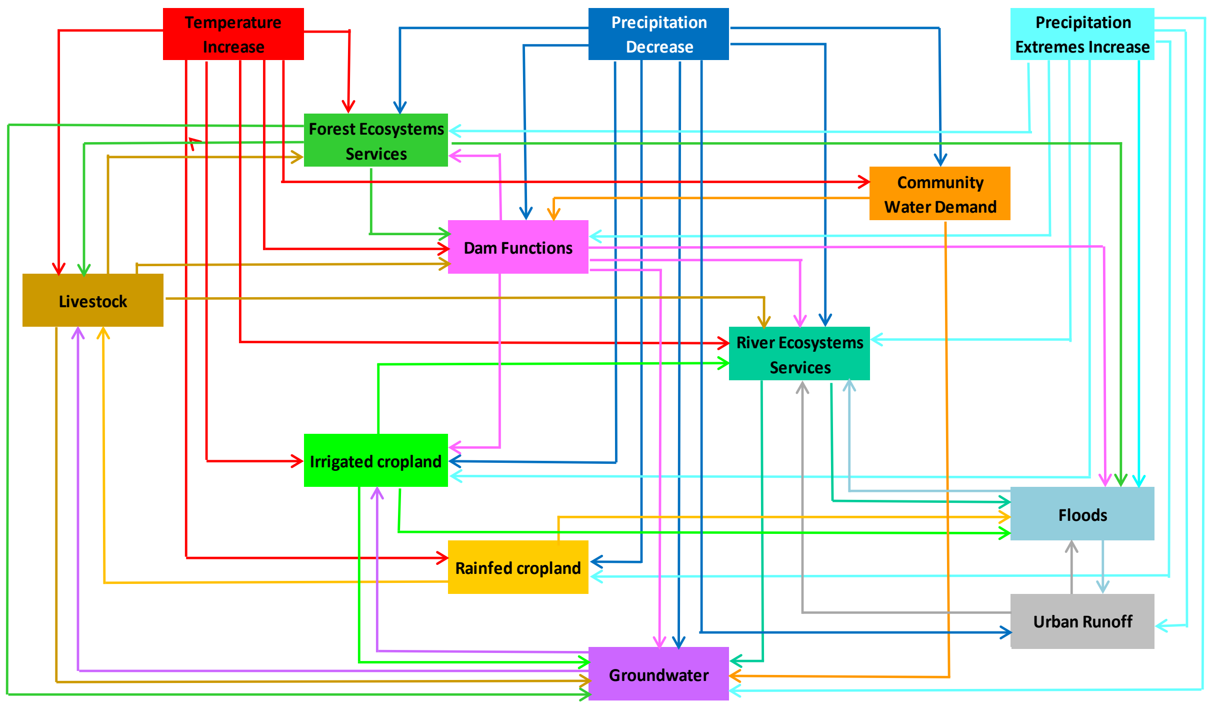


Figure 3.3. Pedieos River Basin conceptual model

3.3.2.4 Evaluating water management options

Water management options have quite different characteristics and impacts on the river basin and the local communities. To evaluate the specific options that should be included in the river basin adaptation plan, a participatory multi-criteria analysis was conducted (Box 3.3).

Box 3.3. Description of multi-criteria analysis

During the second workshop (1 July 2015), 19 stakeholders were asked to select evaluation criteria and to express their opinion on the performance of water management options. The scores and weights of the criteria given by the stakeholders were combined with the characterization of the water management options and the outcomes of the impact assessment (as explained in the section 3.2.3) to evaluate the water management options prepared by experts and scientists. The evaluation results are presented on a scale of 0-100 with 0 indicating the least preferred evaluation outcome and 100 the most preferred evaluation outcome.

According to the multi-criteria analysis results (Figure 3.4), *farm education* (WMO6) was highly preferable among stakeholders to address the quantitative and qualitative status of groundwater (Challenge A) followed by the *awareness campaign for local society* (WMO9). The enforcement of the *Code of Good Agricultural Practices* (WMO13) and *volunteerism* (WMO20) were similarly the highest ranked options for the quantitative and qualitative status of surface water (Challenge B). Finally, *improved stakeholders' cooperation* (WMO25) and *sustainable urban drainage systems* (WMO28) received the highest scores for Challenge C (flooding from the river). The least preferable options were the *construction of flood protection works* (WMO29), *agrotourism development* (WMO10), *use of treated sewage water for irrigation and green infrastructure* (WMO4) and *improved irrigation technologies* (WMO1).

However, the use of multi-criteria analysis for evaluating adaptation options requires careful consideration of normalization, weighting and the combination of continuous and categorical criteria. Thus, an additional evaluation of the water management options was conducted through the direct scoring of the options by the stakeholders. The results suggested that *dynamic dam water management* (WMO8) and *borehole licences and water meters* (WMO2) were highly preferable among stakeholders to address the quantitative and qualitative status of groundwater (Challenge A). The enforcement of the *Code of Good Agricultural Practices* (WMO13) was the highest ranked option for the quantitative and qualitative status of surface water (Challenge B), while the *restoration and maintenance of riverbed* (WMO26) was the most preferable option for the Challenge C (flooding from the river).

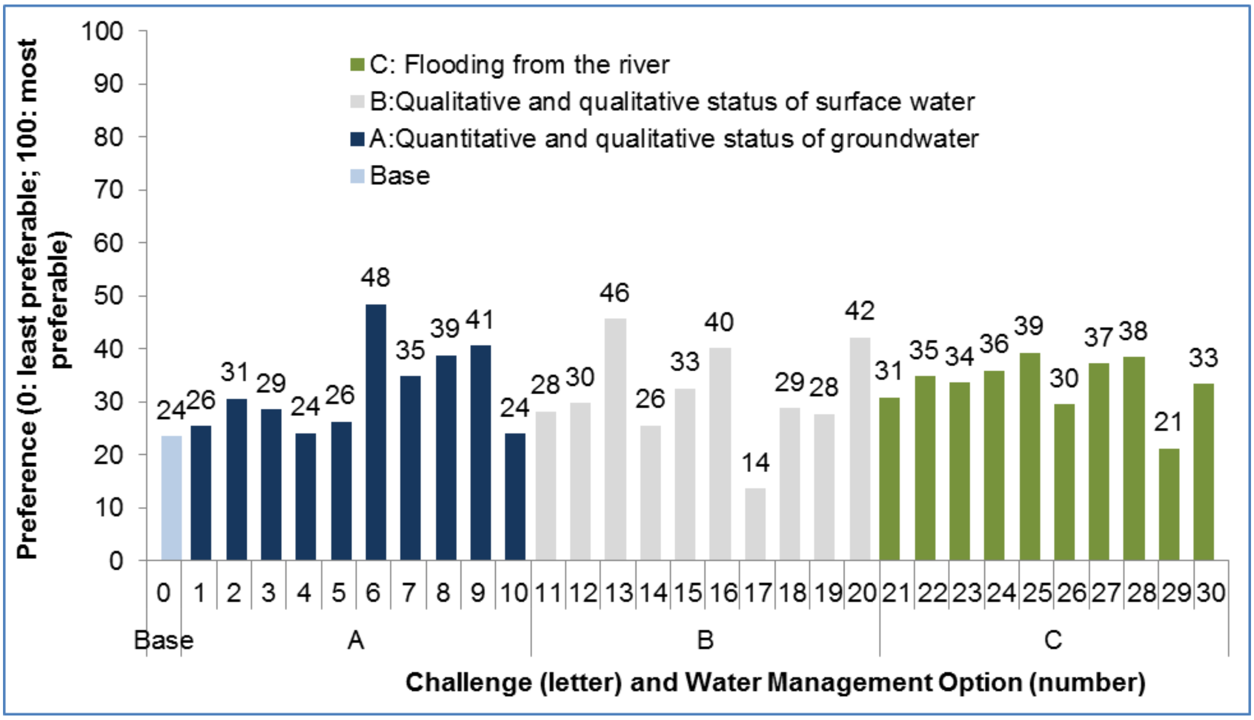


Figure 3.4. Multi-criteria analysis results based on the 15 criteria derived from the conceptual model of the river basin and the characterization of the water management options. Numbers on the x-axis refer to the water management options in Table 4.1; number 0 is the baseline.

Multi-criteria analysis results were used for the development of the bundles of water management options in the Pedieos River Basin Adaptation Plan. In addition, a cost assessment of the selected water management options was conducted from the beginning of their implementation plan (2016) towards 2030. The cost assessment included both capital and operational costs of the required actions for the implementation and maintenance of the options (see Section 4.1.1).

3.3.2.5 Bundling of adaptation options

Stakeholders assessed the potential synergies and conflicts between the adaptation options. More precisely, they compared the impact of different combinations of options with the implementation of individual options. The bundling process was based on the normalised co-benefit scores, the results of the multi-criteria analysis and the time implementation scores. Stakeholders highlighted the effectiveness of implementing bundles of adaptation options compared to implementing individual options. The formulated bundles of adaptation options are presented in Section 4.2.

3.3.2.6 Implementation timeline of bundles of adaptation options

The next step in the bundling of the adaptation options includes the identification of options for implementation in the short, medium or long term. Stakeholders developed the implementation timeline and the priority of the individual adaptation options within the proposed bundles based on their preferences and the effectiveness of the options over time (see Section 4.2).

3.3.2.7 Designing an Adaptation Plan for the Pedieos River Basin

Stakeholders provided valuable feedback regarding the structure of the River Basin Adaptation Plan and acknowledged the contribution of the adaptation plan in mitigating the challenges of the Pedieos River Basin. They also expressed their views on potential barriers and opportunities for the implementation of the adaptation options.

3.4 Adaptation actions

3.4.1 *Context*

3.4.1.1 Water management options for the Pedieos River Basin

In total 30 water management options for Pedieos River Basin were formulated based on input collected from stakeholders during the first stakeholder workshop, as well as through face-to-face interviews with policy officials. In addition, information from a review of policy documents including the national strategy for adaptation to climate change [liii] and other international river basin adaptation plans and strategies, were taken into account. The options range from nature-based to technical and managerial and are listed in Table 4.1; a detailed description of the water management options is provided in Part 2. While the options are grouped together in **bundles** in Chapter 4 according to their synergistic interactions with one another and a common objective they contribute to, this table provides an overview of information that is specific to an option. This information can be used by decision-makers when determining which single option(s) would be most appropriate to achieve targeted objectives.

More specifically, each option is associated with one or more of the challenges identified for the Pedieos River Basin, i.e., 25 options address the quantitative and qualitative status of groundwater (**challenge A**), 24 options address the quantitative and qualitative status of surface water (**challenge B**), and 14 options address the flooding from the river (**challenge C**). Thus, several options address more than one challenge (Table 4.1). However, to facilitate the evaluation of the options, the key challenge that each option addresses was identified (see Table 4.1). Each option is further characterized by a set of additional implementation-oriented factors, such as its acceptability and synergies. These factors help to determine whether there will be barriers to the implementation of an option, or conversely, if there are opportunities that facilitate its implementation.

Considering the 15-year implementation period of the plan (2016-2030), the cost assessment of the selected water management options revealed that the technical options (grey approaches to adaptation) are the most expensive, e.g., *rainwater harvesting systems* (WMO21), *use of treated sewage water for irrigation and green infrastructure* (WMO4) and *sustainable urban drainage systems* (WMO28). On the contrary, managerial and policy oriented approaches to adaptation have low cost, e.g., *volunteerism* (WMO20), *improvement of stakeholders' cooperation* (WMO25) and *improvement of plant genetic resources bank and use of drought tolerant agricultural crops* (WMO7). The acceptability of the adaptation options among the local actors of the river basin is high for 67% of the options, while only for two adaptation options there were serious obstacles (physical, regulatory or organisational) that would be difficult to overcome within the time horizon of the project. These two options refer to *water pricing enforcement* (WMO3) and *dam demolition* (WMO17). Half of the adaptation options create high co-benefits and synergies with the other options, while only two options, i.e., *fire safety measures* (WMO23) and *construction of flood protection works* (WMO29), seem to create low co-benefits.

Table 4.1. Overview of the water management options for the Pedieos River Basin

		Water Management Options	Challenges Addressed	Key Challenge Addressed	Cost[1]	Co-benefits[2]	Acceptability[3]
1		Improved irrigation technologies	A-B	A	€€	+++	++
2		Borehole licences and water meters	A	A	€€€	+++	++
3		Water pricing enforcement	A-B	A	€€	+++	+
4		Use of treated sewage water for irrigation and green infrastructure	A-B	A	€€€	++	+++
5		Water desalination	A-B	A	€€€	++	+++
6		Farm education	A-B	A	€€	+++	+++
7		Improve plant genetic resources bank and use of drought tolerant agricultural crops	A-B	A	€	++	+++
8		Dynamic dam water management	A-B-C	A	€€	++	+++
9		Awareness campaign for local society	A-B	A	€€	+++	+++
10		Agrotourism development	A-B-C	A	€€€	++	++
11		Domestic water saving equipment	A-B	B	€€€	+++	+++
12		Maintenance and repair of water distribution networks	A-B	B	€€€	++	+++
13		Code of Good Agricultural Practices enforcement	A-B	B	€€	+++	++
14		Grazing control	A-B	B	€€	+++	++
15		Improve plant genetic resources bank and use of drought tolerant forest species	A-B	B	€€	++	+++

16		Hydrological studies	A-B	B	€€	+++	+++
17		Dam demolition	A-B-C	B	€€€	++	+
18		Integrated waste management	A-B	B	€€€	+++	+++
19		Construction of multi-purpose cycling/ walking paths across the river	A-B	B	€€€	++	+++
20		Volunteerism	A-B-C	B	€	+++	+++
21		Rainwater harvesting systems	A-B-C	C	€€€	+++	++
22		Improve plant genetic resources bank and use of drought tolerant plants in green infrastructures	A-B-C	C	€€	+++	+++
23		Fire safety measures	A-B-C	C	€€	+	+++
24		Improving land zonation	A-B-C	C	€€	++	++
25		Improve stakeholders' cooperation	A-B-C	C	€	++	+++
26		Restoration and maintenance of riverbed	C	C	€€	+++	+++
27		River runoff retention and groundwater recharge systems	C	C	€€	+++	+++
28		Sustainable urban drainage systems	C	C	€€€	++	+++
29		Construction of flood protection works	C	C	€€€	+	++
30		Cooperation for storm water drainage system	C	C	€€	++	+++

[1] €: low cost (<100,000 euro); €€: medium cost (100,000-1,000,000 euro); €€€: high cost (>1,000,000 euro)
[2] +: low co-benefits; ++: medium co-benefits; +++: high co-benefits
[3] +: low acceptability; ++: medium acceptability; +++: high acceptability

3.4.2 *Bundles of adaptation options*

Evidence from studies of adaptation to past and current climate variability indicates that adaptation options are rarely adopted singly [lxii]. Instead, bundles of adaptation options are adopted together in an attempt to address the multiple impacts of climate change on river basins and maximise the co-benefits between different adaptation options. Local stakeholders also stressed the effectiveness of implementing bundles of adaptation options, compared to implementing individual options. The development of complementary bundles of adaptation options enhances synergistic benefits and reduces trade-offs. However, not all adaptation options are necessarily compatible with one another.

The identified adaptation options for Pedieos River Basin Adaptation Plan were bundled with one another based on their co-benefits and conflicts. Scientists and key expert stakeholders assessed the impact of different combinations of adaptation options in relation to the implementation of individual options. Based on this co-benefits analysis, groups of adaptation options with high co-benefits were grouped together. More precisely, the bundling process was based on three key pieces of information: (a) the results of the multi-criteria analysis, (b) co-benefits with other options (the co-benefit scores) and (c) the urgency and synergies for implementation of the options (time implementation scores). The adaptation options could be included in more than one bundle according to the aforementioned criteria.

The key stakeholders assessed the implementation timeline of the bundled adaptation options, based on their preferences and the effectiveness of options over time. This assessment aimed to identify when each option would best be implemented within each bundle.

The six bundles of adaptation options are presented in Sections 4.2.1 to 4.2.7. These sections provide summarised information for each bundle, including:

- the focus of each bundle
- the adaptation options per bundle
- the adaptation pathway representing the implementation of the options in different time-oriented phases, i.e. short-term (2018), mid-term (2021) and long-term (2025), and
- the way forward, i.e., implementation avenues.

3.4.2.1 Sustainable Irrigation Water Management (Bundle 1)

The sustainable irrigation water management bundle aims to match water demand with the sustainable use of water resources. This is achieved through a holistic/integrated approach including farmers' education, training and knowledge transfer regarding sustainable irrigation management. In addition, the adoption of innovative irrigation systems and other managerial options, such as the full cost recovery for water services via water pricing, the installation of water metering equipment and the strict implementation of the Code of Good Agricultural Practices.

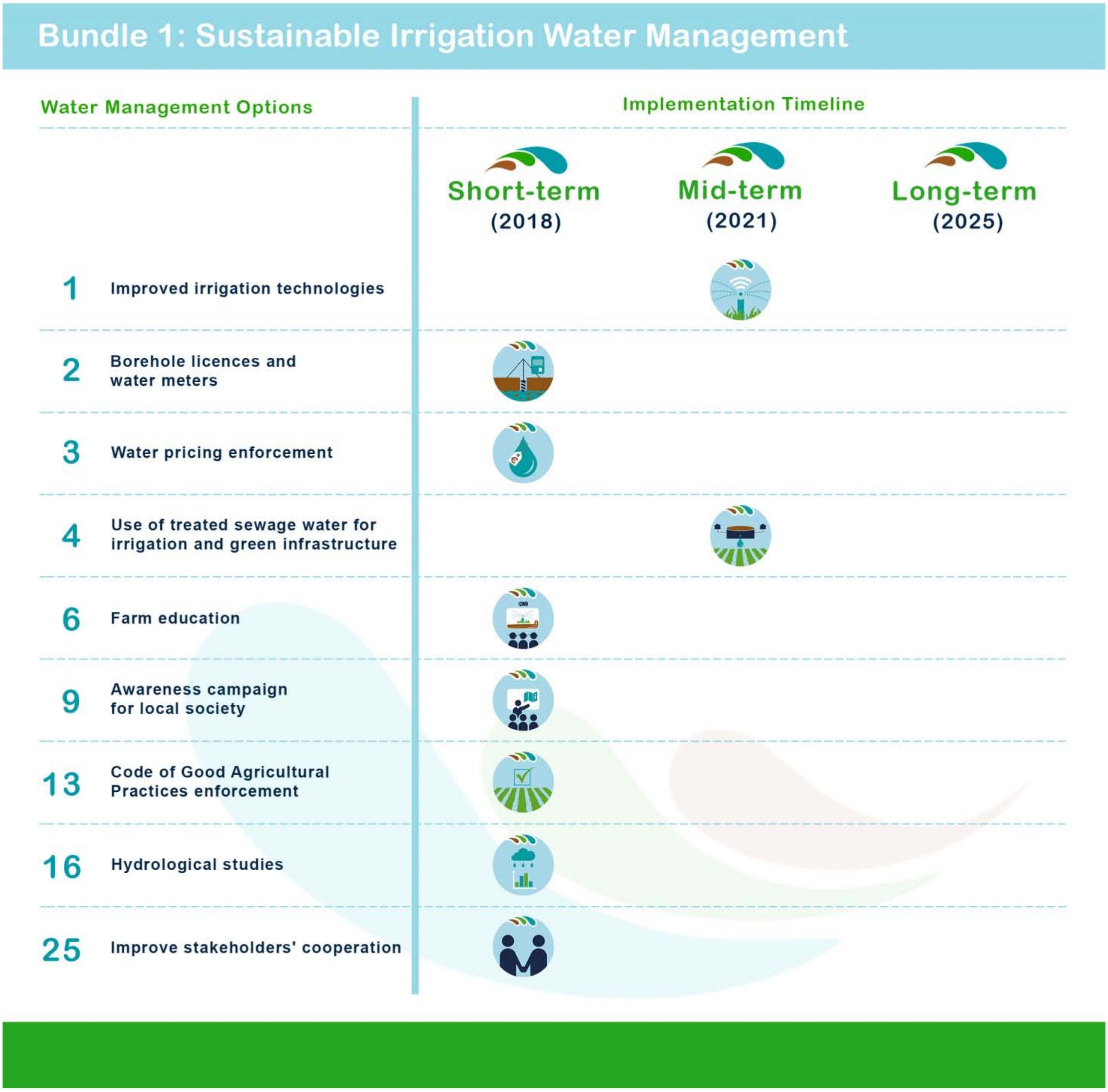
Proposed combination of WMOs

Context	**Water Management Options**	
The installation of modern		**WMO 1: Improved irrigation technologies**

irrigation systems and technologies, namely irrigation scheduling decision support systems, including wireless sensor network, results in savings of irrigation water.		• The option aims to establish 100 irrigation blocks in the midstream areas of the river basin (downstream from Tamassos dam), where groundwater-irrigated crops prevail (e.g. vegetables). • The adoption of irrigation scheduling decision support systems will result in the improvement of the quantitative and qualitative status of groundwater. • Positive effects will be created for irrigated agriculture.
Specific law requirements for granting license for borehole drilling and installation of water meters on groundwater pumps.		**WMO 2: Borehole licences and water meters** • The option targets the whole river basin. • The option aims at measuring and controlling groundwater abstraction and reducing its overexploitation. It aims to install groundwater meters on 10,000 wells • Positive indirect effects will be created for irrigated agriculture and livestock.
The enforcement of a water pricing policy that ensures the full cost recovery of water services and takes into account the polluter pays principle provide adequate incentives for users to use water resources efficiently.		**WMO 3: Water pricing enforcement** • The option targets the whole river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects will be created for irrigated agriculture
The use of non-conventional water resources such as treated sewage water increase water availability for agriculture and amenity use (green spaces) and can substantially alleviate the pressures on water resources which are very high in Cyprus.		**WMO 4: Use of treated sewage water for irrigation and green infrastructure** • The option targets the midstream and downstream areas of the river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive effects will be created for irrigated agriculture and livestock
Global change related farm education. The training of local farmers on the rational use of water resources and agrochemical inputs will improve the resilience of agricultural ecosystems		**WMO 6: Farm education** • The option targets the upstream and midstream areas of the river basin • The improvement of farm education will create significant positive effects to agriculture (both irrigated and rainfed) and livestock. • The ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization and provision of habitat for biodiversity) will be improved as well as the quantitative and qualitative status of groundwater.
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		**WMO 9: Awareness campaign for local society** • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock

		• The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
The strict implementation of the Code of Good Agricultural Practices reduces the leaching and surface runoff of agrochemicals and livestock waste from crop and livestock farming.		**WMO 13: Code of Good Agricultural Practices enforcement** • The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. • The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The strict implementation of the option slightly reduces flooding from the Pedieos River
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		**WMO 16: Hydrological studies** • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		**WMO 25: Improve stakeholders' cooperation** • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.

Adaptation pathway


Bundle 1: Sustainable Irrigation Water Management
Water Management Options
Implementation Timeline
Short-term
(2018)
Mid-term
(2021)
Long-term
(2025)
1 Improved irrigation technologies
2 Borehole licences and water meters
3 Water pricing enforcement
4 Use of treated sewage water for irrigation and green infrastructure
6 Farm education
9 Awareness campaign for local society
13 Code of Good Agricultural Practices enforcement
16 Hydrological studies
25 Improve stakeholders' cooperation

Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO1	• The Rural Development Programme 2014-2020 has identified water scarcity as a major challenge and supports investments in irrigation scheduling infrastructure to provide economic and environmental benefits	• Department of Agriculture (MARDE) • Farmers
WMO2	• Groundwater abstraction control is one of the major requirements of the Water Framework Directive	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO3	• Within the Water Framework Directive, Cyprus is required to set up a water pricing policy that ensures an adequate cost recovery of water services, taking into account the polluter pays principle	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO4	• The Department of Agriculture aims to promote the use of treated sewage water in irrigation. • The Water Development Department aims to further promote the use of treated sewage water. Wastewater collection and treatment infrastructure is being significantly expanded and/or upgraded. The lower water prices set for treated water compared to freshwater creates an incentive for farmers to turn to the use of recycled water. • Department of Environment aims to further promote the use of treated sewage water for green spaces	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Farmers • Civil society (NGOs)
WMO6	• Rural development policy towards 2020 (CAP 'Health Check') extends its intervention domains in the fields of global change, water management and biodiversity. Farmers are urged to be trained on issues such as the integrated and sustainable management of natural resources and the application of farm practices compatible with global change challenges • Cyprus guidelines for urban treated effluents for irrigation requires the training of farmers on the safe and efficient use of treated sewage water	• Department of Agriculture (MARDE) • Farmers
WMO9	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO13	• The Department of Agriculture aims to improve the control system related to the guidelines of the Code of Good Agricultural Practices. The enforcement of cross-compliance requirements is mandatory for all farmers receive farm subsidies. • The Department of Environment is very supportive towards the strict implementation of the Code of Good Agricultural Practices as it will strengthen biodiversity conservation	• Department of Environment (MARDE) • Department of Agriculture (MARDE) • Farmers

WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)

3.4.2.2 Good governance (Bundle 2)

The good governance bundle focuses on policy, social, economic and administrative systems that affect decision-making regarding the water resources management. It includes the manner in which the roles and responsibilities (design, regulation and implementation) by formal and informal institutions are exercised in the water resources management.

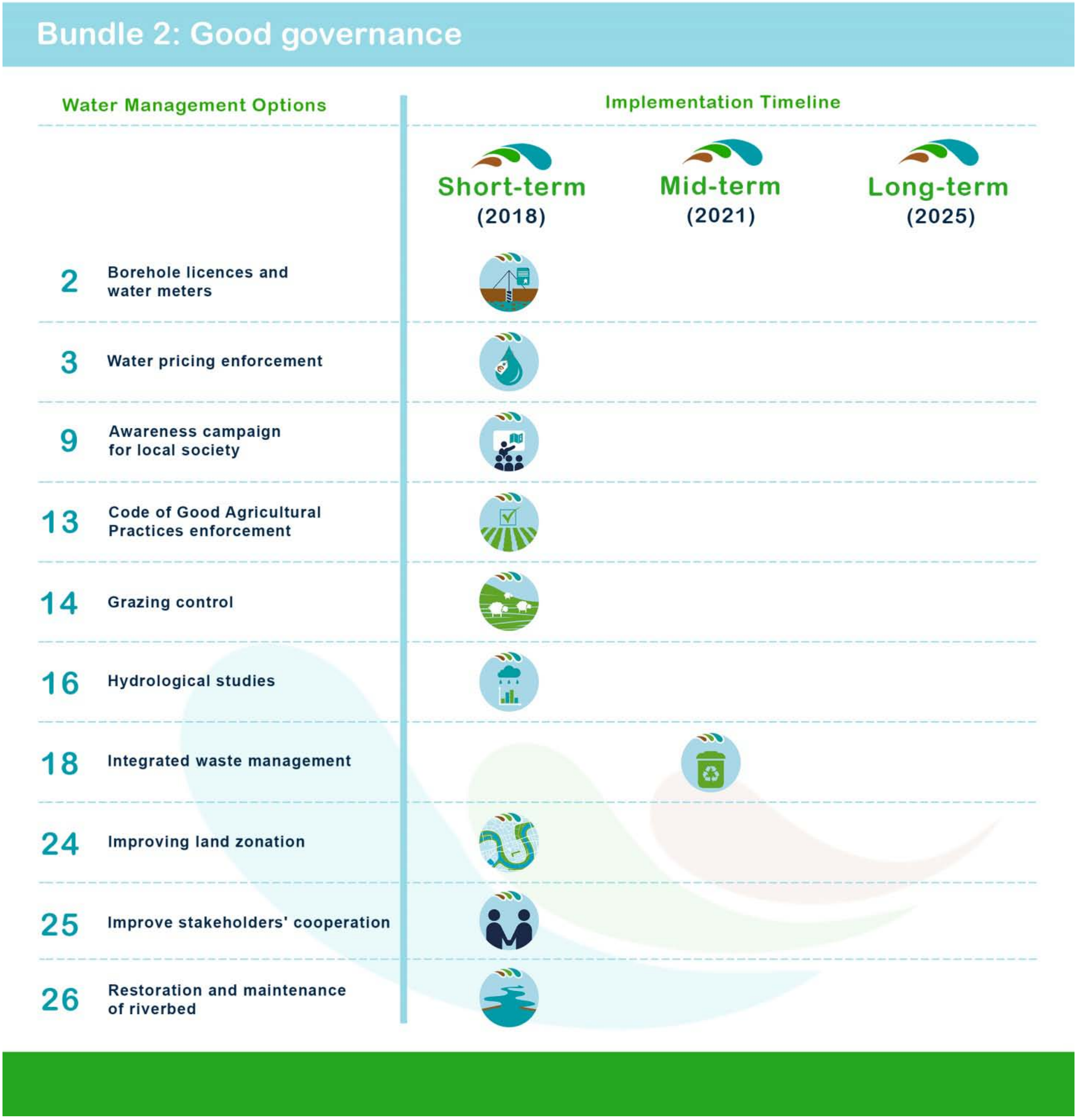
Proposed combination of WMOs

Context	**Water Management Options**	
Specific law requirements for granting license for borehole drilling and installation of water meters on groundwater pumps.		WMO 2: Borehole licences and water meters • The option targets the whole river basin. • The option aims at measuring and controlling groundwater abstraction and reducing its overexploitation. It aims to install groundwater meters on 10,000 wells • Positive indirect effects will be created for irrigated agriculture and livestock.
The enforcement of a water pricing policy that ensures the full cost recovery of water services and takes into account the polluter pays principle provide adequate incentives for users to use water resources efficiently.		WMO 3: Water pricing enforcement • The option targets the whole river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects will be created for irrigated agriculture
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the

		surface runoff of rainwater will slightly decrease.
The strict implementation of the Code of Good Agricultural Practices reduces the leaching and surface runoff of agrochemicals and livestock waste from crop and livestock farming.		WMO 13: Code of Good Agricultural Practices enforcement • The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. • The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The strict implementation of the option slightly reduces flooding from the Pedieos River
The control of grazing by permits on the basis of the carrying capacity of the area reduces soil erosion and runoff.		WMO14: Grazing control • The option targets the upstream and midstream areas of the river basin • The grazing control significantly strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. • It is an effective measure for preventing soil erosion reducing thus runoff and the risk of flooding.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
Establishment of protection zones across river basin to control housing development. Land zonation maps and laws need to be improved, widely disseminated and properly enforced.		WMO 24: Improving land zonation • The option targets the whole river basin • The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water

		• The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River • The implementation of the option improves the qualitative and quantitative status of groundwater.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO2 	• Groundwater abstraction control is one of the major requirements of the Water Framework Directive	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO3	• Within the Water Framework Directive, Cyprus is required to set up a water pricing policy that ensures an adequate cost recovery of water services, taking into account the polluter	• Water Development Department (MARDE) • Farmers

	pays principle	• Civil society (NGOs)
WMO9	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO13	• The Department of Agriculture aims to improve the control system related to the guidelines of the Code of Good Agricultural Practices. The enforcement of cross-compliance requirements is mandatory for all farmers receive farm subsidies. • The Department of Environment is very supportive towards the strict implementation of the Code of Good Agricultural Practices as it will strengthen biodiversity conservation	• Department of Environment (MARDE) • Department of Agriculture (MARDE) • Farmers
WMO 14	• The control of grazing is one of the major objectives of forest policy in Cyprus	• Department of Environment (MARDE) • Department of Forests (MARDE) • Livestock breeders
WMO16	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO18	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO24	• The Department of Town Planning and Housing aims to properly enforce land zonation laws and plans	• Department of Town Planning and Housing (Ministry of Interior)
WMO25	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)

3.4.2.3 *Sustainable urban drainage and flood management (Bundle 3)*

The sustainable urban drainage and flood management bundle focuses on strategies and systems designed to: (a) efficiently manage the drainage of surface water in the urban environment; (b) reduce runoff by reducing impermeable areas; (c) reduce flooding; (d) recharge groundwater resources.

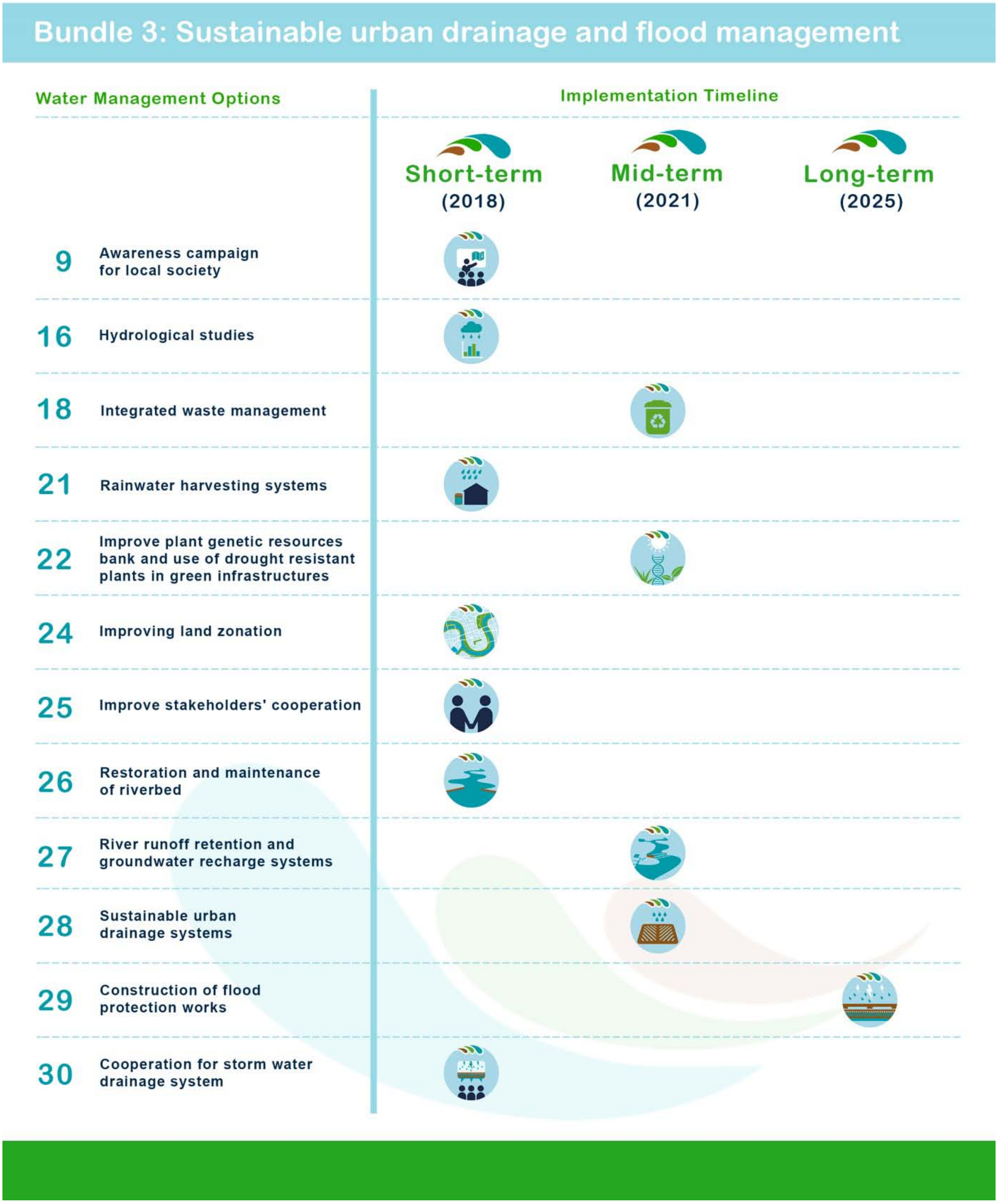
Proposed combination of WMOs

Context	**Water Management Options**	
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and climate change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
The installation of rainwater harvesting systems will supplement water supply at both household (e.g. collect surface runoff from roofs and paved areas in storage tanks; use of stored water for irrigation of gardens) and farm (e.g. collect surface runoff from roofs of farm buildings and greenhouses; use of stored water for irrigation of agricultural crops) level.		WMO 21: Rainwater harvesting systems • The option targets the whole river basin • The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects are created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos River.
Improvement of green		WMO 22: Improve plant genetic resources bank and use of

infrastructures with drought tolerant plants. Parks, gardens and green areas along roads can be grown with plants that maintain a protective land cover and need little or no irrigation. The option aims to improve the systematisation and organisation of the plant genetic resources bank.		drought tolerant plants in green infrastructures • The option targets the midstream and downstream areas of the river basin • The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on the provision of the river and riparian zone ecosystem services (including sediment and nutrient filtering, bank stabilization) as well as the quantitative and qualitative status of groundwater.
Establishment of protection zones across river basin to control housing development. Land zonation maps and laws need to be improved, widely disseminated and properly enforced		WMO 24: Improving land zonation • The option targets the whole river basin • The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water. • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. • The implementation of the option improves the qualitative and quantitative status of groundwater.
The construction of river runoff retention systems including detention basins, retention ponds and check dams prevents flooding and improves groundwater recharge and water quality		WMO 27: River runoff retention and groundwater recharge systems • The option targets the midstream and downstream areas of the river basin. • The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Systems including green roofs and green ditches that capture surface water runoff through local collection, storage,		WMO 28: Sustainable urban drainage systems • The option targets the midstream and downstream areas of the river basin. • The development of sustainable urban drainage systems

recharge, re-use or release into Pedieos River with low environmental impact		improve the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option also reduces the urban runoff and the flooding from the river.
Technical flood protection through the construction of anti-flooding works such as terraces, rectangular culverts and hydraulically designed bridges.		WMO 29: Construction of flood protection works • The option targets the downstream areas of the river basin • The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.
Cooperation between municipalities for the design of storm water drainage systems at the downstream watershed level. This is a soft measure		WMO 30: Cooperation for storm water drainage system • The option targets the downstream watershed areas • The improvement of cooperation between municipalities significantly reduces urban runoff and the flooding from the Pedieos River, while it improves the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO9 	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households

		• Civil society (NGOs)
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO18 	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO21 	• The Department of Agriculture aims to promote the installation of rainwater harvesting systems at farm holdings. Efforts will be made these systems to be subsidized under the Rural Development Programme. • The Water Development Department promotes the installation of rainwater harvesting systems	• Department of Agriculture (MARDE) • Water Development Department (MARDE) • Farmers
WMO22 	• The Agricultural Research Institute of Cyprus is involved in the conservation of genetic resources (including collection, conservation and utilisation of the genetic variability existing in local germplasm) and the genetic improvement of plants for adaptation to climate change by increasing their resistance to abiotic and biotic stresses and their adaptability to the warm and dry environment of Cyprus. • Competent authorities, i.e. municipalities, promote native plants that are drought tolerant and low maintenance for green infrastructures	• Agricultural Research Institute (MARDE) • Municipalities
WMO24 	• The Department of Town Planning and Housing aims to properly enforce land zonation laws and plans	• Department of Town Planning and Housing (Ministry of Interior)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26 	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)
WMO27 	• River runoff retention systems are of high importance within Water Framework Directive and Floods Directive • Municipalities aim to promote the construction of river runoff retention systems	• Water Development Department (MARDE) • Municipalities
WMO28	• Water Development Department promotes the installation of sustainable urban drainage systems • Municipalities promote the installation of sustainable	• Water Development Department (MARDE) • Civil society (NGOs)

	urban drainage systems	
WMO29 	• Water Development Department promotes the construction of flood protection works including bridges, terraces and retaining walls • Municipalities and communities promote the construction of small flood protection works	• Water Development Department (MARDE) • Municipalities
WMO30 	• Floods Directive encourages cooperation between municipalities within sub-basins • Municipalities aim to strengthen cooperation amongst their competent authorities	• Water Development Department (MARDE) • Municipalities

3.4.2.4 *Hydrological Management (Bundle 4)*

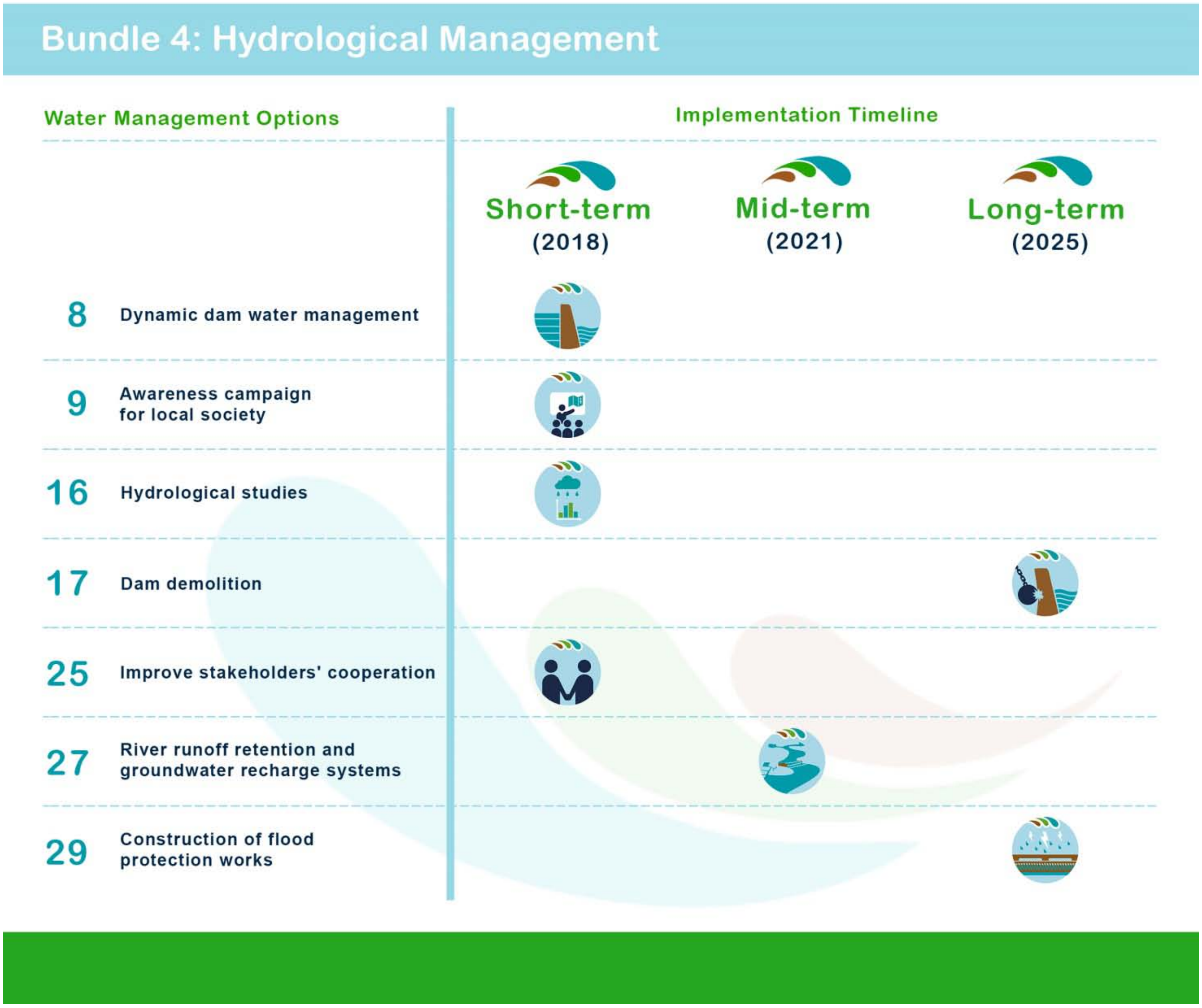
The focus of the hydrological management bundle is to understand the behaviour of hydrologic systems. It aims to improve the quantitative and qualitative status of water resources and to prevent flooding.

Proposed combination of WMOs

Context	**Water Management Options**	
The dynamic management of the water in the reservoir optimizes environmental services, prevents flooding and improves groundwater resources		WMO 8: Dynamic dam water management • The option targets the midstream and downstream areas of the river basin (downstream from Tamassos dam) • It improves the quantitative and qualitative status of groundwater as well as the performance of irrigated agriculture and livestock. • The provision of river and riparian zones' ecosystem services (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity) also increases, while the risk of flooding from the Pedieos river and the surface runoff of rainwater slightly decrease.
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management		WMO 16: Hydrological studies • The option targets the whole river basin. • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater, (b) the ecosystem

		services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), (c) the performance of irrigated agriculture and livestock, (d) the reduction of urban runoff and flooding from the Pedieos river.
The removal of Tamassos dam can contribute to the restoration of the watershed and the upgrade of river ecosystems		WMO 17: Dam demolition • The option targets the upstream and midstream areas of the river basin. • This radical water management option significantly improves the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as irrigated agriculture.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The construction of river runoff retention systems including detention basins, retention ponds and check dams prevents flooding and improves groundwater recharge and water quality		WMO 27: River runoff retention and groundwater recharge systems • The option targets the midstream and downstream areas of the river basin. • The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Technical flood protection through the construction of anti-flooding works such as terraces, rectangular culverts and hydraulically designed bridges.		WMO 29: Construction of flood protection works • This option targets the downstream areas of the river basin. • The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO8 	• Water Development Department aims to promote the dynamic management of water in Cyprus dams	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO9 	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the	• Department of Environment (MARDE) • Water Development Department (MARDE)

	positive contribution of hydrological studies to biodiversity conservation	
WMO17 		• Water Development Department (MARDE)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO27 	• River runoff retention systems are of high importance within Water Framework Directive and Floods Directive • Municipalities aim to promote the construction of river runoff retention systems	• Water Development Department (MARDE) • Municipalities
WMO29 	• Water Development Department promotes the construction of flood protection works including bridges, terraces and retaining walls. • Municipalities and communities promote the construction of small flood protection works	• Water Development Department (MARDE) • Municipalities

3.4.2.5 Domestic water supply (Bundle 5)

The domestic water supply bundle focus on both technical and managerial adaptation options that secure the water supply in the households of the river basin.

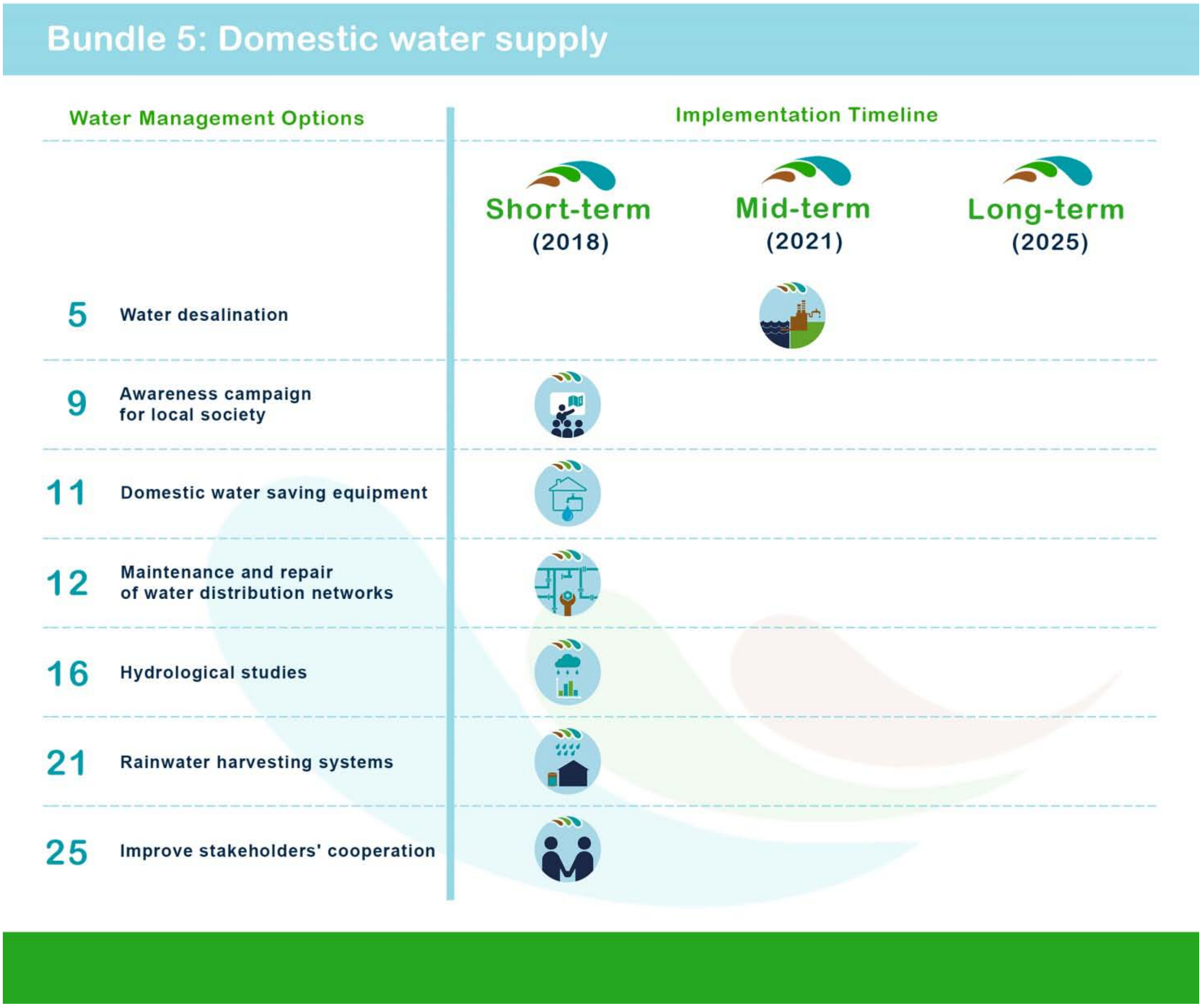
Proposed combination of WMOs

Context	**Water Management Options**	
Expansion of the distribution network to secure domestic water supply in rural communities		WMO 5: Water desalination • The option targets the midstream and downstream areas of the river basin. In particular, it aims to expand the desalination up to Tamassos dam communities (Politiko, Pera, Episkopeio, Psimolofou, Anageia) covering extra 5,400 persons. • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater, while positive indirect effects will be also created for irrigated agriculture and livestock.
Awareness campaigns including		WMO 9: Awareness campaign for local society

lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and globalchange and the importance of water conservation.		• Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
Installation of water saving technologies and equipment for domestic water use and gardens		WMO 11: Domestic water saving equipment • The option targets the whole river basin. • It aims at least 10% of river basin households (7,740) to adopt such water saving technologies and equipment • The adoption of the option will decrease water demand of households for drinking and gardens' watering purposes. Thus, groundwater quantities will increase. • The quantitative and qualitative status of surface water, related to the ecosystem services provided by the Tamassos dam reservoir (including water supply, provision of habitat for biodiversity and recreation) will also improve. • Land cultivated with irrigated crops (such as vegetables and fruit trees) and livestock (mainly intensive livestock farms with sheep, goats, chickens, cows) will be positively affected
The regular maintenance and repair of the water distribution systems and related infrastructure minimizes leakages and water losses		WMO 12: Maintenance and repair of water distribution networks • The option targets the whole river basin • The option contributes to the decrease of water demand of local households for drinking and garden's watering purposes, while it improves irrigated agriculture and livestock.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The installation of rainwater harvesting systems will supplement water supply at both household (e.g. collect surface runoff from roofs and paved areas in storage tanks; use of stored water for irrigation of gardens) and farm (e.g. collect surface runoff from roofs of farm		WMO 21: Rainwater harvesting systems • The option targets the whole river basin • The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects are created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos River.

buildings and greenhouses; use of stored water for irrigation of agricultural crops) level.		
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO5 	• Desalination is considered by the Republic of Cyprus as a secure option that ensures constant domestic water supply throughout the country • Communities require constant supply of domestic water	• Water Development Department (MARDE) • Communities
WMO9 	• Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Department of Environment (MARDE) • Water Development Department (MARDE) • Households • Civil society (NGOs)
WMO11 	• Water Development Department aims at the reduction of drinking water consumption • Cyprus guidelines for drinking water requires the mandatory installation of water saving technologies and equipment in new buildings	• Water Development Department (MARDE) • Municipalities • Department of Town Planning and Housing (Ministry of Interior)
WMO12 	• Water Development Department aims to minimize water leakages in the urban and rural domestic supply distribution networks. • Nicosia Water Board is responsible for the maintenance and repair of the distribution network for domestic water within the urban and sub-urban areas of the river basin.	• Water Board of Nicosia
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO21 	• Department of Agriculture aims to promote the installation of rainwater harvesting systems at farm holdings. Efforts will be made these systems to be subsidized under the rural development programme. • Water Development Department promotes the installation of rainwater harvesting systems	• Department of Agriculture (MARDE) • Water Development Department (MARDE) • Farmers
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)

3.4.2.6 Environmental engagement (Bundle 6)

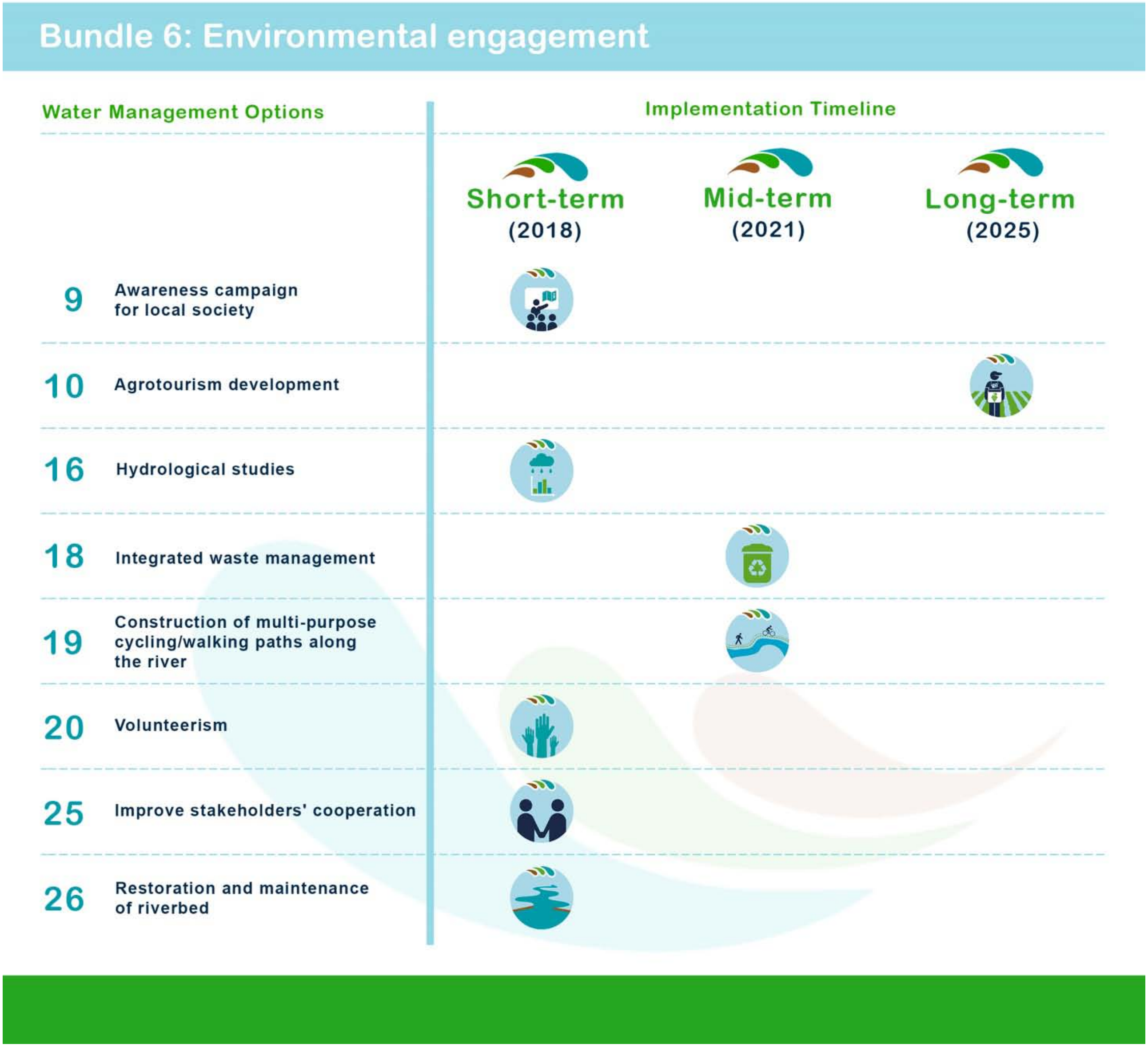
The bundle focuses on engaging civil society in water conservation efforts and in long-term planning for sustainable water resources management.

Proposed combination of WMOs

Context	Water Management Options	
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
Agrotourism could maintain agricultural land in good condition and increase environmental awareness.		WMO 10: Agrotourism development • Agrotourism will be developed in the upstream and midstream areas of the river basin. • Four new agrotourism hotels will be constructed • The development of agrotourism will improve the quantitative and qualitative status of groundwater through the increase of environmental awareness. • The option will create positive impacts on agriculture and livestock through the increase of environmental awareness and the use of local agricultural products by the agrotourism hotels.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
The expansion of walking and cycling paths up to Tamassos dam area can raise environmental awareness and discourage people dumping in the riverbed.		WMO 19: Construction of multi-purpose cycling/walking paths along the river • The option targets the whole river basin. • The implementation of the option includes the maintenance and improvement of infrastructure across

		the river, which can potentially reduce urban runoff and flooding.
Strengthening volunteerism movement improves awareness raising for the importance of water conservation and helps to restore and clean river bed. It is a private initiative.		WMO 20: Volunteerism • The option targets the whole river basin. • The volunteerism movement strengthening contributes to the restoration and cleaning of the riverbed, therefore improving the quantitative and qualitative status of groundwater as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The restoration of the riverbed also reduces urban runoff and flooding from Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. • The implementation of the option improves the qualitative and quantitative status of groundwater.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO9	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO10	• Rural Development Programme 2014-2020 promotes the development of agrotourism as a means of employment diversification in rural areas. • Agrotourism create significant backward and forward linkages within regional economies.	• Department of Agriculture (MARDE) • Farmers • Cyprus Tourism Organization
WMO16	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework	• Department of Environment (MARDE) • Water Development Department

	Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	(MARDE)
WMO18 	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO19 	• The expansion of walking/bicycling paths up to Tamassos dam areas has been already designed by the Department of Town Planning and Housing	• Department of Town Planning and Housing (Ministry of Interior)
WMO20 		• Civil society (NGOs)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26 	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)

3.4.3 *Monitoring*

Adaptive management assigns a strategic and central role to monitoring processes. An adaptive management approach means that plans are adjusted to future conditions as they unfold, taking account of uncertainty over future developments, and constantly updating the adaptation plan with new information from monitoring, evaluation and learning (lxiii). Therefore, this section aims to outline the main elements that should be taken into account when monitoring the outcomes and impact of the proposed adaptation options.

Monitoring the environmental outcomes of implementing a particular water management option in a specific place and time is fraught with difficulties, as it is normally impossible to isolate the water system from the numerous external drivers and pressures affecting it alongside the implemented option. For instance, it is generally very hard to measure directly the impact of an option generating water savings on river flow, as the natural water flows in a system will depend on manifold factors such as recent meteorology, land use and its changes in the basin, behaviour of other users and so on. The same applies to measures addressing other goals, such as water quality. In view of the extreme complexity and the multiple causal chains impinging on single parameters, environmental programmes usually resort to monitoring the (degree of) implementation of a measure. In effect, they rely on scientific consensus about whether a measure delivers the desired effect on a certain parameter and about the expected range of this effect.

In addition to monitoring water management options, monitoring in adaptive management often also addresses the overall system (the river basin in this context), so as to track its development over time and to enable reactions to unforeseen trends and developments.

Indicators for monitoring can assume various forms, each of which contributes to building a comprehensive overview of the options' or bundles' implementation. Types of monitoring indicators include [lxiv]:

- *financial input indicators that are used to monitor progress in terms of the annual payment of the funds available for any operation,*
- *output indicators that measure activities directly realised within options (e.g. number of training sessions organised),*
- *result indicators that measure the direct and immediate effects of the intervention (e.g. successful training outcomes),*
- *impact indicators that refer to the benefits of the option beyond the immediate effects on its direct beneficiaries at river basin level.*

When developing the water management options for this plan, a review of and comparison with existing management plans focussing on the river basin was undertaken (see Part 2). These existing plans, such as the River Basin Management Plans developed in compliance with the European Water Framework Directive, have a monitoring and evaluation network in place where the presented water management options can be integrated.

More precisely, the Water Framework Directive distinguishes three types of monitoring [lxv]: (a) surveillance monitoring, to assess long-term changes resulting from widespread anthropogenic activity; (b) operational monitoring, to establish the status of those water bodies identified as being at risk of failing to meet their environmental objectives; (c) investigative monitoring, carried out where the reason of any exceedance for ecological and chemical status is unknown.

The Water Framework Directive has put aquatic ecology (biological quality elements) at the base of management decisions. However, the linkage between data on biotic communities and the designation of measures has not yet been fully established [lxvi]. These authors found that the links between ecological status and restoration measures were obscure in many of the first European River Basin Management Plans. Reyjol et al. [lxvii] also point to the need for resolving uncertainties resulting from current monitoring approaches and those related to global change and for investigating the usefulness of top-down prediction-based assessments for local decision-making. Thus, it is important to combine long-term, surveillance monitoring with modelling analyses to be able to obtain a better understanding of the effects of natural variability versus the effects of human interventions. Herring et al. [lxvi] also suggest to establish more sampling sites and higher sampling frequency, both before and after the implementation of measures.

The Water Development Department's surveillance monitoring of biological quality elements (e.g., DO, EC, NH_4-N, TP, pH, As, B, Cr, Cu, Fe) in the Tamassos reservoir [lxviii] can be used to assess in more detail the ecosystem services provided by the Tamassos dam, which is one of the factors of the Pedieos River Basin conceptual map (see Section 3.2.3). In addition, some water management options, namely, *improved irrigation technologies* (WMO1), *farm education* (WMO6), *agrotourism development* (WMO10) and *Code of Good Agricultural Practices enforcement* (WMO13) can be monitored under the monitoring system of the Managing Authority of the Rural Development Programme 2014-2020. This monitoring framework within the Rural Development Programme 2014-2020 enables the responsible actors to guide and monitor the implementation of the selected options in a structured way and maximizes the impact of the programme. Other water management options, such as the *improvement of genetic resources banks for drought tolerant species* (WMO7, WMO15, WMO22), *rooftop water harvesting* (WMO21), *fire safety measures* (WMO23), *restoration and maintenance of the riverbed* (WMO26), *river runoff retention and groundwater recharge*

systems (WMO 27), and *sustainable urban drainage systems* (WMO28) could be incorporated in potential future LIFE projects, which include dedicated monitoring and evaluation actions.

3.5 From planning to action: Recommendations for implementation

The Pedieos River Basin Adaptation Plan was based on a participatory approach, which was followed to develop a set of targeted water management options and, subsequently, bundles of these options. The outlined (bundles of) options address the main challenges that were identified by the basin's stakeholders. The information provided throughout the plan is intended to serve as a tool to help to guide policy and decision makers in selecting appropriate options or sets of options to implement within the basin to address the basin's specific needs. This chapter provides guidance and recommendations for decision-makers, individuals and entities that are in a position to implement bundles of synergistic water management options or individual options.

3.5.1 *Implementation of all options within a given bundle*

The six bundles presented in Chapter 4 are sets of options, which have been grouped together on the basis of their foreseen abilities to collectively address the identified challenges within the Pedieos River Basin and to react to additional local opportunities (e.g. increasing sustainable tourism in the area). Implementation of an entire bundle ensures a high occurrence of synergies between the options and the pursuit of one or more common objectives. Two water management options that are strongly aligned may decrease the implementation or maintenance costs if they are implemented together. Other combinations may lead to an increased impact with regards to addressing an existing threat.

In the bundle factsheets in Chapter 4, a wealth of information is provided on the interaction of the water management options to support decision-making processes. This includes, for example, indications of the objectives which may be reached by choosing to implement a given bundle, the costs involved and the potential phasing of the options in time. If an entire bundle is to be implemented, the 'adaptation pathway' provides further information about which options are critical to implement before other water management options in the bundle.

3.5.2 *Implementation of individual water management options*

The existence of very specific objectives, resource or capacity limitations or other considerations may make the implementation of an entire bundle unfeasible. In this case, deciding instead to implement one or more individual options will not necessarily have a negative impact on the performance of these options. While all of the water management options presented are suitable for implementation in the river basin, the decision to implement individual options on their own requires a check that the option is not dependent on any other water management option. Information on the relationship between the options is outlined in the bundle factsheets in Chapter 4.2 and should be consulted in order to reach such conclusions.

Here, a particular focus should be given to prioritised water management options, which have been identified based on suggestions of the stakeholders engaged in the process and taking into account implementation-oriented factors, which were assessed in the multi-criteria analysis, and policy synergies. As such, these options are strongly aligned with community interests and are foreseen to offer large potential in addressing the targeted challenges identified within the basin (see Section 3.2.4 and Table 4.1). In order to assess the best implementation timing, the adaptation pathways as presented in Chapter 4.2 should be consulted.

3.5.3 *General recommendations*

The recommendations are based on the experience developed in the project in close cooperation with local stakeholders and international project partners:

- Participatory approaches can contribute to a more holistic consideration of climate change related challenges and potential adaptation pathways.
- The bottom-up participatory approach followed for the development of the adaptation plan could be useful for the design of public consultations of environmental policies.
- The use of multi-criteria analysis for prioritizing options requires careful consideration of normalization, weighting and the combination of continuous and categorical criteria.
- Bundles of adaptation options better address the multiple impacts of climate change on river basins than the implementation of individual options. Therefore, priority should be given to bundles with high synergies.
- The successful implementation of individual water management options or bundles of options requires the development and execution of a monitoring plan with sound indicators. The alignment of the monitoring needs of the water management options with existing monitoring plans, i.e. River Basin Adaptation Plan and Rural Development Programme, should be strongly considered (Section 4.3).
- There is a need to establish a legislative framework in the Pedieos River Basin that will strengthen the consultations among all involved actors and increase societal awareness.
- Strengthening of institutional partnerships can enhance the adaptation process. A better coordination between competent authorities and stakeholders would be beneficial for assessing the potential impacts of climate change and for implementing the most appropriate options to tackle these changes.
- The adaptation plan is a dynamic document and it should be updated periodically, to incorporate new knowledge on key issues that are directly or indirectly linked with the river basin. The establishment of a steering committee or a coordinating actor could ensure the continuation of the collaboration and the validity of the plan.
- Strong commitment for the adoption of the adaptation options is needed from all involved actors and authorities.

PART 2

3.6 Analytical description of the water management options

	***Improved irrigation technologies (WMO1)***
Short explanation	Installation of irrigation scheduling decision support systems, including wireless sensor network, could result in savings of irrigation water.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option aims to establish 100 irrigation blocks in the midstream areas of the river basin (downstream from Tamassos dam), where groundwater-irrigated crops prevail (e.g. vegetables).
Benefits	The adoption of irrigation scheduling decision support systems will result in the improvement of the quantitative and qualitative status of groundwater. Positive effects will be also created for irrigated agriculture.
Potential negative impacts	Increase of farm production cost
Timeline of implementation	The option can be functioning on very short term (<5 yrs). The expected lifetime of which irrigation scheduling decision support systems are operational without major rehabilitation is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor physical, technical or organisational barriers for the implementation of the option that can easily be overcome. Most significant obstacle is the capital cost of purchasing and setting up the wireless sensors.
Robustness	The option manages to maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option can be complemented with other water management options (e.g. irrigation water pricing) to maximize its efficiency
Costs	The total implementation cost of the option towards 2030 is approximately 700.000€. This cost includes the establishment cost of irrigation blocks, the installation of wireless sensor network and the annual operational costs.

Synergies and conflicts with policy objectives	Significant synergies with policies aiming at the protection and management of groundwater resources, water pricing policies and agricultural policies aiming at strengthening the viability of farm holdings.
Acceptance	The acceptability of the option is not very high because local environmental actors support that the adoption of such technologies will lead to the expansion of irrigated agriculture resulting thus to the increase of water use.
Suggested stakeholder involvement	Ministry of Agriculture, Rural Development and Environment (MARDE); Department of Agriculture
Preconditions for success	Awareness raising amongst farmers for the benefits of the proposed technologies; Subsidies for the adoption of irrigation scheduling decision support systems through the Rural Development Programme. The article 17 of the Rural Development Programme 2014-2020 provides financial incentives for increasing irrigation water use efficiency.
Concrete examples where applied	Very few farms are currently using irrigation scheduling decision support systems in the river basin.

Borehole licences and water meters (WMO2)

Short explanation	Enforcement of borehole drilling permits and installation of water meters on groundwater pumps could control groundwater abstraction and reduce its overexploitation.
Addressed challenges	Quantitative and qualitative status of groundwater
Target locations and water uses	This option targets the whole river basin. The specific objective of the option is the installation of groundwater meters on 10,000 wells.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be created for irrigated agriculture and livestock.
Potential negative impacts	The production cost for farmers will increase as well as the water price for the communities' inhabitants.
Timeline of implementation	The option can be implemented in the short run (<5 yrs). The expected lifetime of which water meters are operational without major maintenance is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs)
Feasibility	There are serious barriers for the implementation of the option including the unwillingness of farmers to install water meters and the lack of political will to impose the legislative framework for groundwater abstraction.
Robustness	The option maintains its effectiveness under various climatic and socioeconomic conditions
Flexibility	The option can be complemented with other water management options (e.g. irrigation water pricing) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 2,5 million €. This cost includes transaction costs of policy implementation plus the installment of 10,000 water meters.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at the protection and management of groundwater resources and the pricing policies for efficient water management.

Acceptance	The acceptability of the option is low among local farmers since it increases the production costs. However, other social actors e.g., environmental NGOs are very positive about this option since it contributes to the protection of the groundwater resources.
Suggested stakeholder involvement	MARDE; Water Development Department; Department of Agriculture
Preconditions for success	Consultations between competent authorities and farmers; Improvement of farm training in order farmers better understand their requirements under cross-compliance schemes; Subsidies for the installment of water meters through the rural development programmes
Concrete examples where applied	The option is currently implemented for agricultural water use, but poorly enforced.

Water pricing enforcement (WMO3)

Short explanation	Water pricing policy enforcement could provide incentives for using water resources efficiently.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be created for irrigated agriculture.
Potential negative impacts	The production cost of farmers will increase.
Timeline of implementation	The option can be implemented in the short run (<5 yrs) since it is a matter of political will. The expected lifetime of the new water prices is medium (5-20 yrs), while the expected time since the policy is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are serious barriers for the implementation of the option including the lack of political will to impose additional costs to farmers. A precondition to efficient and equitable water pricing is the metering and monitoring of groundwater abstractions.
Robustness	Water pricing setting can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Water pricing setting can be easily adjusted to different climatic and socioeconomic conditions and can be complemented with other water management options (e.g. borehole licenses and water meters) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 376,000€. This cost includes transaction costs of policy implementation plus policy control costs.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resource conservation, e.g. the Water Framework Directive and the Rural Development Programme 2014-2020. Potential conflicts with agricultural policy objectives aiming to maintain and strengthen subsistence farming.
Acceptance	The acceptability of the option is low among local farmers since it increases the production costs. However, other social actors e.g., environmental NGOs are very positive about this option since it contributes to the protection of the groundwater

	and surface water resources.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Strict control of policy implementation; Consultations between competent authorities and farmers
Concrete examples where applied	The option is not implemented in the river basin.

Use of treated sewage water for irrigation and green infrastructure (WMO4)

Short explanation	Treated sewage water use could increase water availability for agriculture and parks and roadsides and alleviate the pressures on water resources
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive effects will be also created for irrigated agriculture and livestock.
Potential negative impacts	The long-term impacts of emerging contaminants such as pharmaceuticals that are present in the treated sewage water on soils, groundwater, ecosystems and human health are not known.
Timeline of implementation	The option can be functioning on short term (<5 yrs) since it refers to the construction of a treated sewage water supply (distribution) network. The expected lifetime of the irrigation network is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor physical and technical obstacles for the implementation of the option. These obstacles include the cost of constructing a treated sewage water supply (distribution) network and any potential unknown effects of treated sewage water on irrigated agriculture.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The use of treated sewage water for irrigation and green infrastructure can be complemented with other water management options (e.g. water pricing) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 14,5 million €. This cost includes the construction of the supply network (for 1,000 ha) and the annual operational costs (including the water price).
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation. Synergies also with agricultural policies that aim to alleviate water scarcity pressures on the agricultural sector. Potential conflicts with the already existing strict guidelines on quality standards regarding the use of treated sewage water for irrigation as well as measures for the protection of public

	health.
Acceptance	High acceptability of the option among local actors since it will contribute to the maintenance of the groundwater and surface water resources.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Awareness raising to farmers and citizens regarding the benefits and constraints of treated sewage water for irrigation.
Concrete examples where applied	The option is currently implemented in some of the green spaces of the downstream areas of the river basin.

Water desalination (WMO5)

Short explanation	The expansion of the water distribution network up to the Tamassos dam could secure domestic water supply in rural communities.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the midstream and downstream areas of the river basin. In particular, it aims to expand the desalination up to Tamassos dam communities (Politiko, Pera, Episkopeio, Psimolofou, Anageia) covering extra 5,400 persons.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be also created for irrigated agriculture and livestock.
Potential negative impacts	Desalination is extremely energy intensive. Desalination plants are run on fossil fuels creating negative effect on climate change. Moreover, the brine of the desalination plants that is returned to the sea has a negative effect on marine biodiversity.
Timeline of implementation	The option can be functioning on short term (<5 yrs) since desalination plants are already in operation. The expected lifetime of the option is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no physical, technical or organisational barriers for the implementation of the option.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The use of water desalination can be easily adjusted to different climatic and socioeconomic conditions and can be complemented with other water management options (e.g. domestic water saving) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 4 million €. This cost includes the expansion of the water supply network and the annual operational costs.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation. Potential conflict with environmental policies since desalination is an energy intensive process the residue of which should be carefully treated.

Acceptance	Medium acceptability of the option among the midstream stakeholders because they don't want an increase in the water price.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Adequate financial resources
Concrete examples where applied	The option is currently implemented in the downstream areas of the river basin, i.e. in the urban and sub-urban areas of Nicosia.

Farm education (WMO6)

Short explanation	Farm education on the rational use of water resources and agrochemical inputs could improve agricultural ecosystems resilience
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of the river basin
Benefits	The improvement of farm education will create significant positive effects to agriculture (both irrigated and rainfed) and livestock. The ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization and provision of habitat for biodiversity) will be improved as well as the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	Farm education activities can be effectively functioning on short term (<5 yrs). The expected lifetime of the farm education programmes is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	No barriers for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Farm education is a rather flexible option and can be easily complemented with other water management options (e.g. improved irrigation technologies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 205,000€. The proposed farm training activities are slightly more costly compared to current farm training courses since they are climate change related.
Synergies and conflicts with policy objectives	Significant synergies with: (a) agricultural policies aiming at the sustainability (economic, environmental, social) of agriculture; (b) policies aiming at water resources conservation.

Acceptance	High acceptability of the option among local actors and mainly farmers.
Suggested stakeholder involvement	MARDE; Department of Agriculture
Preconditions for success	Awareness raising among farmers regarding the benefits of professional training.
Concrete examples where applied	Some local farmers are already participating in farm training schemes through rural development programmes and extension services.

Improve plant genetic resources bank and use of drought tolerant agricultural crops (WMO7)

Short explanation	Agricultural land can be cultivated with drought tolerant crops that need little or no irrigation. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on rainfed agriculture and livestock.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the systematisation and organisation of the plant genetic resources bank is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to the lack of personnel to organise and systematise the plant genetic resources bank. However, these barriers can be easily overcome.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the seed bank): 73,000€
Synergies and conflicts with policy objectives	Significant synergies with cross-compliance requirements and policies aiming at water resources conservation.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Agricultural Research Institute
Preconditions for success	Awareness raising to farmers regarding the benefits of cultivating drought tolerant agricultural crops.
Concrete examples where applied	The plant genetic resources bank is currently operating in the Agricultural Research Institute. However, the systematization and organisation of the seed bank needs to be improved as well as seeds' regeneration.

Dynamic dam water management (WMO8)

Short explanation	Dynamic management of the water in the reservoir could optimize environmental services, prevent downstream flooding and improve recharge of groundwater resources
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	This option targets the midstream and downstream areas of the river basin (downstream from Tamassos dam).
Benefits	The dynamic dam water management will improve the quantitative and qualitative status of groundwater as well as the performance of irrigated agriculture and livestock. The provision of river and riparian zones' ecosystem services (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity) will also increase. Moreover, the risk of flooding from the Pedieos river and the surface runoff of rainwater will slightly decrease.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the proposed dam water management outcome is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option, which can be easily overcome. It mainly includes the cost of preparing a study based on which a dynamic management in the reservoir can be achieved.
Robustness	Quite robust option that can maintain its effectiveness under various climatic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. hydrological studies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the study preparation, equipment purchase and maintenance, salaries of technical personnel): 646,000€.
Synergies and conflicts with	Significant synergies with policies aiming at water resources conservation.

policy objectives	
Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Knowhow transfer regarding the benefits of the dynamic management of the water in the reservoir.
Concrete examples where applied	

Awareness campaign for local society (WMO9)

Short explanation	Lectures in schools, seminars and distribution of informative leaflets could educate local society and youth on climate change and water resources challenges and the importance of water conservation.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water.
Target locations and water uses	This option targets the whole river basin.
Benefits	Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity). Positive indirect effects will be also created in irrigated agriculture and livestock. Moreover, the risk of flooding from the Pedieos river and the surface runoff of rainwater will slightly decrease.
Potential negative impacts	-
Timeline of implementation	Awareness campaign can occur on short term (<5 yrs), while the expected lifetime of the knowledge acquired is considered medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no barriers (physical, technical or organizational) for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is highly flexible under different climatic and socioeconomic scenarios and can be easily complemented with other water management options either grey or nature-based.
Costs	Total implementation cost of the option towards 2030 is approximately 248,000€. It includes the purchase of equipment and materials (e.g. leaflets) and the annual operational cost.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation.

Acceptance	High acceptability of the option among local actors and competent authorities.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	-
Concrete examples where applied	Awareness campaigns are taking place in the local schools of the river basin to develop a more conscious attitude towards water conservation. Dissemination activities and awareness campaigns take also place within the framework of Water Framework Directive.

Agrotourism development (WMO10)

Short explanation	Agrotourism could support the maintenance of agricultural land in good condition and increase environmental awareness.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water; Flood risk reduction
Target locations and water uses	Agrotourism will be developed in the upstream and midstream areas of the river basin.
Benefits	The development of agrotourism will improve the quantitative and qualitative status of groundwater through the increase of environmental awareness. Moreover, the option will create positive impacts on agriculture and livestock through the increase of environmental awareness and the use of local agricultural products by the agrotourism hotels.
Potential negative impacts	-
Timeline of implementation	The option can be functioning on short term (<5 yrs), while the expected lifetime for which the option is operational without major rehabilitation is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no barriers (physical, technical or organizational) for the implementation of the option.
Robustness	The option is robust to uncertainties and can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	If the implementation of the option in practice is inappropriate, it can be adjusted or reversed very slowly.
Costs	Total implementation cost of the option towards 2030: 2,356,556€.
Synergies and conflicts with policy objectives	Significant synergies with agricultural policies aiming at the viability of agriculture and the protection of environment.
Acceptance	The acceptability of the option is low among environmental actors (e.g. NGOs). Concerns arise with regards the risk of environmental degradation because of touristic infrastructure.
Suggested stakeholder	MARDE; Department of Agriculture

involvement	
Preconditions for success	Preparation of environmental studies
Concrete examples where applied	Very few agrotourism hotels in the river basin

	Domestic water saving equipment (WMO11)
Short explanation	Installation of water saving technologies for both domestic water use and gardens could result in water saving
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin. In particular, it aims at least 10% of river basin households (7,740) to adopt such water saving technologies and equipment
Benefits	The adoption of the option will decrease water demand of households for drinking and gardens' watering purposes. Thus, groundwater quantities will increase. The quantitative and qualitative status of surface water, related to the ecosystem services provided by the Tamassos dam reservoir (including water supply, provision of habitat for biodiversity and recreation) will also improve. Furthermore, land cultivated with irrigated crops (such as vegetables and fruit trees) and livestock (mainly intensive livestock farms with sheep, goats, chickens, cows) will be positively affected.
Potential negative impacts	-
Timeline of implementation	The option can be functioning on short term (<5 yrs). The expected lifetime of the relative equipment is around 10 years according to its technical specification. The expected time since the option is implemented until it starts to have the desired effect is very short (< 5 yrs).
Feasibility	Minor technical, physical or organizational barriers for the implementation of the option. Most significant obstacle is the cost of purchase of water saving technologies and equipment.
Robustness	Quite robust option to uncertainties since it manages to maintain its effectiveness under different climatic and socioeconomic development scenarios
Flexibility	Quite flexible option since it can be adapted to different climatic and socioeconomic development scenarios
Costs	Total implementation cost of the option towards 2030: 2,2 million €. This corresponds at a 10% of river basin households adoption rate
Synergies and conflicts with policy objectives	Potential synergies with housing and energy policies for promoting sustainable and environmentally friendly buildings

Acceptance	High acceptability of the option from the local actors
Suggested stakeholder involvement	Water Development Department promotes the adoption of water saving technologies and equipment.
Preconditions for success	Citizens should be further informed about the environmental (water saving) and economic benefits of adopting such technologies.
Concrete examples where applied	The option is currently implemented throughout the river basin for drinking and gardens' watering purposes.

Maintenance and repair of water distribution networks (WMO12)

Short explanation	The maintenance and repair of the water distribution systems could substantially minimize leakages and water losses.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The regular maintenance and repair of water distribution systems improves the qualitative and quantitative status of groundwater and surface water. The option contributes to the decrease of water demand of local households for drinking and garden's watering purposes, while it improves irrigated agriculture and livestock.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of water distribution systems repair is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to limited financial resources.
Robustness	Currently, financial resources for maintaining and repairing the related infrastructure have been decreased resulting in a gradual loss of the effectiveness of the option. However, the option can still be characterized as robust to climatic and socioeconomic changing conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. hydrological studies, sustainable urban systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030, including capital and operational costs, based on average daily repairs of the existing network: 1,3 million €.
Synergies and conflicts with	Significant synergies with policies aiming at water resources conservation.

policy objectives	
Acceptance	High acceptability of the option among local actors and competent authorities.
Suggested stakeholder involvement	Water Board of Nicosia
Preconditions for success	The timely identification and repair of defective pipes is a crucial factor for the effective implementation of the option. Awareness raising for developing a more conscious attitude towards water conservation
Concrete examples where applied	The option is implemented throughout the river basin; around 5 repairs daily.

Code of Good Agricultural Practices enforcement (WMO13)

Short explanation	The strict implementation of the Code of Good Agricultural Practices could reduce the leaching and surface runoff of agrochemicals and livestock waste.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of river basin.
Benefits	The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). Moreover, it slightly reduces flooding from the Pedieos river.
Potential negative impacts	Slight reduction in farm incomes due to additional labour requirements and lower yields.
Timeline of implementation	The enforcement of the Code of Good Agricultural Practices can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is also very short (<5 yrs).
Feasibility	No barriers (physical, technical or organizational) for the implementation of the option.
Robustness	Robust option to uncertainties, which can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education, improved irrigation technologies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including transaction and policy control costs): 183,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to improve the environmental performance of agriculture (e.g. cross-compliance requirements).

Acceptance	Medium acceptability of the option among local farmers because they consider the guidelines of the Code too strict that may endanger the viability of their farm holdings.
Suggested stakeholder involvement	MARDE; Department of Agriculture
Preconditions for success	The efficiency of the option depends on the systematic control of a representative sample of farm holdings.
Concrete examples where applied	It is implemented throughout the river basin.

Grazing control (WMO14)

Short explanation	Grazing permits, on the basis of the dynamic carrying capacity of the area, could reduce soil erosion and runoff.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of river basin.
Benefits	The grazing control significantly strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. Furthermore, it is an effective measure for preventing soil erosion reducing thus runoff and the risk of flooding.
Potential negative impacts	-
Timeline of implementation	The control of grazing can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is also very short (<5 yrs).
Feasibility	Minor obstacles mainly organizational that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education, Code of Good Agricultural Practices) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including transaction and operational costs): 228,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to protect forests (e.g. forest policy). Potential conflicts with agricultural policies aiming at the support of livestock raisers income.
Acceptance	Medium acceptability of the option among local livestock raisers because livestock is already declining in the region and the enforcement of strict requirements may endanger the viability of their holdings.

Suggested stakeholder involvement	MARDE; Department of Forests; Department of Environment
Preconditions for success	The efficiency of the option depends on the systematic and sufficient control of a representative sample of livestock holdings.
Concrete examples where applied	It is implemented throughout the river basin (Forest Law 1913; Statement of Forest Policy 1950, Statement of Forest Policy 2000-2010).

Improve plant genetic resources bank and use of drought tolerant forest species (WMO15)

Short explanation	Forest ecosystems could be improved with drought tolerant species. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater
Target locations and water uses	This option targets the upstream areas of river basin.
Benefits	The systematisation and organisation of the plant genetic resources bank significantly improves the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. The option also improves livestock performance. Moreover, it reduces the flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is long (> 20 yrs). The expected time since the option is implemented until it starts to have the desired affect is between 5 to 20 years.
Feasibility	Minor organizational obstacles (including limited personnel) that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. fire safety measures) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the seed bank): 131,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to protect forests (e.g. forest policy).

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Forests; Department of Environment
Preconditions for success	Optimal systematisation and organisation of the plant genetic resources bank and the regeneration of seeds.
Concrete examples where applied	

Hydrological studies (WMO16)

Short explanation	The development of hydrological studies, including risk assessments, could combat desertification and improve water resources management.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater, (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), (c) the performance of irrigated agriculture and livestock, (d) the reduction of urban runoff and flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The preparation of hydrological studies can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	No major obstacles (physical, technical, organizational) for the implementation of the option.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with the majority of the selected water management options.
Costs	Total cost of preparing 3 hydrological studies towards 2030: 479,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to water resources conservation and flood protection.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Adequate financial resources
Concrete examples where applied	Hydrological studies have been conducted in the river basin in the past.

Dam demolition (WMO17)

Short explanation	The removal of the Tamassos dam could contribute to the restoration of the watershed and the upgrade of river ecosystems. However, it may also increase flooding.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the upstream and midstream areas of the river basin.
Benefits	This radical water management option significantly improves the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as irrigated agriculture.
Potential negative impacts	The removal of dam negatively impacts on the qualitative and quantitative status of groundwater and surface water, while it increases the urban runoff and the flooding from the Pedieos river.
Timeline of implementation	The dam removal can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcome of the option is medium (5-20 yrs). The expected time from dam removal until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Serious physical, technical and organizational obstacles that would be very difficult to overcome within the time horizon of the project.
Robustness	It is difficult to assess the effectiveness of the option under different climatic and socioeconomic conditions.
Flexibility	The option is not flexible under different climatic and socioeconomic scenarios. However, it can be complemented with other water management options to trade-off the negative impacts.
Costs	Total cost of dam demolition (including studies and restoration works) towards 2030: 1,5 million €.
Synergies and conflicts with policy objectives	Potential synergies with environmental policies aiming at river ecosystem services protection. However, significant conflicts with flood protection policies.
Acceptance	Low acceptability of the option among local actors and competent authorities due to the high negative impacts.

Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Conduct of hydrological studies (including ex ante evaluation and risk assessment)
Concrete examples where applied	Neither applied in Pedieos River Basin nor in Cyprus

Integrated waste management (WMO18)

Short explanation	The strict enforcement of regulations regarding solid waste dumping at or near the river could provide incentives for waste reuse and recycling.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option targets the whole river basin.
Benefits	The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding.
Potential negative impacts	-
Timeline of implementation	The implementation of an integrated waste management can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome. The major obstacle is the high construction cost.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. awareness campaign for local society, volunteerism).
Costs	Total cost of the option (including construction cost, i.e., garbage collection, garbage disposal, recycling, yard waste composting, and annual operating costs) towards 2030: 3,8 million €.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming environmental protection and water resources conservation.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Environment
Preconditions for success	Strict regulations for permits and regular inspections of waste treatment facilities and collectors
Concrete examples where applied	The option is applied at the urban areas of the river basin

Construction of multi-purpose cycling/walking paths across the river (WMO19)

Short explanation	The expansion of walking and cycling paths up to Tamassos dam area could raise environmental awareness and discourage people dumping in the riverbed.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option targets the whole river basin.
Benefits	The expansion of walking/cycling paths will increase environmental awareness and discourage people from waste dumping in the riverbed, thus contributing to the improvement of the quantitative and qualitative status of groundwater. The implementation of the option includes the maintenance and improvement of infrastructure across the river, which can potentially reduce urban runoff and flooding from Pedieos river.
Potential negative impacts	-
Timeline of implementation	The construction of multipurpose cycling /walking paths across the river can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. awareness campaign for local society, volunteerism).
Costs	The total cost of expanding the cycling and walking path across the river towards Tamassos dam (14.6 km) (including operational costs) towards 2030 is approximately 8,2 million €
Synergies and conflicts with policy objectives	Significant synergies with policies promoting environmental protection and physical activity.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	Department of Town Planning and Housing
Preconditions for success	Financial resources commitment for the expansion of cycling/walking paths up to Tamassos dam
Concrete examples where applied	Multi-purpose cycling/walking paths (10 km) have been constructed in the urban areas of the Pedieos River Basin (including Lakatamia, Strovolos and Nicosia).

Volunteerism (WMO20)

Short explanation	Volunteer movement can help to restore and clean the riverbed, and improve awareness raising for the importance of water conservation
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the whole river basin.
Benefits	The volunteerism movement strengthening contributes to the restoration and cleaning of the riverbed, therefore improving the quantitative and qualitative status of groundwater as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The restoration of the riverbed also reduces urban runoff and flooding from Pedieos river.
Potential negative impacts	-
Timeline of implementation	Strengthening of volunteerism movement can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (< 5 yrs).
Feasibility	No major obstacles (physical, technical, organizational) for the implementation of the option.
Robustness	The option is very robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is very flexible under different climatic scenarios and can be easily complemented with the majority of the proposed water management options.
Costs	Total cost of the option towards 2030: 36,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies promoting environmental protection and water resources conservation.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	Environmental NGOs (e.g. Let’s Do It Cyprus)
Preconditions for success	Willingness of local society to support such movements.
Concrete examples where applied	Environmental NGOs have participated in Pedieos river bed cleaning activities

Rainwater harvesting systems (WMO21)

Short explanation	We can capture surface runoff from roofs and paved areas in storage tanks. We can use the stored water for irrigation of gardens or agricultural crops.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the whole river basin.
Benefits	The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects are also created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos river.
Potential negative impacts	-
Timeline of implementation	Installation of rainwater harvesting systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome.
Robustness	The option is robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. river runoff retention and groundwater recharge systems; improved irrigation technologies)
Costs	The cost of the option towards 2030 (including plastic water storage tanks and pipes, operational costs) is approximately 26,4 million €.
Synergies and conflicts with policy objectives	Significant synergies with policies promoting water resources conservation and farm viability.

Acceptance	Medium acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Awareness raising campaigns to local society and farmers regarding the benefits of the rainwater harvesting systems
Concrete examples where applied	Small-scale application of the option throughout the river basin

Improve plant genetic resources bank and use of drought tolerant plants in green infrastructures (WMO22)

Short explanation	Parks, gardens and green areas along roads can be grown with plants that maintain a protective land cover and need little or no irrigation. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on the provision of the river and riparian zone ecosystem services (including sediment and nutrient filtering, bank stabilization) as well as the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the systematisation and organisation of the plant genetic resources bank is long (> 20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to the lack of personnel to organise and systematise the plant genetic resources bank. However, these barriers can be easily overcome.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios.
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the plant genetic resources bank): 363,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Agricultural Research Institute
Preconditions for success	Awareness raising to local society and competent authorities (e.g. municipalities) for the benefits of adopting the option.
Concrete examples where applied	The plant genetic resources bank is currently operating in the Agricultural Research Institute. However, the systematization and organisation of the plant genetic resources bank needs to be improved.

Fire safety measures (WMO23)

Short explanation	Construction and maintenance of water reservoirs, firebreaks and forest roads helps to protect our forests against fires. A healthy forest reduces soil erosion and downstream floods.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the upstream areas of the river basin.
Benefits	Fire safety measures improve the forest ecosystem services (including ecological, sociocultural, scenic and landscape services and values) as well as the qualitative and quantitative status of groundwater and surface water. The implementation of the option helps to maintain the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), while it improves the performance of livestock. Moreover, fire safety constructions reduce the surface runoff and the flooding of the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the fire safety measures outcome is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	No major obstacles (physical, technical or organizational) for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be complemented with other water management options (e.g. grazing control) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including wood protection constructions, reservoir constructions, maintenance of firebreaks and forest roads): 486,000€.
Synergies and conflicts with policy objectives	Significant synergies with forest policies.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Forests
Preconditions for success	Adequate financial resources
Concrete examples where applied	Fire safety measures have been applied in the upstream areas of the river basin.

Improving land zonation (WMO24)

Short explanation	We should not construct buildings along the Pedieos River, along streams and in flood prone areas. Land zonation maps and laws need to be improved, disseminated widely and properly enforced.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water. The implementation of the option also improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the land zonation improvement outcome is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. restoration and maintenance of riverbed) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the preparation of a study and policy recommendations as well as the operational costs): 496,000€.
Synergies and conflicts with policy objectives	Significant synergies with groundwater conservation and riverbed protection policies.

Acceptance	Medium acceptability of the option among local actors due to the high housing demand.
Suggested stakeholder involvement	Department of Town Planning and Housing
Preconditions for success	Land protection zones across rivers have been already established by laws indicating that no housing development is allowed. However, these laws have not been properly applied due to a lack of effective control.
Concrete examples where applied	Land zonation laws and plans have already been established but they are not properly enforced

Improve stakeholders' cooperation (WMO25)

Short explanation	Public consultation events, environmental impact assessments and other transparency and accountability mechanisms are a key element for effective water resources management.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The implementation of the option also improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of stakeholders' cooperation improvement is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. volunteerism) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 50,000€.
Synergies and conflicts with policy objectives	Significant synergies with water resources management policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department; Department of Agriculture
Preconditions for success	The organization of regular consultation events is necessary for the improvement of cooperation between stakeholders and authorities.
Concrete examples where applied	Water Development Department is currently organizing awareness and dissemination events within Water Framework Directive.

Restoration and maintenance of riverbed (WMO26)

Short explanation	The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including removal of illegal constructions, allows undisturbed river flow and reduces flooding.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. The implementation of the option improves the qualitative and quantitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the riverbed's cleaning and maintenance is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. They mainly relate to the cost of implementing the option.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. improving land zonation, volunteerism) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 545,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department; Volunteer movements
Preconditions for success	Public awareness and participation to foster a sense of individual responsibility and proactive environmental attitude.
Concrete examples where applied	Pedieos riverbed has been cleaned and maintained by Water Development Department actions and NGOs volunteer events.

River runoff retention and groundwater recharge systems (WMO27)

Short explanation	Check dams slow down the river flow and allow water storage in detention ponds in or next to the Pedieos River. This reduces downstream flooding and improves groundwater recharge and water quality.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The construction of river runoff retention and groundwater recharge systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. They mainly include the high cost of constructing these runoff retention systems.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. restoration and maintenance of riverbed, sustainable urban drainage systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including 20 detention basins & retention ponds plus 20 check dams): 748,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection and water resources conservation policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	-
Concrete examples where applied	The option has been implemented in several parts of the midstream and downstream areas of the river basin

Sustainable urban drainage systems (WMO28)

Short explanation	Green roofs, grassed ditches and permeable pavements collect and store runoff water locally. The water will recharge soil and groundwater bodies or could flow slowly to the Pedieos River.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The development of sustainable urban drainage systems improve the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The implementation of the option also reduces the urban runoff and the flooding from the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The development of sustainable urban drainage systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. These obstacles mainly relate to the high implementation cost of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. river runoff retention and groundwater recharge systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 8,6 million €.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	Water Development Department; Individual citizens
Preconditions for success	Awareness raising to local society regarding the benefits of sustainable urban systems
Concrete examples where applied	Small-scale sustainable urban drainage systems have been implemented in the river basin

Construction of flood protection works (WMO29)

Short explanation	Construction of anti-flooding works such as concrete walls, terraces and higher bridges could reduce flooding from the Pedieos River.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the downstream areas of the river basin.
Benefits	The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.
Potential negative impacts	Constructions harm the natural condition and the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).
Timeline of implementation	The construction of flood protection works can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. These obstacles mainly include the high cost of implementing the option.
Robustness	This option cannot be characterized as robust since it cannot maintain its effectiveness under changing climatic and socioeconomic conditions.
Flexibility	Similarly, this option is not flexible under different climatic and socioeconomic scenarios.
Costs	Total implementation cost of the option towards 2030: 3,3 million €.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	Medium acceptability of the option among local actors.

Suggested stakeholder involvement	Water Development Department
Preconditions for success	Targeted installation of anti-flooding works
Concrete examples where applied	The option has been implemented throughout the river basin

Cooperation for storm water drainage system (WMO30)

Short explanation	Cooperation between municipalities is needed to make sure that all surface flows can fit through storm water drainage network.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the downstream watershed areas.
Benefits	The improvement of cooperation between municipalities significantly reduces urban runoff and the flooding from the Pedieos River, while it improves the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).
Potential negative impacts	-
Timeline of implementation	The improvement of cooperation for storm water drainage systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of cooperation strengthening is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (mainly organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option since it can maintain its effectiveness under changing climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with the majority of water management options addressing flood protection issues.
Costs	The total implementation cost of the option towards 2030 is approximately 384,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among municipalities.
Suggested stakeholder	River basin municipalities

involvement	
Preconditions for success	The creation of a coordinating center between municipalities for the design and evaluation of storm water drainage systems
Concrete examples where applied	There is cooperation between river basin's municipalities but it is not effective

Annex I. List of stakeholder engagement activities held in Pedieos River Basin

Engagement Activity	**Objectives**	**Target group**	**Date(s)**
First stakeholder workshop	– to inform stakeholders on the BeWater Project, particularly its case studies, objectives and expected results – to inform stakeholders on what is known about the river basin and what is projected to occur in the following years in the context of global change – to map specific challenges and issues for the river basin – to clarify objectives for the watershed – to discuss water management options to tackle the identified challenges.	20 stakeholders from several thematic areas of activity: – agriculture – infrastructure – water – environment – energy – forest management and various organizational affiliations: – business and economy, – government and public authorities – civil society – practitioners – media – youth – education	2 July 2014
Two meetings with expert stakeholders	– to better understand global change impacts on Pedieos River Basin – to define the steady-state conditions of the fuzzy cognitive map based on stakeholders' views	12 expert stakeholders and the Cyprus Institute researchers with different expertise on: – water – agriculture – biology – climate – infrastructure – energy	24 March 2015 & 31 March 2015
Second stakeholder workshop	– to collect stakeholders' comments on the formulated water management options – to evaluate by stakeholders of the water management options through an on-the-spot multi-criteria analysis.	19 'key stakeholders' representing several thematic areas of activities: – agriculture – infrastructure – water – environment – energy – forest management	1 July 2015

		and various organisational affiliations: – business and economy – government and public authorities – civil society – practitioners	
Outdoor public event along the Pedieos park bike/walking path	– to capture some more general opinions of the suggested water management options from a larger group of stakeholders	84 users of Pedieos linear park	23 October 2015
Third stakeholder workshop	– to identify and discuss potential synergies and conflicts between the identified in previous workshops water management options – to identify the implementation timeline of the options based on their effectiveness over time and stakeholders' preferences – to provide input and feedback for the development of the adaptation plan	13 stakeholders representing several thematic areas of activities including water, environment, agriculture, tourism, energy and forest management.	18 March 2016

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4 Rmel River Basin, Tunisia

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Preface

Climate change projections for the Mediterranean region estimate an increase in water scarcity and drought episodes, as well as more frequent floods and other extreme events [1]. There is a high likelihood that these events will evoke substantial socio-economic losses and negative environmental impacts if no action is taken to support territories' adaptation efforts. Furthermore, changes in population and land use, such as urban expansion or the abandonment or intensification of agriculture, also affect the response of territories to these events. In this context, sustainable water management strategies are urgently needed as they will enhance the resilience of socio-ecological systems, referring both to society and the environment.

Current water management practices focus on the river basin level as the natural geographical and hydrological unit. Resilient water management strategies focusing on the river basin can respond to pressures within this unit in an appropriate way, while trying to minimize disruptions to the socio-ecological systems.

'Making Society an Active Participant in Water Adaptation to Global Change' (BeWater) is an EU-funded project which responds to the above challenges by promoting dialogue and collaboration between science and society for sustainable water management and adaptation to the impacts of global change. The BeWater project, taking place from 2013 to 2017, focuses on the design of adaptive water management approaches at a river basin scale in the Mediterranean region. More specifically, the project aimed to develop a River Basin Adaptation Plan for each of four pilot case studies, namely for the Tordera (Spain), Pedieos (Cyprus), Rmel (Tunisia) and Vipava (Slovenia) River Basins. These basins are representative of various Mediterranean conditions with regards to climate, topography, environment, socio-economic and political conditions, land use and water demands.

The adaptation plans were developed in a collaborative process according to a common methodology developed within BeWater, and utilising existing information on the local dynamics of global change. Over the course of the three and a half-year project, the subsequent plan and the plans of the other three pilot cases were co-produced by experts and stakeholders in the respective river basins as well as with scientists and experts from within the BeWater consortium, with guidance from the project's advisory board.

The four River Basin Adaptation Plans (RBAPs) aim at fostering adaptation to climate change within the four basins, and serve as a reference for other basins within the Mediterranean region and beyond, that wish to increase their resilience and undertake such a participatory development process. To facilitate the transferability potential, the BeWater project is also producing a handbook presenting lessons learned from throughout the development process. The adaptation plan presented here focuses specifically on the Rmel River Basin.

Table of contents

Executive summary

Sustainable water management under global change is an urgent challenge for the Euro-Mediterranean region. Future climate change projections estimate an increase in water scarcity and droughts in the region, causing substantial socio-economic losses and environmental impacts.

In this context, efforts are needed to strengthen public participation and embed a sense of responsibility within the society concerning water management and adaptation towards these threats. The combination of improved awareness, mutual learning processes and shared responsibility of the civil society and stakeholders is key to ensuring successful adaptation strategies and their implementation, leading to increased resilience of the social-ecological system of a river basin.

The Rmel river basin was selected due to the need for increased awareness of challenges facing its citizens and the environment due to global changes. The plan that has been developed over the course of the BeWater project is thus the result of intense team effort, targeted information gathering, scientific analysis, wide stakeholder involvement, critical reflection, and thoughtful planning.

The main emphasis of this river basin adaptation plan is on the selection of water management options that will improve sustainable water management in the Rmel river basin in the short and long term future. The project has identified 19 individual water management options for the Rmel river basin, which have been further grouped into six thematic bundles.

The wider goal of the adaptation plan is to act as a catalyst for the development of river basin adaptation plans in the Mediterranean region, as well as across Europe more broadly.

خلاصة

يعتبر التصرف المستدام في المياه من أهم التحديات المتعلقة بالمنطقة الأورومتوسطية في ظل التغيرات المناخية. إذ من المتوقع أن يؤدّي تغير المناخ إلى زيادة ندرة المياه والجفاف في هذه المنطقة، مما سوف يسبب خسائر اجتماعية واقتصادية كبيرة إلى جانب التأثيرات البيئية السلبية. في هذا السياق، هناك حاجة ماسة إلى بذل مزيد من الجهود لتعزيز الشراكة بين العلم و المجتمع وترسيخ الشعور بالمسؤولية في إطار مواكبة الموارد المائية للتغيرات المناخية و العالمية. وتمثل عمليات تبادل المعارف والخبرات، تحسين الوعي إلى جانب الشراكة الفعّالة بين المجتمع المدني والبحوث التنموية، المفتاح لضمان استراتيجيات التكيف الناجحة و دراسة سبل تنفيذها. إن العمل على هذا المنوال سوف يؤدي إلى زيادة مرونة النظم الاجتماعية و الإيكولوجية في الأحواض المائية.

وفي إطار مشروع BeWater تم تطوير خطة لمواجهة التحديات المناخية المستقبلية و هي عبارة عن نتيجة للجهود المكثفة لفريق العمل من خلال جمع المعلومات اللازمة ، التحليل النقدي الهادف، التخطيط المدروس والمشاركة الواسعة لأصحاب المصلحة. ولقد تم اختيار حوض وادي "رمل" نتيجة للحاجة الملحَة إلى زيادة الوعي بالتحديات التي تواجه المجتمع المدني نتيجة للتغيرات المناخية. تم التركيز في هذه الخطة على خيارات التصرف في المياه التي من شأنها تحسين الإدارة المستدامة لحوض وادي "رمل" على المدى القريب والطويل. إذ تمثل هذه المنهجية حافزا لتطوير خطط تكيًف الأحواض المائية مع التغيرات المناخية في منطقة البحر الأبيض المتوسط و في جميع أنحاء أوروبا.

Glossary of key terms

- **Acceptability (as criteria for water management options) -** an option is considered as acceptable if there is not significant reason a priori for actors in the basin to reject the option, e.g. because of its design [i]
- **Adaptation pathway -** portrays a sequence of actions and their implementation prioritisation over the short, medium and long-term, with regards to achieving a set of pre-specified objectives under uncertain changing conditions [ii]
- **Adaptive management -** an approach to reduce ecological uncertainty and increase resilience by emphasising that management regimes should be regularly adjusted to changes in the ecological system being managed and to managers' evolving understanding of this system
- **Bottom-up approach -** entails the participation of local actors in decision-making about the selection of the priorities and actions to be pursued in their local area; the approach can interact and be combined with top-down approaches from national and/or regional authorities in order to achieve better overall results [iii]
- **Bulk water** - water obtained from the source and provided to a water service entity for distribution to end-users
- **Carrying capacity** - the maximum capacity of the natural environment in a certain area to provide ecosystem services (e.g. water, fertile soil for the production of crops, growth of natural vegetation or a healthy interplay between species that controls pests and diseases) to sustain the development of human activities; overriding the carrying capacity of a territory means disrupting its functionality
- **Citizen participation** - a process in which ordinary people take part – whether on a voluntary or obligatory basis and whether acting alone or as part of a group – with the goal of influencing a decision that will affect their community; this can take place within an institutional framework, and may be organized either by members of civil society or by decision makers [iv]
- **Challenge -** something that by its nature or character serves as a call to a special effort; the RBAP focuses on the challenges related to the impacts of global change in the river basin - now and in the years to come
- **Climate change -** any long-term change in climate over time, whether due to natural processes or as a result of human activity [v]
- **Climate change adaptation -** appropriate action to prevent or minimise the damage that climate change impacts can cause, or taking advantage of opportunities that may arise due to climate change [vi]
- **Climate change scenario -** the difference between a climate scenario (i.e. a plausible and often simplified representation of the future climate) and the current climate [vii]
- **Co-benefits (as criteria for water management options) –** options are considered to have co-benefits when their combined implementation amplifies the total impact-related

benefits, as compared to the benefits which would arise from implementing each option individually

- **Environmental flow regime** - describes the amount of water that is needed by the river ecosystem to sustain its natural functioning
- **Extreme climate event –** an event that is rare within its statistical reference distribution at a particular place (i.e. normally as rare as or rarer than the 10th or 90th percentile); specific characteristics may vary from place to place [viii]
- **Extreme weather event** - an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. rainfall over a season) [ix]
- **Feasibility (as criteria for water management options) -** an option is considered as feasible if physical, technical, regulatory or organizational obstacles are not existing or can be easily overcome during option's implementation [x]
- **Flexibility (as criteria for water management options) -** an option is considered flexible when it can be adjusted/ complemented or reversed when it turns out to be inadequate or inappropriate in practice [xi]
- **Fuzzy cognitive map -** a tool to graphically represent the knowledge about or the perception of a given system; can be converted into simple mathematical models to run simulations and calculate outcomes of possible scenarios to facilitate the discussion and exploration of complex issues [xii]
- **Global change** - changes in the global environment that may alter the capacity of the Earth to sustain life, encompassing climate change as well as other critical drivers of environmental change that may interact with climate change, such as land use change, population trends, the alteration of the water cycle and changes in ecosystem functionality [xiii]
- **Good status (of a water body)** – a term to describe a condition under which water bodies have the biological and chemical characteristics expected under sustainable conditions [xiv]
- **Governance -** the way rules, norms and actions are produced, sustained, regulated and held accountable; it refers to the processes of interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions [xv]
- **(Invasive) alien species –** plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health [xvi]
- **Impact assessment –** a method to identify the environmental, social and economic impacts of an action or project prior to decision-making
- **Implementation barrier or opportunity -** elements deriving from the implementation context influencing the foreseen or ideal development of an action
- **Karst -** a special type of landscape formed by the dissolution of soluble rocks, including limestone, dolomite and gypsum; it is characterised by underground drainage systems with sinkholes and caves; Karst regions contain aquifers that are capable of providing

large supplies of water [xxvii]; subterranean drainage may limit surface water with few to no rivers or lakes

- **Knowledge transfer –** the process of engaging with researchers, decision-makers or the community and decision-makers to generate, acquire, apply and make accessible the knowledge necessary to successfully develop and enhance evidence-based initiatives which enhance human, material, social and/or environmental wellbeing [xviii]
- **Meander -** a bend in a watercourse or river formed by erosion on the outer banks due to the flow of moving water and resulting in a winding water course; when a meander gets cut off from the main stream, an oxbow lake forms
- **Multi-criteria analysis -** a tool for supporting complex decision-making situations with multiple and often conflicting objectives (e.g. economic, ecological and social) that stakeholder groups and/or decision-makers value differently [xix]
- **Mutual learning -** a learning process experienced and shared by different actors developed through direct interactions; the process is conducive to adaptive water management and includes the exchange of information on technical features of river basin management, scientific findings, as well as political aspects, so as to arrive at a shared understanding of issues and possible solutions
- **Non-conventional water resources -** in the context of this plan, unconventional water resources are the desalination of brackish and seawater and cloud seeding, which present potential options for balancing future demands on water and available supplies [xx]
- **Oxbow lake -** a crescent shaped body of water lying alongside a winding river; formed when a wide meander from the main stem of a river is cut off [xxi]
- **Participatory co-creation -** an approach which integrates all stakeholders in the entire design process of an action, i.e. problem definition, solution generation, evaluation of proposed solutions during development, and implementation of solutions, to help ensure the result meets user needs and increase acceptability
- **Policy framework -** a broad set of laws, regulations, or processes that structure political, social, cultural or economic activities in a society; these policies form an interacting web and therewith impact the functioning of exiting policies as well as new policy developments and policy amendments [xxii]
- **Pressure -** anthropogenic factors inducing environmental change (impacts), including for example the release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities [xxiii]
- **Resilience -** the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change [xxiv]
- **River basin -** the area of land from which all surface water runs off through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta [xxv]. It is a natural geographical and hydrological unit that is used e.g. by the European legislation to manage a single drainage area [xxvi]

- **River Basin Adaptation Plan -** management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.
- **River Basin District** - the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters [xxvii]
- **Robustness (as criteria for water management options) -** an option is considered robust to uncertainties if it can maintain its effectiveness under different climatic and socio-economic development scenarios [xxviii]
- **Sediment management -** organized and coordinated actions to reduce the impact of human activities or natural changes on the quantity and quality conditions of solid material that is or can be transported by or deposited from the river's water [xxix]
- **Shelterbelts -** a row of trees planted across the direction of wind to deflect and reduce wind speed without causing turbulence; generally, provide protection from desiccating winds to the extent of 5 to 10 times their height on windward side and up to 30 times on leeward side, thus reducing evaporation losses and wind erosion [xxx]
- **Socio-ecological system –** consists of 'a bio-geophysical' unit and its associated social actors and institutions; delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context [xxxi]
- **Stakeholder** - any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome; the term is usually reserved for well-organised and active groups and organisations, thus making a distinction from the general public
- **Terrace -** a permanent berm and channel arrangement either constructed along the face of a slope at regular intervals or constructed as a continuous series of horizontal steps on the face of a slope in order to reduce erosion damage by capturing or slowing down surface runoff and directing it to a stable outlet at a velocity that minimizes erosion [xxxii]
- **Water management option –** activity developed within the scope of the BeWater project which aims to impact the interactions between water uses and the water body; can be characterised as nature-based approaches (enhancing natural regulation of ecosystem functionality), soft approaches (acting on management or policy norms and regulations) or technical approaches (developed through engineering)
- **Water scarcity –** a lack of sufficient available or safe water resources to meet water needs within a region; this can involve water stress, water shortage or deficits, and water crisis as a result of climate change, increased pollution, or increased human demand and overuse of water [xxxiii]
- **Watershed -** the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater; this area is typically smaller than a river basin, meaning that several watersheds may comprise a single river basin [xxxiv]

List of acronyms

AEPR	Drinking Water in the Rural Area (Alimentation en Eau Potable Rurale)
EU	European Union
IRDP	Integrated Rural Development Programs
Ha	Hectares
GDA	Agricultural Development Groups
Km	Kilometers
Mm	Millimeter
Mm^3	Million m^3
PMU	Management Unit Programs
RBAP	River Basin Adaptation Plan
ROAD	Regional Office of Agricultural Development
SONEDE	National Company of Water Exploitation and Distribution
WMO	Water Management Option
° C	Degree Celsius
WSC	Water soil conservation

PART 1

4.1 Introduction

4.1.1 Context of the plan

Global changes (e.g., climate, population, land use, economic development) are considered major challenges in the Rmel river basin. In fact, water resources in this watershed, as in most parts of Tunisia, are limited, unevenly distributed and annually variable. In light of future climate conditions, the growing demand for water by various sectors (agriculture, drinking water, industry, tourism, etc.) will exert acute pressure on these resources in the next years and will therefore bring a confrontation between resource supplies and needs. Consequently, the management of water resources remains a prominent issue whose resolution requires the roll-out of management plans not only on a large-scale (national level) but also on a small scale (watershed level).

The development of an adaptive management plan for a watershed requires a good knowledge of the general context (e.g., existing resources, the main problems and issues) and a strong mobilization of stakeholders at both national and local levels. The involvement of the local population (e.g., public actors, farmers, civil society and associations) is fundamental as it allows a better understanding of the current needs and constraints as well as an acceptance of commonly agreed solutions. In addition, a participatory approach leads to rising awareness among local actors on the challenges related to integrated water management and displays the need to adapt to global changes. It promotes a deeper sense of ownership of the water management.

At the same time, in view of the complexity and technicality of the matter, the development of an adaptive management plan for a watershed requires also the use of a scientific approach. In the BeWater project, a science driven approach is combined with a bottom-up participatory approach: the technicality and neutrality science offers is combined with the benefits of stakeholder participation.

Text box 1: Definition of RBAP

The BeWater River Basin Adaptation Plans (RBAPs) are management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.

4.1.2 Objectives and vision

The Rmel river basin adaptation plan is a pilot case developed within a science and society project (BeWater). One of the underpinning objectives was to develop a novel approach to engage with society on matters related to sustainable water management and adaptation to global change. This document presents the synthesis of the initiative and key

recommendations. It deals with climate change and the adapted water management options to the Rmel watershed while considering the six main key challenges: 1- Water quantity, 2- Water quality, 3- Agriculture, 4-Forest and biodiversity management, 5- Awareness of civil society and 6- Human resources and employment.

The objectives of the river basin adaptation plan, and the processes that led to it, are:

- To raise public awareness on sustainable water management, with particular focus on the expected climate change impacts at river basin scale;
- To actively engage with local communities, discuss current water uses related problems and consider potential solutions;
- To present in a synthetic way a range of options and key recommendations that would increase the capacity of the Rmel river basin to adapt to the impact of global changes while considering water resources.

As such, the plan is voluntary and should be seen as a source of inspiration and ideas for the future management of the Rmel river basin and beyond. [14]

4.1.3 Overview of content

This document is divided into two main parts.

The first part comprises 5 major chapters.

- The first chapter introduces the BeWater project, the global context and main objectives of the plan for adapting the Rmel watershed to climate change.
- The second chapter presents the current and future status and the policy context of the watershed. In addition, the key challenges for the Rmel river basin are introduced.
- The methodology developed and adopted in the BeWater process and an overview of the detailed steps are presented in the third chapter.
- In the fourth chapter, the adaptation actions are introduced and synthesised in six bundles corresponding to the six key challenges identified for the Rmel river basin. Approaches to monitoring are also presented.
- The last chapter is devoted to the next steps and recommendations for the Rmel river basin.

The second part of this document includes detailed information on the individual water management options for the Rmel river basin as identified together with the stakeholders. In addition, an overview of the main achievements is presented.

4.2 Rmel River Basin

4.2.1 Current status and dynamics

4.2.1.1 Land

The watershed of wadi Rmel is located on the eastern coast of Tunisia, about 80 km south of Tunis. It provides a transition between different regions: the north of the Tunisian Dorsal, the Sahel and the Cap Bon. This basin extends essentially on the Zriba delegation of the governorate of Zaghouan and a substantial part of the same governorate with a total area of approximately 87 ha. (Figure 1)

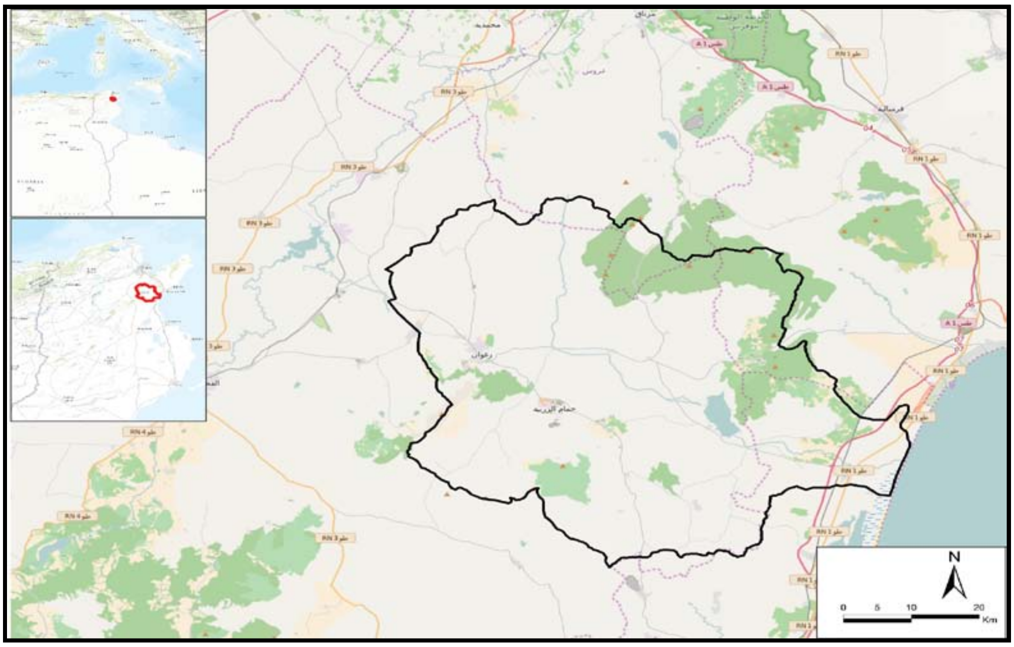

Figure 1: *Geo-localization of the Rmel River Basin*

The Rmel river basin is spread over 17 local territorial units and covers administratively four governorates (70% in Zaghouan, 19% in Sousse, 8% in Nabeul and 3% in BenArous). Several administrative departments are included in the Rmel river basin: four in Zaghouan (Zriba, Zaghouan Saouaf and Bir Mchergua), one in Sousse (Bouficha), another at Nabeul (Hammamet) and the last one belongs to Ben Arous (Mornag) [2].

The Rmel watershed is characterized by a relatively rugged land, especially in the mountains of south-west and the north-east, and by medium to steep slopes. Slopes are between 0 and 10% over most of the basin. The steepest slopes are encountered mainly in south western and north-eastern sides [2].

The basin is covered by forest formations ranging from degraded scrubland to dense forest. Bushes or scrubland areas as well as forest relics of Aleppo pine occupy deposit slopes, forming the catchment. In the hills connecting the mountain, low lands lopes and agro cereal. Plains and piedmonts are under a heavy human pressure. They are systematically

cultivated, mainly with cereals, which speeds up the process of soil erosion and consequently land degradation [2].

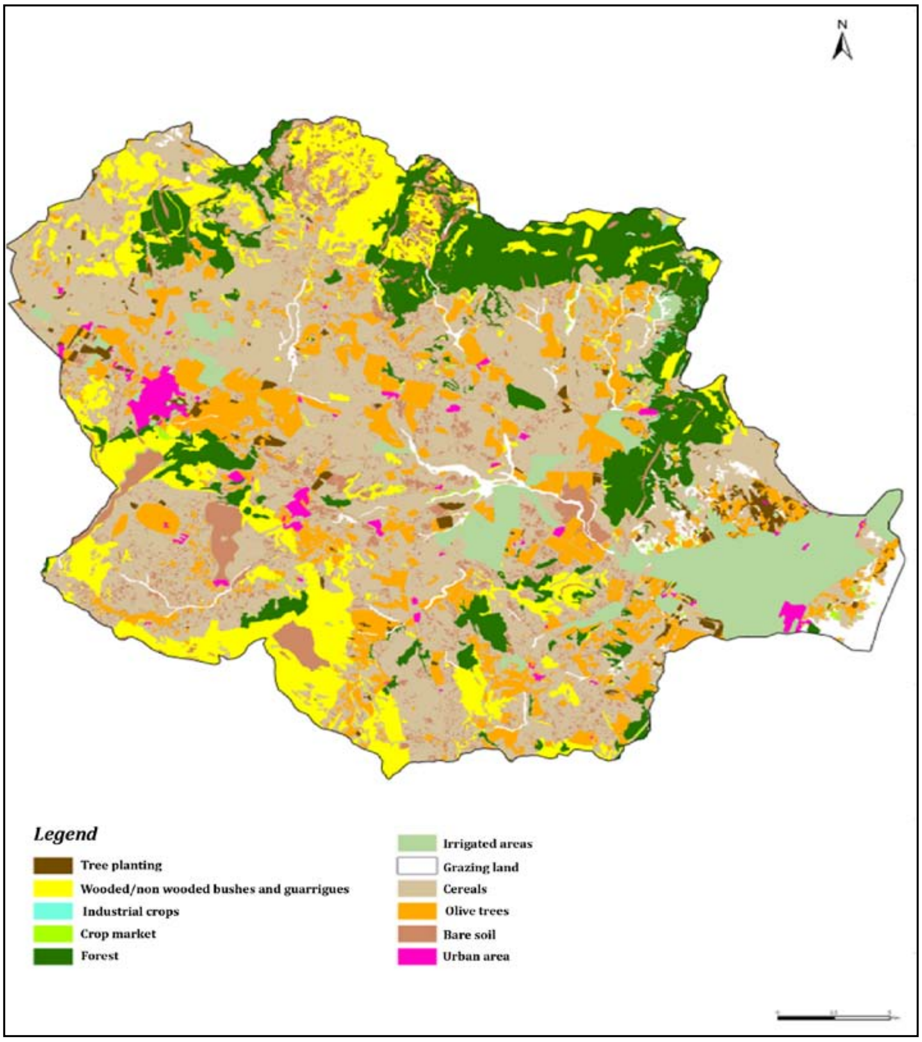

Figure 2: *Soil cover at Rmel river basin*

Agriculture in the Rmel river basin will be impacted in multiple ways by climate change. In the occurrence of a succession of dry years, lower production of olive and cereal areas in the central and southern part of the country is likely to be observed. Cattle raising is also affected during the droughts.

During the wet years, the olive oil production and the crop yields increase by 20% [4]. In case of flooding, irrigated areas and crop yields are affected. In the Southern part, climate change impacts the situation of oasis (microclimate) more critically [2].

In the next years, the climate projections display that more risk of large fires in the Northern part of Tunisia will be observed. Rising temperatures and sea levels (50 cm by 2100) are likely to increase coastal erosion and will cause the advance of the sea to the mainland coastal areas, posing threats to the integrity of coastal wetlands. All sebkhas with an area of 730 ha will turn into lagoons. The same is true for the Gulf of Hammamet, where about 1400 ha will be affected [4].

4.2.2 Climate change and water

The Rmel watershed is subject to a double climate influence, Mediterranean and continental, with an average temperature of 18.5°C and an average rainfall between 350-600 mm that is characterized by high annual and seasonal irregularity. In addition, the basin has two deep groundwater bodies with a capacity of 8.38 million m^3 [5].

The basin is part of the average semi-arid bioclimatic stage [5]. The limits in the south west are located in a sub humid region. The overall annual amount of precipitation is rather low and characterized by high irregularity [5]. The summer rain is generally of the convective type and breaks out as storms. During these short, sudden and violent storms heavy runoff is typical. The floods that originate in the mountains spread onto the coastal plains in the eastern part, where they represent either a source of life for the farmers or a catastrophe that destroys their assets. The wadis are quite wide and shallow and are known to be unpredictable. Almost everywhere during rainstorms they carry large quantities of water and sediments, blocking traffic for hours, and threatening the lives and property of the people along their usually dry banks.

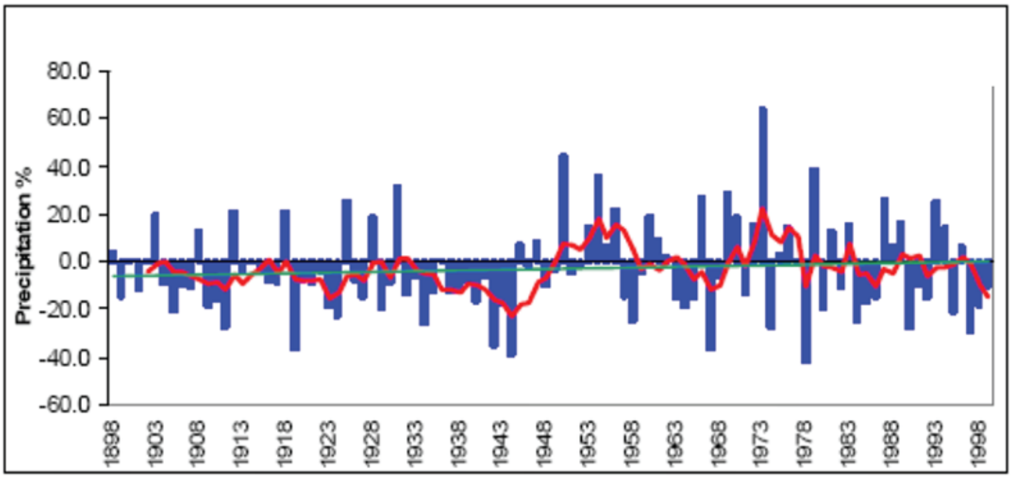

***Figure 3**: Irregularity of annual precipitation (1898-1998)*

Water resources in semiarid areas are a limiting factor. In fact, the problem of storing a near-annual volume of rainwater that falls in only 5 months is a known issue to sustain agricultural activities within the different geomorphological units. Consequently, rainfall variability represents one of the biggest challenges regarding water resource development in the Rmel river basin. A dam with an initial capacity of 22 million m^3 was built in 1998 about 9 km from the city of Bouficha. Water is intended mainly for the irrigation of 5900 ha of cropland in Bouficha and about 500 ha in Zaghouan [2] [5].

Water demand in Tunisia is estimated at 2 689 Mm^3 in 2010 and projected to reach 2 770 Mm^3 by the year 2030. Main water uses are irrigation, tourism, industry and drinking water (Figure 4). The demand for irrigation presents 77% of the total potential in 2030, making agriculture by far the largest water consumer. Drinking water demand was estimated at 381 Mm^3 in 2010 and is projected to reach 491 by the year 2030 due to population growth (inhabitants will reach 12 million by 2030). As far as industry is concerned, the projected

needs will almost double between 2010 and 2030 going from 136 Mm^3 to 203 Mm^3. Water demand in the tourism sector was estimated at 19 Mm^3 in 2010, the projected needs will reach 41 Mm^3 by the year 2030. Overall, the trend of water resources (groundwater & surface water) mobilization will reach 95% by 2025. Moreover, starting from 2020, Tunisia will have recourse to unconventional water resources to respond the demand of different sectors.

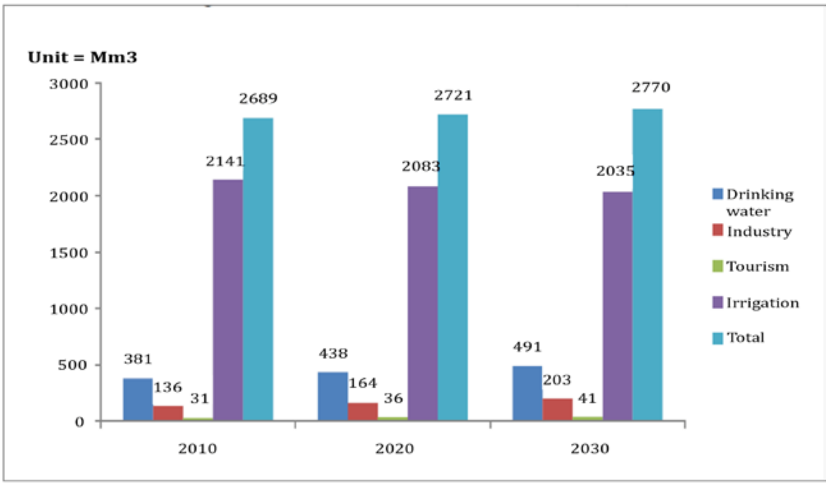

Figure 4*: Future demand for water resources in Tunisia (2010-2030)*

Additional infrastructure has been developed to exploit water resources. These are: 13 used natural springs, 104 boreholes, 370 shallow wells and 22 hill lakes. Groundwater use and drilling is primarily intended for irrigation and drinking water supply, and to provide a "security" supply during dry years. Hill lakes are intended either for supplementary irrigation, for groundwater recharge, or for the protection of the Rmel dam against siltation [5].

For climate projections over Tunisia, the HadCM3 model (general circulation model coupled atmosphere-ocean) was used to quantify and evaluate the increase in temperature and the likely decrease of rainfall in addition to the study of the variability of precipitation and the extremes horizons of 2020-2050 as compared to the reference period 1961-1990 [4]. The average annual increase over the entire country while considering scenarios A2 and B2 will be + 1.1 ° C in 2020 and + 2.1 ° C by 2050. (Figure 5)

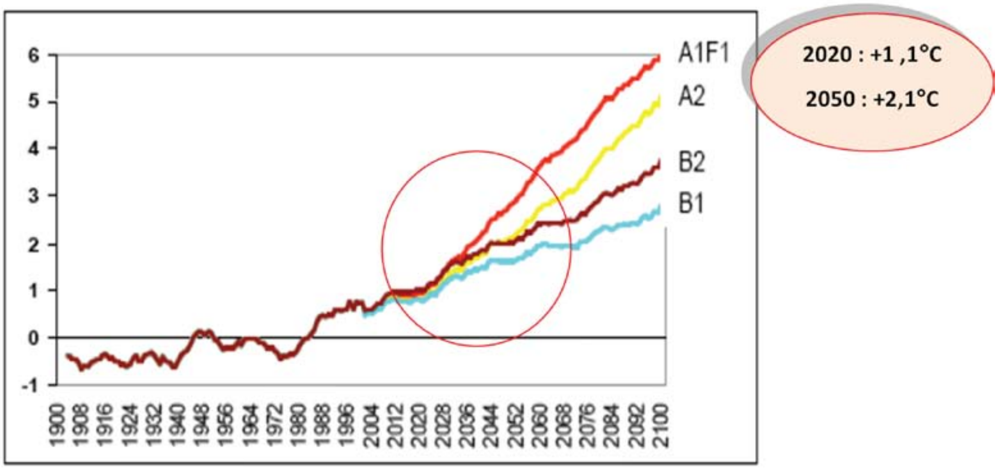

Figure 5: *Elevated Temperature (° C) related to the four scenarios A1-F1 (high scenario), A2, B2 (average scenarios) and B1 (low scenario) from 1900 to 2100[4]*

Regarding the projections of annual rainfall for 2020 and 2050, a general downward trend is displayed. This decline seems moderate in 2020, but high in 2050 while considering A2 model. (Figure 6)

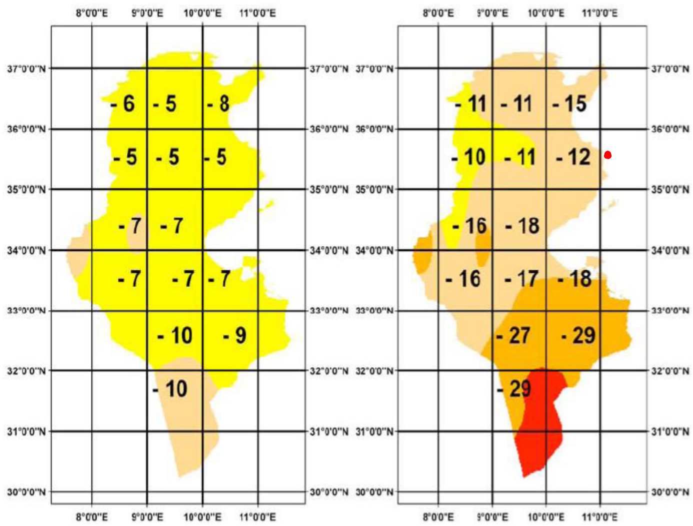

Figure 6*: Drops (%) of annual rainfall (HadCM3 -A2) compared to the reference period for 2020 and 2050*

The main resources affected by climate changes are water resources, ecosystems and agro-systems. Groundwater resources, coastal aquifers and non-renewable aquifers are forecasted to decrease by 28% in 2030. Sea level rise will put additional pressure on coastal groundwater through saline intrusion. The decrease in surface water will be about 5% in the same horizon. The exploitable water will decrease slightly. The decrease in summer precipitation will increase the lack of soil moisture [4].

4.2.3 Biodiversity

At the site of the dam of the wadi Rmel and its depression zone, the vegetation cover of the area is generally dominated by herbaceous crops, grazing areas, tree crops and forest plantations. The predominant vegetation in this zone is generally formed by formations of Olea europea and Pistacia lentiscus, Eucalyptus spp, Tetraclinis articulata, Pinnus halepensis, and Quercus ilex. Regarding animal communities, they are usually dominated by water bird species [2].

The Rmel watershed is a region rich in wildlife, as reflected in the variety of species such as boar, jackal, fox, wild cat and partridge. It is important to stress some species of birds such as hawks that are sedentary, while others are migratory as the booted eagle or dove. The wealth of wildlife has declined but remains important and deserves to be developed as it may be the basis of a great contribution to launch the green tourism in the areas near Tunis, Hammamet, Sousse, in an attractive environment where the forest and hill dams are highly valued landscapes [4].

4.2.4 People

The total population was estimated in 2014 at about 135 438 inhabitants, with about 46% living in urban areas and 54% in rural areas [7]. The distribution of the population in the basin is closely related to water resources. Indeed, valleys, wadis, small lakes and groundwater (aquifers and springs) are among the factors encouraging sedentary populations in the basin. In addition the Rmel river basin has a strong cultural heritage around water resources (see Text box 2).

***Text box 2. Cultural heritage in the Rmel river basin: the Water Temple [*8]**

A historic feature of Zaghouan Governorate, which is the most important part of the basin under study, is the roman monument "the Water Temple", located behind the Zaghouan city and right under the mountain of Jebel Zaghouan. It was built near the water spring known since antiquity. In addition to the water temple, there is an aqueduct connecting Zaghouan to Carthage, allowing the water supply to reach the Terms of Antonius and a source for the temple.

In mountainous regions, drinking water provision is manual or through cisterns that are transported along 3kms of the water source. However, households are increasingly seeking connection to a drinking water network. Since 2007, new rehabilitation projects aim to provide households access to the drinking water network [9].

In the Rmel river basin, agriculture is still the largest economic sector for employment with 31.9% (as opposed to 20% for Tunisia as a whole), closely followed by the manufacturing sector with 28%. Agricultural employment has gained momentum with an increase of 9.2% employment between 1999 and 2010. In rural areas, agriculture accounts for 34% the main source of employment and it provides jobs to almost all rural women [9].

The Rmel river basin holds an industrial zone with an area of 44 ha. It is located in the delegation of Zriba and contains 38 companies with a total workforce of 4 500 employees. This area is causing a water pollution problem due to direct dumping of waste in waterways [9].

In addition to agriculture and industrial activities, the Rmel river basin consists of 20% of forests that are used mainly for firewood, the extraction of oil, and the production of Alep seeds. Given the mountainous landscape, several areas of the watershed have been considered for agro-tourism projects.

The financing of agricultural private investments in the governorate of Zaghouan is largely provided by self-financing and bank loans, which represent 92% of the total. These investments were in the order of 23 million dinars in the year 2012. Agricultural activity is supervised by technicians assigned to agricultural extension, animal production, irrigation and crop production. Agricultural extension is provided by local cells of the extension. Future economic development is likely to result in growing water demand. With limited available resources and increased aridity due to climate change, the rising pressure on water resources is a challenge for the near future [9].

4.2.5 Policy context

The Rmel river basin and its citizens nevertheless face great challenges in relation to sustainable water management. Important gaps with regards to drinking water supply and wastewater treatment remain, while demand for further economic opportunities and development is high.

Tunisia has undertaken a prospective thinking initiative on the impacts of climate change on the agriculture and natural resources. For this reason, a national strategy for the adaptation of Tunisian agriculture and ecosystems to the climate change [6] and a study on protecting ecosystems and climate change adaptation [4] have been developed.

The Tunisian Government has established an extensive national legal framework, reflecting, on the one hand, an awareness of the problems related to the management of natural resources, and, on the other hand, its commitment to improve the rational and sustainable use of water for future generations. This legal framework is composed of provisions contained in codes such as the water code [10], the forestry code [11], the investment incentives code [12], as well as a wealth of laws, regulations, and ministerial orders. However challenges remain, in particular regarding levels of enforcement, which are closely linked to the lack of financial resources to support implementation and effective governance to support collaboration across the large range of actors relevant for sustainable river basin management (see Text box 3).

The “Water Code”, now being revised, is the major legislative instrument for water management in Tunisia since 1975. This code is the legal baseline organizing the ownership and exploitation of water in Tunisia. In addition, every five years, the Tunisian Government sets its “Development Strategy” which includes a core component on water. Management is based primarily on a system of financial incentives for the promotion of facilities and water-saving technologies. The government offers subsidies for farmers to promote the rationalization of water in agriculture. In addition, the “Development Strategy” promotes the decentralization of the state and the participation of users in water management. The authorities display an interest in the water saving policy domain; authorizations or concessions affecting water, drinking and agricultural water, as well as the efforts put to reduce water pollution.

In Tunisia, rural development is considered in the context of five-year socio-economic development plans. The Ministry of Agriculture and Water Resources is the body responsible for water resources mobilization and development, to ensure access to drinking water for the urban and rural population and supply water to the agriculture, industry and tourism sectors. Technical bureaus within the Regional Offices for Agricultural Development (ROAD) enforce all programs and projects at the regional level. These are the government's main agricultural development institutions in each governorate. The districts are represented in the delegations by representatives. Often under Integrated Rural Development Programs (IRDP), the representatives are supported by a management unit (PMU). It is divided into the departments for water resources, forests, land resources and agricultural engineering. In addition, the ROAD works closely with Agricultural Development Groups (GDA) which brings together owners and users to jointly manage natural resources.

In Tunisia, the Ministry of Agriculture and Water Resources (MAWR) is the supervisory authority that organizes the varying frameworks responsible for water management and the development of public irrigated perimeters. The ministry carries out studies and water mobilization work and manages large reservoirs. Furthermore, it promotes user groups in the field of irrigation, and develops and implements management tools for water demand in the agricultural sector. The present Regional Offices of Agricultural Development (ROAD) represent the ministry in each Tunisian governorate. These offices have the human resources, engineering equipment, financial and legal means to ensure preservation of the water resources, watershed management, hydro-agricultural development, agricultural extension, financial incentives and approvals (Berndtsson and al., 2016).

The creation of ROAD in 1987 intended to encourage the revitalization of the associative movement to support the management of water projects by the beneficiaries. Following this trend of decentralization, regulatory texts relating to collective interest associations (AIC) were revised in 1991. In 1999, these associations evolved to collective interest groups (GIC) under contract with the CRDA. In 2007, new regulations required the GIC to evolve into Groups for Agricultural Development (GDA). The GDA undertake other management activities related to the protection and exploitation of natural resources. However, the water management activities are predominant. Eventually, the state retained the maintenance, rehabilitation, and upgrading of large structures. People who use water from hydraulic infrastructure financed by the state have to join these associations (Selmi and Sai 1998).

Text box 3: Water management in Tunisia: historical development and current challenges

Early on, the risk of water scarcity has prompted the political class to take decisions and to set specific strategies in this sector. The first strategy of water resources management that Tunisia undertook after independence was considered as a technical investment phase (1960-1980). It was marked by the construction of large hydraulic structures that mobilized more than 50 per cent of total agricultural investment. These projects stored, allocated, transferred, treated and distributed water resources. These choices were based on the logic of better resource allocation between different regions in order to accelerate the country's development. This infrastructure was intended to increase agricultural production in the northern region, ensure the supply of drinking water, promote the tourism industry in the Sahel, and supply large cultivated areas with irrigation. However, the legal and structural component that accompanied these programs resulted in a policy which encouraged intensification of agriculture and natural resource use.

Since 2000, a period of adjustment has been occurred, characterized by the launch of several studies (e.g., Water 2000 [13] - water sector strategy) for the rational and sustainable exploitation of water resources. This policy aims to promote a number of “modern” water management approaches such as water demand management, better water pricing, encouraging water saving, reinforcement of collective management, and promotion of small and medium hydraulic infrastructure.

Nevertheless, several challenges regarding water management in Tunisia remain, in particular in rural river basins such as the Rmel. Investments in large hydraulic projects did not always result in widespread benefits and the emergence of a resilient rural economy. Rural society is suffering from unemployment and underemployment, rural exodus with the loss of know-how in traditional irrigation practices, the accentuation of regional imbalances favoring urban development and the industrial and touristic sectors, and the emergence and a deepening, chronic food deficit. Small hydraulic structures, which have the potential to benefit small farm holders, are mobilizing less than 10 per cent of total agricultural investment. In parallel, decentralization and local water governance remain to be fully established and appropriated by the government and society. Water associations have had a relative success, affected by challenges regarding enforcement, empowerment, commitment and inclusion of marginalized farmers.

4.2.6 Main challenges

As part of the participatory process, stakeholders were actively involved in identifying the main challenges characterizing the Rmel river basin. In fact, during the first workshop that took place in Zaghouan on 24 June 2014, all the participants had to answer the following questions [14]:

- From your perspective, what are the biggest challenges in the medium-long term for this river basin?
- If you are allowed to dream and looking from your perspective, what should water management have achieved by 2030, in this river basin?
- What options do you see to help achieve that desired state by 2030?

Building on the information collected during this workshop and additional interviews that were conducted in the Rmel river basin, six main challenges were identified.

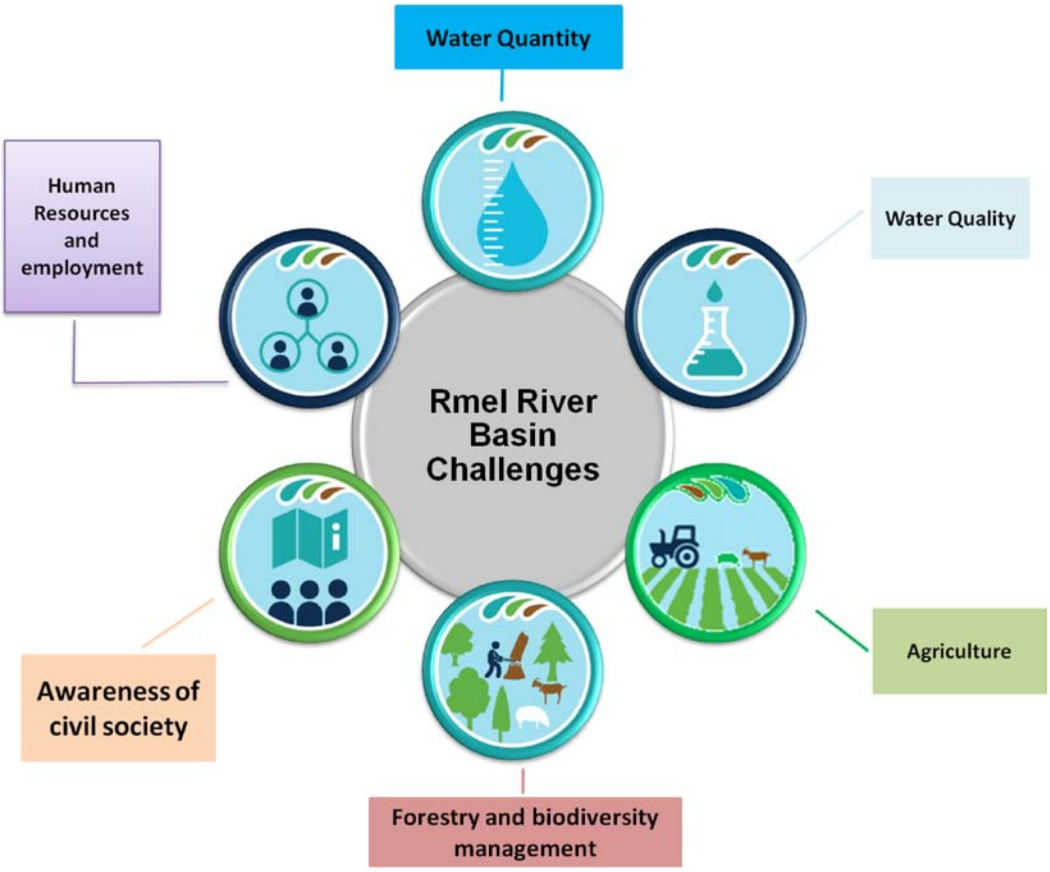

***Figure 7**: The main challenges of Rmel River basin*

➢ Challenge A: Water quantity

In the study area, the rainfall regime is characterized by irregularity and high intensity that cause soil degradation. Also, inappropriate human activities (overgrazing, unsustainable agricultural practices, etc.), accelerate water erosion processes. The limited use of water and soil conservation techniques all over the catchment is causing a reduction of the dam storage capacity. Certain areas remain disserved of drinking water. Losses in the drinking water supply network and low flows affect the quantity of water especially during peak hours. Responding to the needs of the local population by considering sound water management is a priority in our basin.

This challenge is related to: water and soil conservation techniques, soil degradation, flooding, surface water, ground water, irrigated cropland, soil water reserve, water demand and water availability in reservoirs.

➢ Challenge B: Water quality

This region consists of 33 enterprises that release their waste liquids (waste of olive presses, lime) in the Rmel river. These waste liquids have a high influence on the water quality in the basin. Waste water treatment and control of contamination of the river is necessary to preserve the water quality in the basin.

This challenge is related to: water quality, industry and tourism, surface water and ground water, water demand.

➢ Challenge C: Agriculture

The current situation of the irrigated sector is characterized by several levels of overuse and an overall modest increase resulting from various constraints, mainly related social and land pressures. The agriculture sector can face water shortage during summer time. In fact, the mobilized water at the Rmel dam is limited and can't supply all downstream irrigated perimeters. The majorities of farmers are very aged and are practicing ancient techniques and old agricultural customs; moreover, they are struggling with land conflicts. Good management of irrigated perimeters, support of farmers and improving operational and management requirements constitute a challenge to improve agriculture that represents the main occupation of the basin.

This challenge is related to: population livelihood and settlements, irrigated cropland, rainfed cropland, job creation, water quality.

➢ Challenge D: Forestry and biodiversity management

The forest is both a valuable protective mantle for soil and an incomparable set of sites and landscapes but it is particularly threatened. The over-exploitation of the forest and the intensive agro-pastoral practices have led to severe degradation of forest resources. Consequently, it becomes crucial to highlight the economic, social, and ecological importance of forests. Future strategies need to develop and ensure the protection of this precious and fragile heritage.

This challenge is related to: forest fire, forest resources, soil degradation, pasture and cattle rising, population and settlements.

➢ Challenge E: Awareness of civil society

The lack of awareness of civil society about the importance of natural resources is due to the lack of coordination between the authorities and civil society, as well as the fact that local people are kept out of decision making processes (not only in the basin, but in the whole region). Therefore, awareness, training and integration of civil society in studies and the coordination between society and science are necessary for the success of adaptive water management.

This challenge is related to: population and settlement, forest resources, surface water and ground water, soil degradation, pasture and cattle rising, irrigated cropland, industry and tourism.

➢ Challenge F: Human resource and employment

The analysis of socio-economic issues has identified constraints that concern the future beneficiaries: the main constraints mentioned by young people are, namely, guidance

difficulty towards vocational training, lack of generating income projects, unemployment, migration, and lack of specialized manpower. A better exploitation of existing human resources in the basin and the creation of jobs are a relevant challenge for the development of the area.

This challenge is related to: job creation, industry and tourism, population and settlements, irrigated cropland, rainfed cropland.

4.3 Participatory development of River Basin Adaptation Plan

4.3.1 Development process of Rmel River Basin Adaptation Plan

The Adaptation plan of Rmel River Basin was developed through an interactive process of mutual learning, participatory techniques and a bottom-up approach to ensure that stakeholders played an active role in developing appropriate strategies for the management of river basins. Several groups of stakeholders were invited to express their interest and views on managing water resources in the Rmel river basin. Relevant discussions were conducted every time to describe the current situation and the main issues regarding water resources. Therefore, specific local knowledge, several suggestions and different water management options that would be considered at the Rmel watershed scale emerged.


Development of river basin
2014
January–March
1st general project meeting in Barcelona
Identification and mapping of river basin stakeholders and key actors
April–June
1st stakeholder workshop on identifying the current and desired status of the river basin
Review and analysis of river basin adaptation plans and strategies from around the world
2015
January–March
Stakeholder consultation on draft narratives and the basin's graphical representation (fuzzy cognitive map)
April–June
Finalisation of river basin narrative, fuzzy cognitive map, and main challenges
Formulation of water management options to tackle challenges
2nd stakeholder workshop on evaluating water management options
2016
January–March
Characterisation of policy and stakeholder basis of water management options
Assessment of water management option synergies and co-benefits
Design of draft bundles of water management options
April–June
3rd stakeholder workshop on desired content and implementation of the River Basin Adaptation Plan
Finalisation of adaptation pathways and bundles of water management options

adaptation plan

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July–September

Stakeholder interviews on the river basin context and challenges

October–December

2nd general project meeting in Nicosia

July–September

Finalisation of water management options

Impact assessment, multi-criteria analysis and economic assessment of water management options

October–December

Stakeholder consultation event to present and gather opinions on final water management options

3rd general project meeting in Barcelona

Finalisation of impact assessment, multi-criteria analysis and economic assessment

July–September

Completion of River Basin Adaptation Plan

Next steps

Development of policy recommendations to support river basin adaptation

Compilation of lessons learned during the River Basin Adaptation Plan development process

Local policy forum to present river basin adaptation plan and highlight potential paths forward

European policy workshop in Brussels to highlight BeWater outcomes and key messages for policy makers

River basin adaptation conference and final project meeting in Nova Gorica, Slovenia

4.3.1.1 Identification of stakeholders

The identification process of stakeholders focused on ensuring a sufficient diversity of identified stakeholders taking into consideration the activity's area (agriculture, infrastructure, water, environment, energy and forest management), gender and organizational affiliation such as business and economy, government and public authorities, civil society, practitioners, media, youth and education. Therefore, a stakeholder database was developed in order to facilitate the selection of participants for major stakeholder engagement activities, according to a selection process based on Prospex' CQI method. The latter established some selection criteria, together with target quota, in order to achieve a balanced group of stakeholders. Scientists from the National Research Institute for Rural Engineering Water and Forestry (INRGREF) are involved in the BeWater project and have organized several workshops to discuss water management in the context of global change for the Rmel river basin [15].

4.3.1.2 Integration of stakeholders

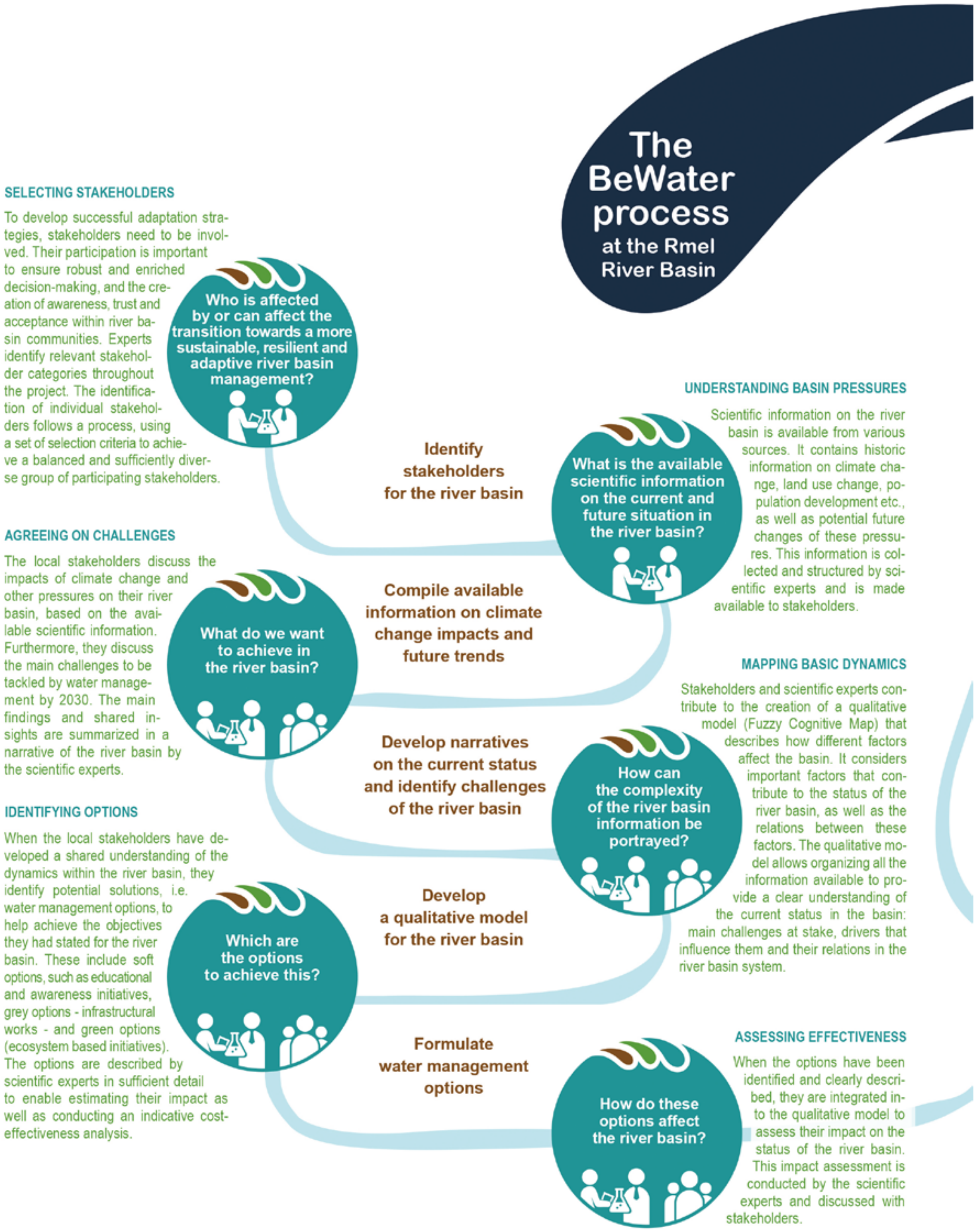
The first BeWater workshop aimed to gather a representative and knowledgeable stakeholders's group for discussing the current water use problems. They identified issues and challenges for the medium-long term and created their preliminary vision for Rmel river basin. The **second BeWater stakeholders' workshop** held in Yasmine Hammamet (Tunisia) on the 4th of June 2015 was attended by 24 stakeholders and the research team. The main objectives of this workshop were to gather the Rmel basin stakeholders together in order to discuss the registered progress since the first stakeholder workshop (2014) and screening for their evaluations concerning the water management options (WMOs) [16].

On the 7th of October 2015, the BeWater stakeholder event took place in Tunis (Tunisia). About 50 participants attended this event, including engineers, educators, administrators, sociologists, policy makers and planners who covered various sectors such as agriculture, education, associations, technical directions, irrigation, and development. Participants in the third stakeholder workshop reviewed the 19 options defined in previous workshops and gave their options according to their knowledge, experience and expertise. Furthermore, participants discussed their experience with each option, as well as any barriers (political, social, and economical) in order to implement options and costs [17].

The following BeWater stakeholder workshop took place in Tunis on Thursday, 7th of April 2016, as a close cooperation with experts from Ecologic Institute. This workshop was attended by about 50 participants and it involved interactive sessions for identified options from the previous workshops and their possible combinations, as well as potential synergies and conflicts between them. Furthermore, the workshop explored how options can be eventually implemented.

Furthermore, in order to present the project and its objectives, several events and awareness campaigns were conducted by the project team in the Rmel river basin (primary school, public areas….). All these events are detailed in Annex 1.

4.3.2 Methodological overview




BeWater
Society Adapting to Global Change
EVALUATING OPTIONS
To evaluate the water management options, the stakeholders select the criteria on which the options will be evaluated, as well as the relative weight of each criterion. The information from the multi-criteria analysis is combined by scientific experts with the outcome of the options' impact assessment and results in the identification of options that have a desirable impact on the river basin, according to the local stakeholders.
Which options have desirable impacts on the river basin?
Assess the impacts of the options through the qualitative model
REVIEWING THE POLICY FRAMEWORK
Policies and programmes on the local, national and EU level can hinder or support the implementation of the options. Their potential role is determined by a scientific expert evaluation of whether the policy objectives, targets and timescales are in line with those of the options, what funding is available, and if eligibility or selection criteria create barriers to adopting the options. This evaluation is then verified by the local stakeholders.
How do the options fit within the relevant policy and decision-making frameworks?
Evaluate the options based on multiple decision criteria
IDENTIFYING POLICY ACTORS
As local stakeholders and policy actors will be directly involved in or affected by the implementation and maintenance of the options, their willingness and capabilities to support the implementation of the options are important to inform the selection and design of options. They are validated via interactive exercises with them.
How could stakeholders be involved in the implementation of the options?
Evaluate the role of existing policies in the implementation of the options
BUNDLING OPTIONS
Implementing multiple options together can result in different impacts than the individual options would produce on their own. These potential interactions are assessed using scientific expert judgment and validated via interactive exercises with the local stakeholders. Using these outcomes and the previously determined basin challenges, the options are grouped into bundles by challenge.
Which synergies or conflicts arise between the options and how can they be grouped together?
Identify key stakeholders and their potential roles in implementing the options
DEVELOPING AN IMPLEMENTATION TIMELINE
The timeline for implementing each of the options within a bundle is based on their effectiveness over time, local stakeholder preferences and the policy framework. Developing the timeline for implementation takes into account factors such as the time lag between implementation and effectiveness, feasibility, acceptability, the policy cycle, associated costs, and the availability of funding. The initial scientific expert assessments were verified by the local stakeholders.
When should the options be implemented?
Assess co-benefits and conflicts arising between options in order to group them in bundles
FINALIZING THE ADAPTATION PLAN
Based on existing examples of adaptation plans in other river basins and an open dialogue between stakeholders and academics, the content and design most relevant to the local reality in the river basin are determined and integrated into a tailored river basin adaptation plan.
How can all this information be integrated and presented in the most effective way?
Assess the optimal timing for implementing the options
River Basin Adaptation Plan

4.3.3 Methodological description

In order to formulate and evaluate water management options (WMOs) for adapting the functioning of the Rmel river basin to global change, we conducted the following series of steps: (i) Elicit the main challenges in each river basin based on the current state and future expectations, (ii) Formulate water management options for each of the challenges, and (iii) Evaluate the water management options [18].

The BeWater project has set up clear mechanisms of sustained stakeholder engagement, integrated in a well-defined science-based methodology. The integration of science-driven and stakeholder-driven approaches clearly contributes to the societal relevance of the scientific activities. Indeed, stakeholders feed the scientific process with knowledge, arguments, suggestions, ideas, and challenge the outcome of the scientific approach.

The first step of the BeWater process in the Rmel river basin consisted in collecting scientific information related to climate change, land use, development of population, economic activities and potential future pressures. This information was collected and structured by scientific experts and discussed with stakeholders during the first workshop. The latter was organized in 2014 as part of the participatory process that aimed to discuss current water use problems, to identify issues and challenges for the Rmel basin and to create a preliminary vision for the river. In order to be able to evaluate the water management options against the different challenges expressed by the stakeholders, a method called Fuzzy Cognitive Mapping was applied.

During a series of workshops and consultations, a group of carefully selected stakeholders expressed their views on challenges faced in the Rmel river basin. Stakeholders also suggested a range of solutions to tackle these challenges. Each of the options was described in detail and was characterised using a set of descriptors concerning the approach to tackle the challenges, the time needed to implement options, the implementation estimated costs, etc. To ensure that the options suggested by the stakeholders were correctly understood, the refinement and characterisation of all of the options was carried out in close cooperation with experts and stakeholders through interviews, consultations and workshops.

The cost effectiveness analysis was based on an estimation of the costs of each of the options. This was performed using information on the cost of implementing and running similar options in other basins or on an implementation scenario defined with local stakeholders. Given available information, these costs are ranges rather than actual costs. The cost effectiveness was calculated using the results of the multi-criteria analysis, based on the impact criteria only, and the estimated cost as a ratio. These analyses give information to help select appropriate water management options based on their expected impacts and characteristics, and their cost-effectiveness.

Using the outcomes of previous workshops and the results of FCM, MCA and co-benefits, the options were grouped into bundles. The choice of bundles was based on the main identified challenges. In fact, we associated a bundle to each challenge in order to maximize the best options on six challenges identified. The options most directly associated to every challenge were called "priority options". The next step was to identify, for each challenge, synergies and conflicts between the priority options and other options.

However, the options, the analyses and the plans within which these elements are contained lay the foundation for successful future water management efforts within the river basin. Furthermore, these elements represent an important contribution to river basin adaptation planning within the Mediterranean and beyond.

Further information on the methodology and results introduced within this adaptation plan, as well as the BeWater project more generally can be found on the project website (www.bewaterproject.eu).

Text box 4: Fuzzy Cognitive Mapping

To be able to evaluate the water management options against the different challenges expressed by the stakeholders, a method called Fuzzy Cognitive Mapping was applied. A Fuzzy Cognitive Map is a graphical representation of a system - in this case a river basin - where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the sign and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system based on the understanding of individuals. Fuzzy cognitive maps allow all the information available on the basin to be organized in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them and their relationships in the system. The maps were constructed with inputs was used to assess the impacts of the water management options on the river basin. In this way, the BeWater team was able to produce a semi-quantitative estimate of the impacts of water management options and their ability to effectively face the challenges of the basin, as input to a multi-criteria analysis that was conducted in a series of Stakeholder Workshops.

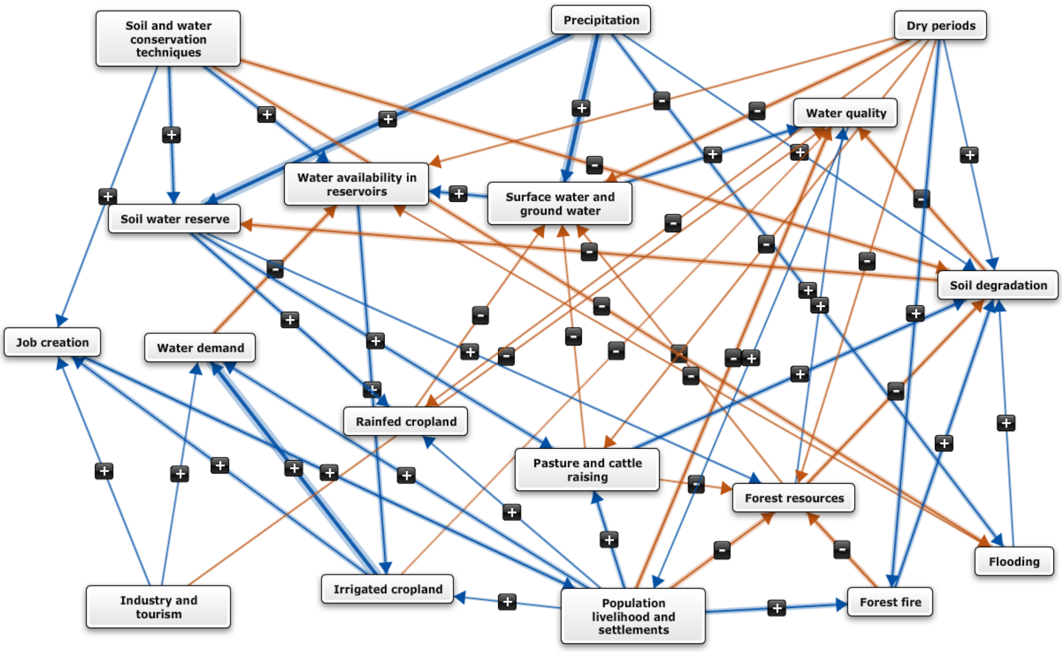


Figure 8: *Cognitive map of the Rmel river basin (blue: +, red:-; strength: thin line: 1, medium width: 2, wide line: 3)*

Text box 5: Multi-Criteria Analysis

Water management options have quite different characteristics and impacts on the water basin and the local communities. Selecting the specific options that should be included in the river basin adaptation plan is a complex endeavour. To support this process, a participatory multi-criteria analysis was conducted. During a workshop, stakeholders were asked to select the evaluation criteria to decide how well options perform, as well as the importance of each of these criteria in relation to each other. Criteria referred to both the design of the water management options and their expected impacts on the river basin, as estimated with the fuzzy cognitive map. The scores and weights of the criteria given by the stakeholders were combined with the characterization of the water management option and the outcomes of the impact assessment to evaluate the water management options prepared by experts and the research team. The evaluation results are presented on a scale of 0-100 with a 0 indicating the least preferred evaluation outcome and a value of 100 as the most preferred evaluation outcome. More detailed information on the individual criteria can be found in Chapter 4.1.

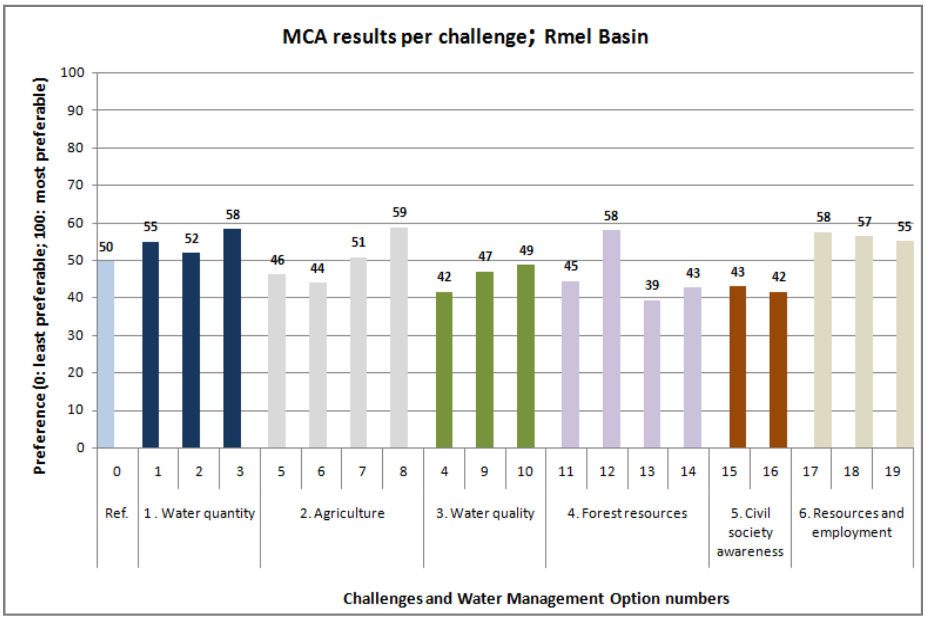


Figure 9: *Outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment.*

4.4 Adaptation actions

4.4.1 Overview of Water Management Options

Table 1 below lists the water management options (WMOs) developed for the Rmel river basin and presents a selection of additional information associated with each option. While the options are grouped together in bundles in Chapter 4 according to their synergistic interactions with one another and a common objective they contribute to, this table provides an overview of information that is specific to individual options. This information can be used by decision-makers when determining which single option(s) would be most appropriate to achieve their targeted objectives.

More specifically, the table associates each option with one of the challenges identified for the Rmel basin (see Chapter 2.3) and a score from the multi-criteria analysis. This score is based on the characterization of the option, the result of an assessment of the option's impact when applied in the river basin and stakeholder evaluations ('weights') of the importance of different possibilities for option features and impacts. A higher score from the multi-criteria analysis (ranging from 0 to 100) represents a stronger overall performance than that of possible alternatives in view of the criteria important to local stakeholders (see Box 5 for more information about the multi-criteria analysis).

Each option is further characterized by a set of additional implementation-oriented factors, such as its feasibility, acceptability and policy synergies. These factors help to determine whether there will be barriers to the option's implementation or, conversely, if there may already be elements in place that facilitate its implementation. The costs represent an indicative estimate of the full cost of implementing the water management option and can be used to determine which options fall within a given allocated budget. Finally, the priority associated with each option is a combination of how an option performs according to stakeholder preferences and implementation-oriented factors evaluated through expert opinion.

The information presented below also enables stakeholders to compare the various options and identify individual ones that fulfill desired expectations, such as selecting an option which addresses a specific challenge within certain cost limitations, while meeting an individual criterion such as having high "acceptability".

- *All water management options identified are feasible and acceptable.*
- *14 options performed particularly well in the multi-criteria analysis and are therefore presented mostly with high priorities. Nevertheless, 5 options are involved with medium priority.*
- *8 options have strong synergies with national policies and 7 options have medium synergies.*
- *Three options (WMO 1, 2 &3) were identified to cope with the challenge to increase water quantity (challenge A). This bundle presents the highest costs.*
- *The majority of options designed to cope with challenge D have high priority. The implementation of water management options enhancing sustainable forest management seems therefore most crucial when making adaptation planning for the Rmel river basin.*

- *16 water management options are characterized by a high co benefits while 3 options have a medium co benefits.*

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium,2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
1		Promote new water and soil conservation techniques.		51	2	2	2	€€€	1,21	High
2		Consolidation of existing water and soil conservation techniques.		40	2	2	2	€€€	1,21	High
3		Creation and rehabilitation of hydraulic infrastructure		41	0	1,5	2	€€€	1,36	Medium
4		Application of taxes.		47	1	0,5	1	€	1,50	High
5		Developing agricultural cooperatives.		42	1	0,5	2	€€	1,60	High

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium,2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
6		Good use of agriculture land.		37	1	1	2	€€	1,42	High
7		Developing financial awareness tools.		39	0	1,5	1	€€€	1,11	Medium
8		Use of water irrigation technologies		40	1	2	2	€€€	1,30	Medium
9		Improvement of the treatment of waste water.		46	0	0,5	2	€€€	1,33	Medium
10		Water discharge control.		42	1	0,5	1	€€€	1,29	Medium

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium,2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
11		Reduction of society pressure on forests		39	1	0,5	1	€€	1,38	High
12		Protection against forest fire		48	1	2	1	€€€	1,50	High
13		Introduction of new agro forestry species and enrichment of existing forest.		37	1	0,5	1	€€€	1,45	High
14		Better governance of forest resources		42	1	1,5	0	€€	1,38	High
15		Awareness campaign and learning		40	1	1,5	2	€	1,12	High

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium,2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
16		Improved decision making		38	1	1,5	2	€	1,13	High
17		Promote projects that generate more income.		45	2	1,5	2	€€€	1,00	High
18		Encourage investments		41	1	1,5	2	€€€	1,00	High
19		Developing skills for young people		44	2	1,5	1	€€	1,00	High

***Table 1**: Overview of the identified water management options for Rmel River Basin*

4.4.2 Bundle factsheets

4.4.2.1 Bundle on water quantity (Challenge A)

The main objective of this group of options is the quantitative management of water resources with emphasis on the conservation of water and soil while improving and developing water supply infrastructure.

Situational analysis	Context	Priority options
The availability of water is a major issue. Indeed, the Rmel watershed is characterized by a semiarid climate and a very irregular rainfall. However, there is strong demand to improve the supply and meet the needs of the local population. It is crucial to have sufficient drinking water and resources to support the development of economic activities. Currently, users in various sectors present in the basin already exert significant pressure on water resources.. Human activities such as agriculture have also contributed to land degradation with consequent reduction of the capacity of soil to retain water and inducing siltation of reservoirs as well as the hydraulic infrastructure located downstream. .Climate change contributes to intensifying the pressure on water resources and increases the risk of water erosion.	The phenomenon of water erosion is a major issue in the basin, with impacts on soil quality, their ability to retain water, siltation of downstream reservoirs and reducing their storage capacity.	***WMO-01. Promote new water and soil conservation techniques*** The objective of this option is to reduce the impact of the phenomenon of water erosion, promote infiltration and collecting runoff water via WSC conservation techniques as well as soft techniques placed on agricultural land upstream. Examples: mechanical benches, dry stone cords, hill lakes, recharge works, dry stone thresholds and bowls. Cost (15 years): 3 508 769 TND.
	The water and soil conservation techniques are in poor condition and thus currently have limited effectiveness.	***WMO-02. Consolidation of existing water and soil conservation techniques*** This option aims to improve the function of existing water and soil conservation techniques Examples: Consolidation of mechanical benches, rehabilitation of irrigation schemes, re-profiling and clearing of wadis. Cost (15 years): 1 526 920 TND.
	The distribution of water from source to recipients (drinking and irrigation water) is done primarily by hydraulic infrastructures that become increasingly dilapidated, causing losses of water.	***WMO-03. Creation and rehabilitation of hydraulic infrastructure*** The objective of this option is to meet the needs of the population while controlling the demand for water resources. It consists, among other things, of encouraging rehabilitation and upgrading of existing drinking water and irrigation networks. Example: Rehabilitation and modernization of existing drinking water and irrigation networks, Creation of discharge stations, cisterns construction. Cost (15 years): 1 110 253 TND.

Co-benefits with other options

Several water management options will have strong co-benefits along with the priority options WMO-01, WMO-02 and WMO-03 on the issue of “water quantity ". WMO-06 fosters the proper use of agricultural land, WMO-13 aimed at protecting forests and WMO-17 incites investment in diversification projects and consolidation of the rural economy (e.g. organic farming; eco-tourism, crafts). They all contribute to strengthening the impact of WMO-01 and WMO-02 on the control of water erosion and runoff. WMO-05 is designed to organize farmers in cooperatives while WMO-08 promotes the adoption of efficient irrigation techniques contributing to strengthen the impact of WMO-03 on saving water. Finally, WMO-15 has a specific section on water savings to strengthen WMO-03.

Associated options [Synergy: strong (dark); medium (light); low to zero (white)]	**WMO-01**	**WMO-02**	**WMO -03**
WMO-04: Application of taxes			
WMO-05. Developing agricultural cooperatives			
WMO-06. Good use of agriculture land			
WMO-07. Developing financial awareness tools			
WMO-08. Use of water irrigation technologies			
WMO-09. Improvement of the treatment of waste water			
WMO-10. Water discharge control			
WMO-12. Protection against forest fire			
WMO-13. New agro forestry species and enrichment of existing forest			
WMO-15.Awareness campaign and learning			
WMO-16. Improved decision making			
WMO-17. Promote projects that generate more income			
WMO-18. Encourage investments			
WMO-19. Developing skills for young people			

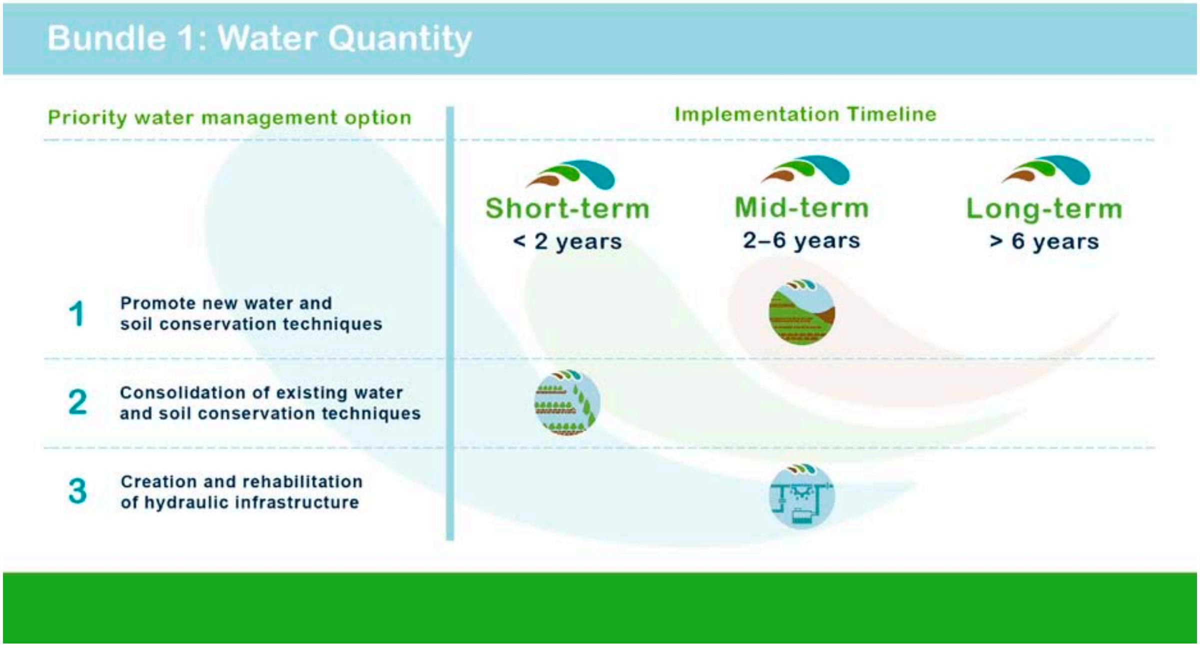
Political and participatory implementation of priority options

WMO-01. Promote new water and soil conservation techniques	
At the present time, this option is mainly supported by the Conservation Code of water and soil. It is also reinforced by the 11th Plan for Agricultural Development Policy.	It will be necessary to raise awareness among farmers and local people while also involving associations.
WMO-02. Consolidation of existing water and soil conservation techniques	
This option is also supported by the Conservation Code of water and soil, and reinforced by the 11th Plan for Agricultural Development Policy. These actions can help overcome the problems due to the lack of transparency on land and the lack of an updated register of properties.	It will be necessary to strengthen the involvement and awareness of farmers and local people (through associations) of the benefits and importance of the protection of the realized developments.
WMO-03. Creation and rehabilitation of hydraulic infrastructure	

This option is reinforced by the Water Code. Corresponding work aims at the development, the economy, and the improvement of water quantity. The protection of national water resources is now declared a public utility.	The management of rural drinking water supply systems is provided either by the National Company of Water Exploitation and Distribution (SONEDE) through its own network or by user associations called Agricultural Development Group (GDAP) for AEPR systems carried out by the Office of Rural Engineering.

Temporal implementation of priority options

The WMO-02 is to be implemented in the short term as it has been assessed as priority during the participatory process. Through multiple previous experiences in the basin, its implementation is facing some technical difficulties and can rely on a favorable regulatory framework. Local actors have a good knowledge of these techniques. The WMO-01 seeks to complement in the medium term the WMO-02 by extending the implementation of technical conservation of water and soil on new surfaces. The WMO-03 must be done in the medium term.



4.4.2.2 Bundle on Water Quality (Challenge B)

The main objective of this group of options is the protection and improvement of water quality in the Rmel watershed via strengthening economic incentives, a stricter implementation of laws and regulations, and recycling of unconventional resources.

Situational analysis	**Context**	**Priority options**
Water resources are heavily polluted by discharges from industries, small factories, domestic population and other human activities. Pollution is not only harmful to the ecological balance of rivers but also may reduce the opportunities for using the downstream resource for agriculture and drinking water. The pollution of watercourses may also increase water treatment costs. The wastewater treatment is still limited in the basin, with little infrastructure and effective management systems in place. The valuation of wastewater is poorly developed although the opportunities for recycling exist for irrigation uses.	Even though there is a tax system on industrial wastewater discharges; its implementation is currently limited.	***WMO-04. Application of taxes*** The option proposes to support a stricter implementation of penalties, which will encourage the adoption of more efficient water treatment systems. Cost (15 years): 8 267 TND
	The waste water can be treated and reused for irrigation of certain crops. This will contribute to the reduction of the risk of pollution in the environment and reduce the pressure on conventional resources.	***WMO-09. Improvement of the treatment of waste water*** This option consists of investing in the domestic and industrial wastewater treatment facilities (eg. Upgrading, expansion of networks, creation of waste water treatment plants) and to value the treated water for specific irrigated crops. Example: Create mini-stations for wastewater treatment, maintenance of existing stations. Cost (15 years): 546 934 TND.
	Random disposal of solid waste and the non-compliance of emissions by operators pose a risk to water quality in the wadis. The lack of solid waste management systems, especially in rural towns, contributes to this deterioration.	***WMO-10. Water discharge control*** The action aims to strengthen controls in connection with the regulation and support the development of effective solid waste management systems. It also aims to encourage the recovery of waste from food processing, particularly olive presses, as fertilizers (spreading). Example: Creation of controlled new landfill sites, setting up of solid waste management systems in rural towns. Cost (15 years): 4500 000TND.

Co-benefits with other options

The WMO-05 will have strong co-benefits along with WMO-09 priority options on the issue of "water quality", particularly by encouraging established cooperatives to use treated wastewater for irrigation of certain crops. The WMO-15 will help strengthen the WMO-10 by sensitizing local actors on the importance of controlling discharges.

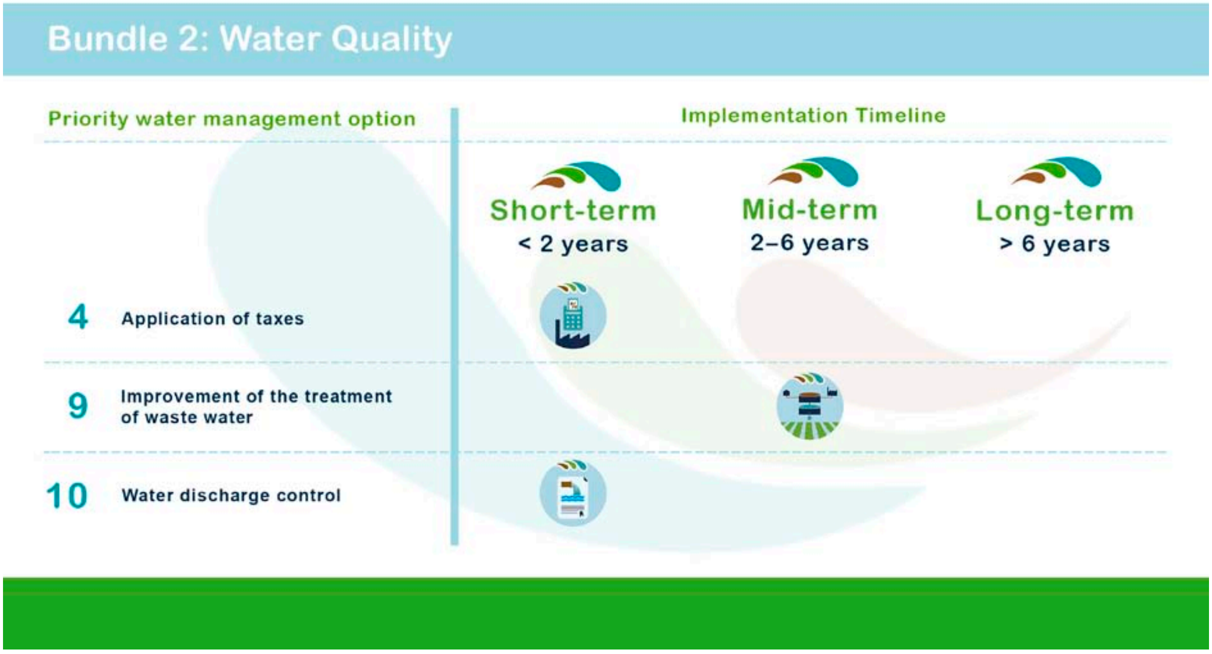
Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-04	WMO-09	WMO-10
WMO-01: Promote new water and soil conservation techniques			
WMO-02. Consolidation of existing water and soil conservation techniques			
WMO-05. Developing agricultural cooperatives			
WMO-08. Use of water irrigation technologies			
WMO-15. Awareness campaign and learning			
WMO-16. Improved decision making			
WMO-19. Developing skills for young people			

Political and participatory implementation of priority options

WMO-04: Application of taxes	
This option is backed by environmental policy on sanitation and waste management. Such a policy recognizes industrial pollution as one of the most important sources of quality degradation of natural resources as well as the health and environmental situation.	This option is based on communication, awareness and environmental education programme considered as basic element of any strategy to promote behaviour change. Such an option can be accompanied by awareness campaigns for the public and the private sectors (in particular industry).
WMO-09. Improvement of the treatment of waste water	
This option is mainly supported by the Water Code which aims to fight against any actions that may cause or increase water degradation by modifying its physical, chemical, biological or bacteriological characteristics, whether it be surface water or groundwater.	Awareness campaigns should be organized for public and private industries in order to enlighten them on the importance of their roles in the protection of natural resources in general and in particular water resources. This option also requires significant involvement of associations to raise awareness among farmers.
WMO-10. Water discharge control	
Waste management is a central component of the National Strategy of Sustainable Development in Tunisia. Similarly, it is reinforced by the Water Code and the Investment Incentives Code.	The option can be supported by awareness campaigns for the public and the private sector to foster responsible behaviour towards the environment. Similarly, a greater involvement of associations can be encouraged (e.g. Through training, technical and financial assistance, etc.). Also, collaboration between associations and local authorities should be supported.

Temporal implementation of priority options

The WMO-04 is to be applied in the short term because strengthening the implementation of taxes on waste water at industrial level can provide significant income and implicitly strengthen the implementation of laws and regulations on wastewater treatment. The WMO-09 demands greater technical capacity and investment, which will require the means and continued preparations in the medium term.



4.4.2.3 Bundle on Agriculture (Challenge C)

This group of options aims to protect water resources through better organization of the agricultural sector, particularly through the implementation of collective solutions, improving the land situation, and promoting conservation farming and an efficient irrigation.

Situational analysis	Context	Priority options
Agriculture is the main industry in the Rmel watershed and strongly impacts water resources. Water demand by the agricultural sector continues to grow from one year to the next and induces increasing pressure on natural resources. The dominant agricultural techniques that tend towards the intensification of agriculture promote uncontrolled water consumption and accelerate the phenomenon of water erosion and impoverished land. The local population which is mostly rural is mainly based on agriculture as a primary source of income. However, the lack of means, knowledge and the complexity of the land situation constitute obstacles to the implementation of sustainable solutions.	The agricultural sector in Rmel watershed remains fragmented and the lack of communication (between farmers and the public authority) adds complexity to the promotion of comprehensive and integrated solutions.	***WMO-05. Developing agricultural cooperatives*** The option is designed to encourage farmers to organize themselves into cooperatives to strengthen collaboration between private and public actors. This option facilitates the implementation of more comprehensive solutions, especially the sector of sustainable agriculture. Example: Creation of agricultural cooperatives, employers Training, Organization of awareness campaigns. Cost (15 years): 170 380 TND.
	The intense agricultural land use and farming practices based on highly water-consuming crops are destroying the quality of soil (Salinization) and promote the water erosion phenomenon.	***WMO-06. Good use of agriculture land*** This option is intended to encourage conservation agriculture and use of suitable crops. This will improve productivity while also reducing irrigation. Example: Promotion of appropriate cultures, awareness campaigns. Cost (15 years): 292 834 TND.
	The farmers commonly face a deficit of financial and technical resources to sustainably improve their farms.	***WMO-07. Developing financial awareness tools*** This option aims to improve land and tax situation of farmers through programmes of counselling and greater involvement of farmers in the grant procedure. Example: Improvement of land, counselling on subsidies. Cost (15 years): 917 555 TND.
	Water efficient and Saving irrigation techniques remain infrequently used in the watershed.	***WMO-08. Use of water irrigation technologies*** This option aims to encourage farmers to reduce their water consumption through the adoption of efficient water irrigation techniques. Example: Adoption of efficient water irrigation techniques. Cost (15 years): 2 210 433 TND.

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-05, WMO-06, WMO-07 and WMO-08 on the issue "Agriculture". Options WMO-01 and WMO-02 will strengthen the impact of the WMO-06 on the protection of soil fertility and natural water storage. The WMO-03 and WMO-09 will strengthen the options WMO-05 and WMO-08 by promoting individual and collective technical solutions. The WMO-11 and WMO-13 options will increase the impact of the WMO-06 on soil protection. The WMO-15 and WMO-16 options will support the impact of the WMO-05 by sensitizing local stakeholders and facilitating their integration into the process of decision making. The WMO-17 and WMO-18 will strengthen the impact of the WMO-07 by encouraging farmers to organize themselves collectively (eg. Channels) and sustainably invest in their farms.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-05	WMO-06	WMO-07	WMO-08
WMO-01. Promote new water and soil conservation techniques	light	dark	light	
WMO-02. Consolidation of existing water and soil conservation techniques	light	dark	light	
WMO-03. Creation and rehabilitation of hydraulic infrastructure	dark	light	light	dark
WMO-09. Improvement of the treatment of waste water	dark			light
WMO-11. Reduction of society pressure on forests		dark	light	
WMO-13. Introduction of new agro forestry species and enrichment of existing forest	light	dark		
WMO-14. Better governance of forest resources			light	
WMO-15. Awareness campaign and learning	dark	light	light	light
WMO-16. Improved decision making	dark	light	light	light
WMO-17. Promote projects that generate more income		light	dark	light
WMO-18. Encourage investments	light	light	dark	light
WMO-19. Developing skills for young people		light	light	light

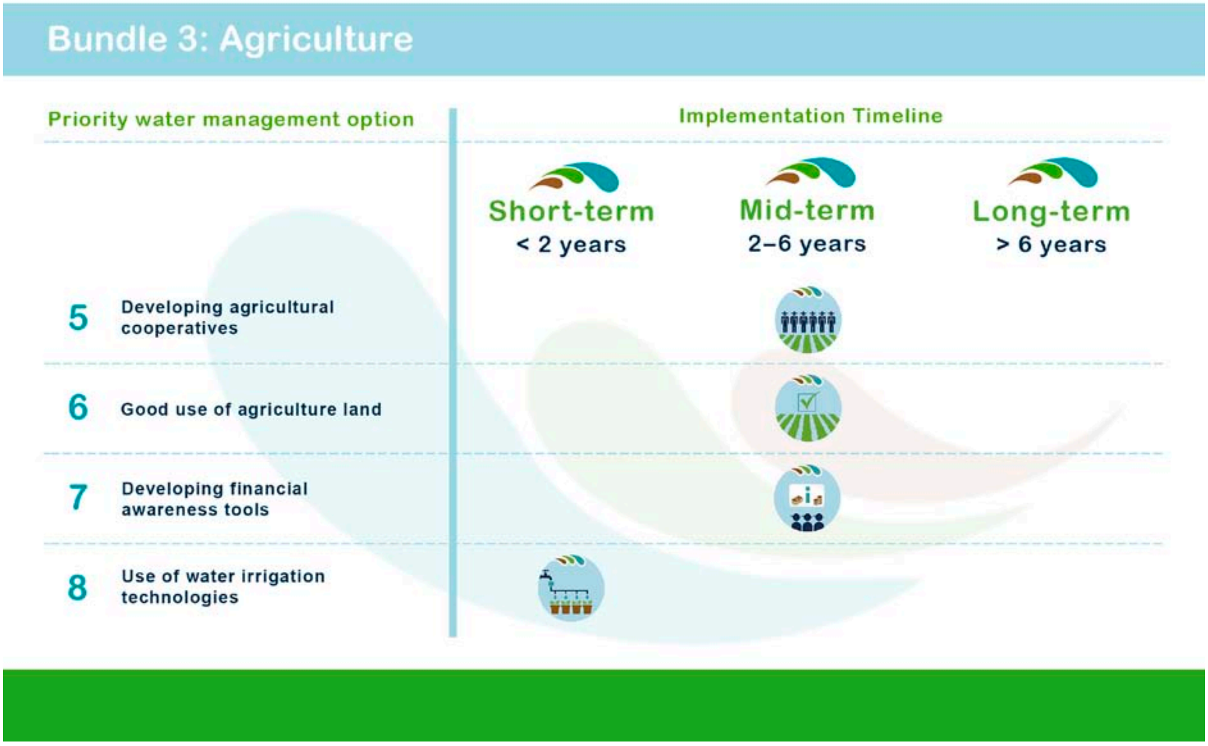
Political and participatory implementation of priority options

WMO-05. Developing agricultural cooperatives	
This option is synergistic with the goals of most state programmes advocating a stronger structuring of the agricultural sector and collaboration between farmers. This can be based on the Law relating to companies of Agricultural Services.	The awareness raising of farmers about the importance of taking part and fit in a cooperative in order to improve profitability and minimize the production cost.
WMO-06. Good use of agriculture land	
This option is backed up by the Water Code. Similarly, the National Development Strategy of the Ministry of Environment focuses on the implementation of innovations and developments in	Sensitizing beneficiaries to the impact of climate change on agricultural production and the involvement of associations in organizing awareness campaigns, training and extension

the field of climate change, among others by considering the agricultural practices.	services.
WMO-07. Developing financial awareness tools	
This is mainly supported by the incentive code of Investments.	The awareness rising of farmers and their organizations within cooperatives.
WMO-08. Use of water irrigation technologies	
This option is synergistic along with several articles of the Water Code. Similarly, the option is in accordance with the investment code.	Raising awareness among farmers and professional organizations to the principle of "saving water" and less water- consuming crops. Similarly, associations must actively contribute to the public awareness of the scarcity of water resources, the necessity for proper management, and preservation and protection of water.

Temporal implementation of priority options

Although it may face financing difficulties, WMO-08 is to be implemented in the short term because it allows a quick water savings. WMO-06 can complete WMO-08 in the medium term by ensuring a smooth transition of farms to more sustainable production methods. Due to their administrative and organizational complexity, WMO-05 and WMO-07 are also options for the medium term.



4.4.2.4 Bundle on Forest and biodiversity management (Challenge D)

The aim of this group of options is to protect the forest resources by improving technical and environmental solutions, as well as those of legislative nature that already exist.

Situational analysis	Context	Priority options
Forests are natural resources that strongly influence the water and soil resources. Forest cover can for example contribute to reducing soil exposure to wind and heavy rain. It reduces runoff and water erosion. The forest is also a strategic resource with economic opportunities in timber exploitation and development of eco-tourism. However, they are increasingly threatened by multiple pressures: forest fires, unsustainable logging or the development of agriculture and pastoralism. Climate change by increasing the temperature during the summer season and increased dry periods contribute to intensifying the risks of their damage.	Forest resources are subjects of multiple societal pressures such as economic development and pastoralism. Hence the importance of strengthening the implementation of management plans and participation of the local population.	***WMO-11. Reduction of society pressure on forests*** This option aspires to reach greater involvement from local population in forest protection and better management of the adjacent pastoral areas. Example: Review of forest management plans, eco-tourism projects, pasture improvements. Cost (15 years): 350 192 TND.
	The increase in temperature in recent decades equally increases the risk of forest fires. Similarly, the human factor in the region plays an important role in the reporting of fires.	***WMO-12. Protection against forest fire*** This option aims to strengthen options to protect and respond to fires as well as putting together awareness campaigns for the local population. Example: Creation and maintenance of forest roads and firewall trenches, equipment maintenance of forests massifs, organization of awareness campaigns. Cost (15 years): 2 600 413 TND.
	The lack of reforestation actions or resumption of operations in areas affected by the fires limit the renewal of forest cover and increases the vulnerability of the forest sector.	***WMO-13. Introduction of new agro forestry species and enrichment of existing forest*** This option aims to increase forest cover and strengthen the forestry sector through the development of agro forestry, enriching existing forests and a forestation of areas devastated by fire. Example: Forest plantations. Cost (15 years): 502 001 TND.
	The implementation of the Forest Code is limited. Local and national actors could benefit from better collaborative framework.	***WMO-14. Better governance of forest resources*** The option consists of a better implementation of existing forest laws, and the settlement of the lease situation of forest communities as well as setting a framework for cooperation between governmental, forestry, agricultural and more generally social actors. Example: Strengthening governance. Cost (15 years): 100 000 TND.

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-11, WMO-12, WMO-13 and WMO-14 on the "forest resources" issue. The WMO-01 and WMO-02 on water conservation techniques and soil contribute to strengthening the impact of the WMO-13 on the protection of plant and forest cover. By encouraging the preservation and better use of agricultural land, the WMO-06 significantly promote (in an indirect way) to reduce the pressure on forests (WMO-11) and recovery (WMO-13). The WMO-15 will be mobilized to strengthen the action of the WMO-12, WMO-13 and WMO-14 on the participation from the local population in the protection, promotion and collective management of forest resources.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	**WMO-11**	**WMO-12**	**WMO-13**	**WMO-14**
WMO-01. Promote new water and soil conservation techniques				
WMO-02. Consolidation of existing water and soil conservation techniques				
WMO-05. Developing agricultural cooperatives				
WMO-06. Good use of agriculture land				
WMO-07. Developing financial awareness tools				
WMO-15. Awareness campaign and learning				
WMO-16. Improved decision making				
WMO-17. Promote projects that generate more income				
WMO-18. Encourage investments				
WMO-19. Developing skills for young people				

Political and participatory implementation of priority Options

WMO-11. Reduction of society pressure on forests

This option can rely on the Forest Code which sets a number of regulations on users that aims to control the impact of society on forest resources.	User awareness and participation in collective associations should be strengthened.

WMO-12. Protection against forest fire

This option is an integral part of both the Forestry Code objectives and articles regulating the activities in the forests and their vicinity to limit the risk of fire.	Raising awareness is an important line of action in order to increase the interest of local people to protect the forest (e.g. Forest as a source of income). Collaborative co-management projects between local residents, landowners and public authorities will also be involved.

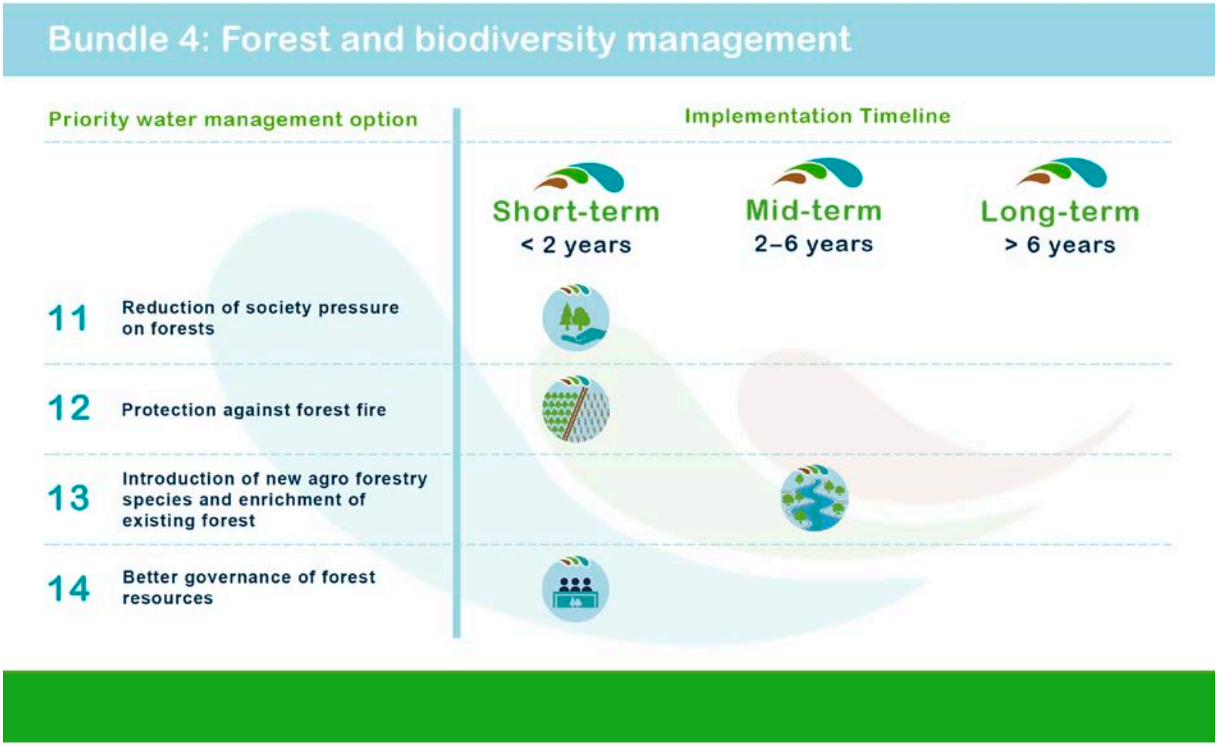
WMO-13. Introduction of new agro forestry species and enrichment of existing forest

This option is consistent with the objectives of the Forestry Code, which aims at ensuring the protection, conservation and rational exploitation of forest resources and also to guarantee users	Strengthening awareness actions and training among the local population. These actions can help overcome the overexploitation problems of

the lawful exercise of their rights.	forest resources.
WMO-14. Better governance of forest resources	
The creation of an institutional and regulatory environment and strengthening favourable capacity for sustainable engagement of stakeholders (users, institutional partners) is a central component of the National Strategy for Development and Sustainable Management of Forests and Ranges.	To give more importance to the existing legislation in the forestry sector through the strengthening of institutional and individual capacities in the sector and achieve coordination between regional and central departments within and between the Ministry, research and civil society.

Temporal implementation of priority options

The WMO-14 as well as the WMO-11 and WMO-12 are a priority in the short term because they do not require new technical skills. The WMO-13 will become far more acceptable along with the awareness raising of the local population on forest issues and water resources.



4.4.2.5 Bundle on Sensitization of civil society (Challenge E)

The objective of this group of options is primarily to ensure the awareness of the population on the challenges of integrated water management in Rmel watershed. It facilitates greater participation of civil society in the management of natural resources as well as their protection.

Situational analysis	Context	Priority options
Although civil society is aware of water management issues in the Rmel watershed, resource protection remains rather secondary in relation to economic development needs. In addition, the management of natural resources is traditionally controlled by government authorities with little involvement of civil society. Collaboration between stakeholders and research remain exceptional.	Sustainable natural resource management is not a priority for local actors, in particular when it comes to increased protection. The economic opportunities offered by the sustainable management of natural resources are not known.	***WMO-15. Awareness campaign and learning*** This option aims to raise awareness among Rmel population on the importance of protecting natural resources and promoting sustainable development of the basin, including encouraging water savings, diversification of activities, sanitation or again the protection of forests. Example: Organisation of awareness campaigns. Cost (15 years): 70 856 TND.
	The participation of civil society in decision making can ensure better ownership of sustainable development policies and sustainable management practices of natural resources.	***WMO-16. Improved decision making*** This option aims to improve decision making through a stronger collaboration among politics, civil society and research, particularly in agricultural cooperatives and forestry associations. Example: Consultation meetings. Cost (15 years): 41 833 TND.

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-15 and WMO-16 on the «sensitization of civil society» issue. The options WMO-03, WMO-05, WMO-08, WMO-10, WMO-11 and WMO-12 all have strong commitments in terms of awareness of local actors. Their application along with the WMO-15, will seek to reinforce better and conducive behaviours to the sustainable development of the basin. WMO-05 and WMO-14 options seek to strengthen collective management for the sustainable management of agricultural and forest areas. Their combination along with the WMO-16 will facilitate the organization of work within cooperatives and strengthening the implementation of public policies.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-15	WMO-16
WMO-01. Promote new water and soil conservation techniques		
WMO-02. Consolidation of existing water and soil conservation techniques		
WMO-03. Creation and rehabilitation of hydraulic infrastructure		
WMO-05. Developing agricultural cooperatives		

WMO-06. Good use of agriculture land		
WMO-07. Developing financial awareness tools		
WMO-08. Use of water irrigation technologies		
WMO-09. Improvement of the treatment of waste water		
WMO-10. Water discharge control		
WMO-11. Reduction of society pressure on forests		
WMO-12. Protection against forest fire		
WMO-13. Introduction of new agro forestry species and enrichment of existing forest		
WMO-14. Better governance of forest resources		
WMO-17. Promote projects that generate more income		
WMO-18. Encourage investments		
WMO-19. Developing skills for young people		

Political and participatory implementation of priority Options

WMO-15. Awareness campaign and learning

The different national strategies (e.g. Water resources, forest resources, conservation of water and soil, etc.) emphasize the importance of awareness of civil society for their implementation.

It will be necessary to progressively and gradually introduce new forms of partnerships to promote civil participation and ensure the sustainability of project actions. Leadership training and operators are becoming a necessity.

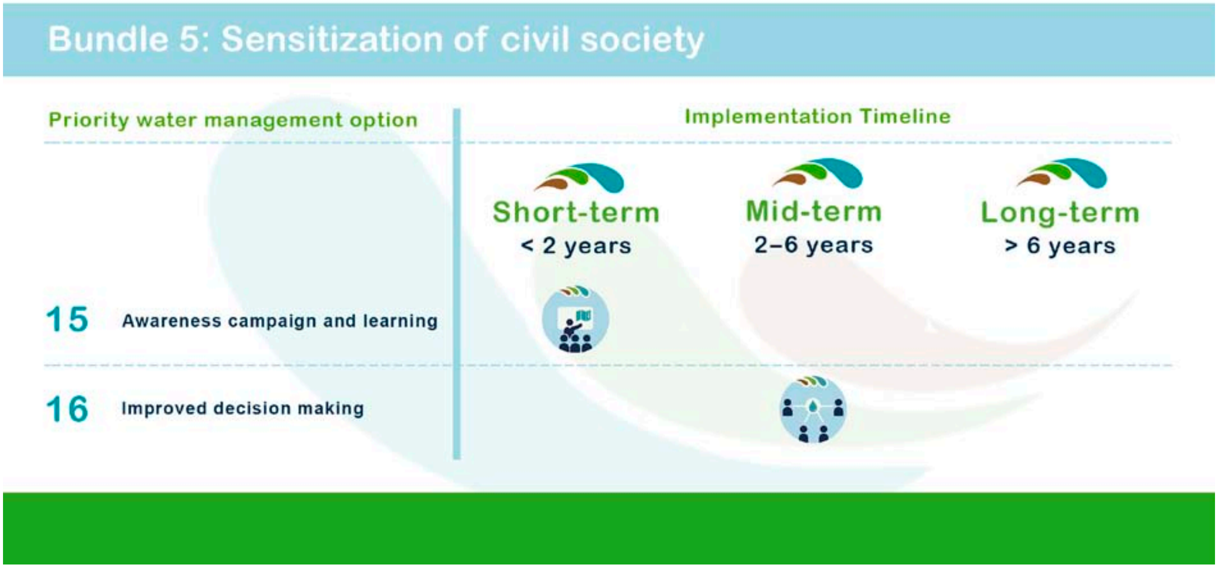
WMO-16. Improved decision making

The different national strategies (e.g. Water resources, forest resources, conservation of water and soil, etc.) emphasize the importance of moving from a hierarchical approach to a participatory approach for more relevant results.

This option requires collaboration between development agents, researchers and civil society. Similarly, awareness campaigns must bring together the different actors (e.g. Public authorities, civil society) to discuss the main points related to the area.

Temporal implementation of priority options

The importance of the human factor on the achievement and success of improvement actions in the basin makes awareness and integration of local actors in the process of decision making a priority. The organization of education campaigns should be considered in the short term but the involvement of stakeholders will be more effective after being sensitized and trained, so this option should succeed option 15 and be applied in the medium term.



4.4.2.6 Bundle on Human and Resources Employment (Challenge F)

This group of options aims to improve the standard of living of the population of the Rmel basin by means of project promotion, investment and youth training programmes showcasing sustainable development and protection of natural resources.

Situational analysis	**Context**	**Priority Options**
The Rmel basin's natural resources suffer from pressures exerted by economic activities. However, their protection will increase by improving economic and social conditions of the local population. The Rmel faces significant challenges due to the lack of economic opportunities and particularly with a high unemployment rate among the youth. The development and improvement of living standards of the local people of the area requires a better use of existing human resources and encouragement of the state as well.	The Rmel basin is facing a lack of opportunity for the implementation of projects that enhance living standards while also reducing the impact on water resources and preserving soil quality.	***WMO-17. Promote projects that generate more income*** This option aims to encourage investment in projects that diversify the rural economy: eco-tourism, organic agriculture and handicrafts for women. Example: Agricultural Micro projects, micro craft projects for rural women. Cost (15 years): 1 338 670 TND.
	The Rmel basin is facing a lack of access to liquidity for the implementation of projects that enhance living standards while complying with the natural environment.	***WMO-18. Encourage investments*** This option is designed to facilitate investment in agriculture, industry and tourism through the provision of loans and grants for small farmers and the youth. Example: Facilitation of obtaining short-term loans, facilitating obtaining grants (advice and assistance). Cost (15 years): 1 004 002 TND.
	The youth of Rmel basin face a lack of information on the various steps of projects creation as well as modern techniques that could be used in a context of development of sustainable agriculture.	***WMO-19. Developing skills for young people*** This option aims to improve the professional skills of young people of the basin, to facilitate their integration into working life and to create a generation of skilled technicians in the use of sustainable and innovative techniques. Example: Organization and training in sustainable agriculture and handicraft courses programmes, staff training for the regional commission of Zaghouan. Cost (15 years): 131 357 TND.

Co-benefits with other options

Several options will have strong co-benefits with the priority options WMO-17, WMO-18 and WMO-19 on the issue of “Human resources and employment". Just like WMO-17, WMO-01 and WMO-02 options are designed to promote agricultural projects that protect water resources and soil fertility. The WMO-07 is designed to encourage farmers to adopt the projects receiving state aid. This latter will increase family income as sought by the WMO-17 and boost a more general agricultural investments drawn by the WMO-18. The WMO-15 will

strengthen WMO-17 options by encouraging farmers to invest in sustainable development projects and the WMO-19 by supporting the motivation of young people to participate in training sessions to improve their skills.

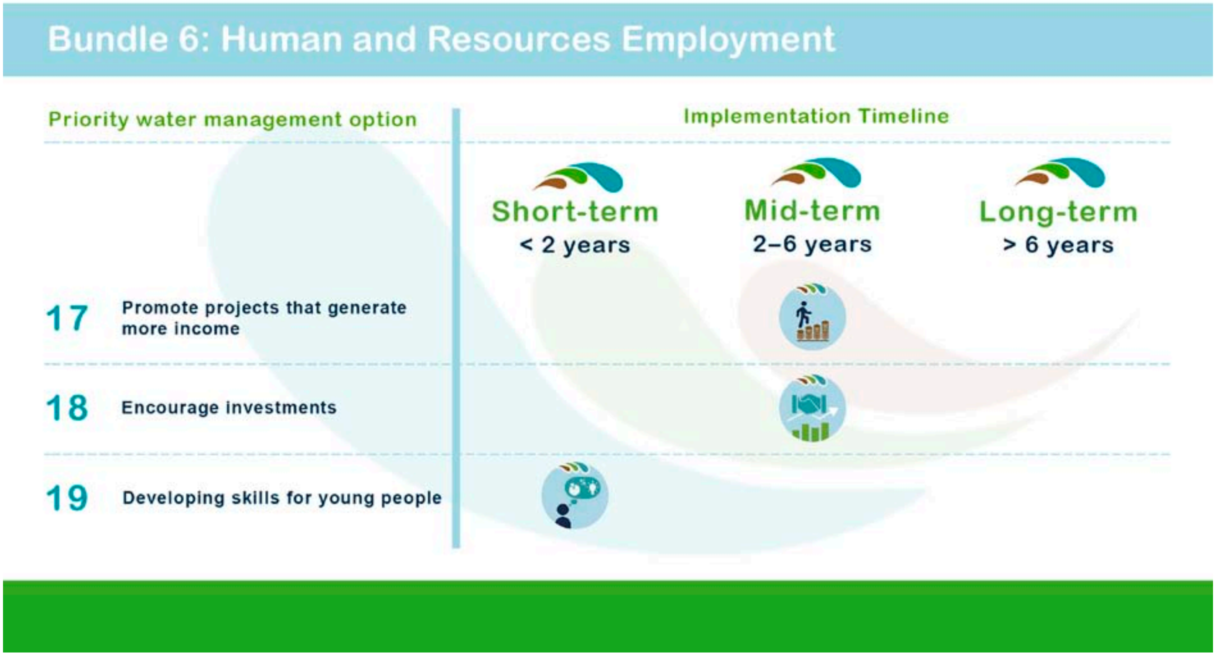
Related Options [Synergy: strong (dark); medium (light); low to zero (white)]	**WMO-17**	**WMO-18**	**WMO-19**
WMO-01. Promote new water and soil conservation techniques			
WMO-02. Consolidation of existing water and soil conservation techniques			
WMO-03. Creation and rehabilitation of hydraulic infrastructure			
WMO-05. Developing agricultural cooperatives			
WMO-06. Good use of agriculture land			
WMO-07. Developing financial awareness tools			
WMO-08. Use of water irrigation technologies			
WMO-09. Improvement of the treatment of waste water			
WMO-10. Water discharge control			
WMO-11. Reduction of society pressure on forests			
WMO-13. Introduction of new agro forestry species and enrichment of existing forest			
WMO-14. Better governance of forest resources			
WMO-15. Awareness campaign and learning			
WMO-16. Improved decision making			

Political and participatory implementation of priority Options

WMO-17. Promote projects that generate more income	
The option is consistent with the Investment Incentive Code, which encourages local operators to use natural resources as a source to increase their income and improve their economic and social life.	The common awareness of civil society by identifying the options and specific development actions on their roles in the use of natural resources and their responsibility in the protection and conservation of these resources. It also requires the integration of civil associations in sensitization.
WMO-18. Encourage investments	
The Code of Investment Incentive promotes investments in the sectors of agriculture, industry, tourism, crafts and the area of services. The National Development Strategy is also favourable to the option.	Awareness raising and involvement of beneficiaries in all actions carried out. Some non-governmental organizations can act as an intermediary to facilitate obtaining loans and grants.
WMO-19. Developing skills for young people	
The National Development Strategy is promoting training of the youth and job seekers in light of a local economic development.	This option will require the involvement of civil society and NGOs. It will be important to ensure the awareness and involvements of beneficiaries in all actions carried out, and address appropriate trainers and training centers.

Temporal implementation of priority options

The WMO-19 is to be implemented in the short term to rapidly ensure better participation and better prospective employment among young people. The WMO-17 and WMO-18 options will take longer because of public funds and private investment should be mobilized.



4.4.3 Monitoring

Adaptive management assigns a strategic and central role to monitoring processes. An adaptive management approach means that plans are adjusted to future conditions as they unfold, taking account of uncertainty over future developments, and constantly updating the adaptation plan with new information from monitoring, evaluation and learning[1]. Therefore, this section aims to outline the main elements that should be taken into account when monitoring the outcomes and impact of the proposed adaptation options.

Monitoring the environmental outcomes of implementing a particular water management option in a specific place and time is fraught with difficulties, as it is normally impossible to isolate the water system from the numerous external drivers and pressures affecting it alongside the implemented option. For instance, it is usually very hard to measure directly in the river flow the impact of an option generating water savings, as the natural water availability in a system will depend on manifold factors such as recent meteorology, land use and its changes in the basin, behaviour of other users, behaviour in other regions (e.g. upstream), and so on. The same applies to measures addressing other goals, such as water quality. In view of the extreme complexity and the multiple causal chains impinging on single parameters, environmental programmes usually resort to monitoring the (degree of) implementation of a measure. In effect, they rely on scientific consensus about whether a measure delivers the desired effect on a certain parameter and about the expected range of this effect

<u>Indicators for monitoring implementation</u>

Indicators for monitoring can assume various forms, each of which contributes to building a comprehensive overview of the measure's or bundles' implementation. Types of indicators include those of a financial nature which typically measuring input (e.g. the costs that were invested in the implementation of the measure), or those which assess project outputs as relates to the activities associated with the given water management option, i.e. what the options achieved.

<u>Technical and financial monitoring</u>: This monitoring primarily consists of the collection and compilation of information about the physical achievements and financial execution. This collection of information will be carried out by a management unit and through a Territorial Sector Unit (TSU) and in collaboration with stakeholders. The tool used for this step is a dashboard with indicators of the progress of the project and which are connected to the implementation of water management options. The indicators are factors that reflect changes that have occurred in the watershed Rmel and which can be either qualitative or quantitative. All indicators should be of type SMART (Specific, Measurable, Achievable, Relevant, Time bound)

[1] European Environmental Agency, 2013. Adaptation in Europe: Addressing risks and opportunities from climate change in the context of socio-economic developments. EEA Report No 3/2013

Text Box 6 : SMART indicators [19]

Select indicators can be complex and time-consuming.
SMART is a popular acronym for selecting indicators:
- **Specific**: Is the indicator specific enough to measure progress to-wards the results?
-**Measurable**: Is the indicator a reliable and clear measure of results?
-**Achievable**: The target value of the indicator is achievable within the defined timeframe.
-**Relevant**: Is the indicator relevant to the intended outputs and out-comes?
-**Time bound**: An expected date of accomplishment needs to be set.

Such technical and financial monitoring will help obtain the following information with a well-defined frequency for each already executed option or an option that is being executed:

- Physical objective
- Level of realization
- Expected costs (budget monitoring)
- Actual costs
- Discrepancies and explanations for any discrepancies.

Table 2: Sample dashboard for monitoring the implementation of WMOs

UST/bundle/ challenge	**Example : WMO**	**Unit**	**Reference stiuation**	**Forecasts**	**Execution**	**Execution rate (%)**	**Anticipated costs**	**Actual costs**
Water Quantity	Promote new water and soil conservation techniques	Ha						
Human Resources & employment	Awareness campaign and learning	Day / training compaign						

This information will be used for the drafting of progress reports of the adaptation project of Rmel watershed to climate change.

➢ **Impact evaluation**: the evaluation of impacts of the adaptation plan will be done through periodic surveys. This evaluation can be done through Territorial Sector Unit (TSU) of the Project that will represent the sample on which the impacts will be measured. The evaluation will therefore focus on a specific number of indicators mainly of type:

- **Economic**: Income, investment promotion
- **Social**: Job creation, improving access to infrastructure, the workforce qualification, etc.
- **Environmental**: Improving the quality of water, reduction of land degradation

The criteria and indicators must emanate out of the cognitive FCM map initially developed.

The assessment methodology consists of measuring the indicators defined in the reference situation (situation without the project), on the midterm situation as well as the completion of the project on the same TSU specified (same sample) which will allow to monitor and assess the implementation rate and to undertake corrective measures for steering and learning.

The evaluation of impacts will be carried out at all stages in a participatory manner with the stakeholders, who will be involved in the whole evaluation process. The results of the evaluation shall be restituted to the stakeholders themselves and discussed with them. The implementation of this evaluation will be conducted by the project team, in addition to workshops of two to three days with all partners in order to validate the assessment and to reprogram activities.

When developing the water management options for this plan, a review of and comparison with existing management plans focussing on the river basin was undertaken (see Part 2). These existing plans, established during the two specific strategies called CES I & CES 2 and conducted by the *Farmland Conservation and Management Department* have a kind of monitoring and evaluation network in which the monitoring and evaluation of the presented water management options can be integrated. Such potential monitoring synergies exist, for example, with regards to Option 1 (Promote a new water and soil conservation techniques) and Option 2 (consolidation of existing water and soil conservation techniques).

However, some water management options are unique to this river basin adaptation plan and therefore do not have specific links to existing monitoring strategies. For some of these options, opportunities exist to implement them within the frame of an ongoing project, such as PDRIGRN: “Projets de développement Régional Intégrée pour la Gestion des Ressources Naturelles in Tunisia” Within this river basin adaptation plan, monitoring for the following options could be funded via the state’s own resources or an external budget (EU contribution, ABD, AFD, etc.)[19] [20]

4.5 BeWater recommendations for Rmel River Basin

4.5.1 From planning to action: Recommendations for implementation

The Rmel River Basin Adaptation Plan is based on the participatory approach which was followed to develop a set of targeted water management options and, subsequently, bundles of these options. The outlined (bundles of) options serve to address the main challenges that were identified by the basin’s stakeholders. This chapter provides guidance and recommendations for decision-makers, individuals and entities that are in a position to implement bundles of synergistic water management options or individual options. The information provided throughout the plan is thus intended to serve as a tool to help to guide policy and decision makers in selecting appropriate options or sets of options to implement within the basin to address the basin’s specific needs.

Based on the results of group discussions during the various workshops, the main recommendations are:

- To conduct scientific studies on the estimated impacts of climate change on the availability of water resources and hydrological extremes (drought, floods);
- The legal framework needs to be updated. Therefore there is a need for a major review of existing codes (e.g., forestry code, water code, water and soil conservation code and the investment incentives code);
- Research needs to adopt transdisciplinary methods to work together with society in the development of solutions and innovations for sustainable agriculture and sustainable water use. Society including farmers, local economy, and communities need to strengthen the market of sustainable agriculture.
- To reinforce the capacity of local and national actors to better manage collectively water and forestry resources (Bundles 1 and 2)
- To increase and improve investment by solving the problems of the Land rights and property rights.(Bundle 5)
- To involve farmers in decision making: farmers' preferences on the management of resources, overall planning and development of a legal framework are crucial from now. (Bundle 6)
- Policy needs to provide the adequate legal framework to enable education institutions, research, farmers, and community to make use of their capabilities in becoming agents for change toward sustainable water management. Efforts should be made to raise environmental awareness and behavior among all citizens, including the sustainable use of water. (Bundle 6)
- Financial support as well as awareness development can be used to enlighten and educate landowners and land users, and hence let them become more directly involved. Such a commitment can lead to the conception and spreading of interventions that could be understood and streamlined by the local population. (Bundles 5 and 6)

Implementation of all options within a given bundle

The bundles presented in Chapter 4 are sets of options, which have been grouped together on the basis of their foreseen abilities to collectively address the identified challenges within the Rmel river basin and react to additional local needs (e.g. increasing sustainable tourism in the area). Implementation of an entire bundle ensures a high occurrence of synergies between the options and the pursuit of one or more common objectives. Two water management options that are strongly aligned may decrease the implementation or maintenance costs if they are implemented together. Other combinations may lead to an increased impact with regards to an addressing an existing threat.

In the bundle factsheets in Chapter 4, a wealth of information is provided on the interaction of the water management options to support decision-making processes. This includes, for example, indications of the objectives which may be reached by choosing to implement a given bundle, the costs involved, the ideal phasing of the options in time, etc. If an entire bundle is to be implemented, the 'adaptation pathway' provides further information about which options are critical to implement before other water management options in the bundle. For example, implementing Bundle 1 would focus on achieving quantitative management of water resources. Should conservation of water and soil while improving and developing water supply infrastructure be prioritized as a key objective and limited financing be a main consideration, water quantity would be a more appropriate bundle.

Implementation of individual water management options

The existence of very specific objectives, resource or capacity limitations or other considerations may make the implementation of an entire bundle unfeasible. In this case, deciding instead for the implementation of one or more individual options will not necessarily have a negative impact on the performance of these options. While all of the water management options presented are suitable for implementation in the river basin, the decision to implement individual options on their own requires a check that the option is not dependent on any other water management option. Information on the relationship between the options is outlined in the bundle factsheets in chapter 4.2 and should be consulted in order to reach such conclusions.

Here, a particular focus should be given to prioritized water management options, which have been identified based on the wishes and needs of the stakeholders engaged in the process and taking into account implementation-oriented factors such as the multi-criteria analysis, performance with regards to the challenges, feasibility, acceptability and policy synergies. As such, these options are strongly aligned with community interests and are foreseen to offer large potential in addressing the targeted challenges identified within the basin (see Table 4.1). In order to assess the best implementation timing, the adaptation pathways as presented in Chapter 4.2 should be consulted. Following these criteria, the following water management options are recommended within the river basin:

- WMO5: Application of taxes will provide the protection and improvement of water quality (Challenge B) in the Rmel watershed via a stricter implementation of laws, penalties and regulations. This
- WMO13: Introduction of new agro forestry species and enrichment of existing forest related to challenge D (bundle 4) is consistent with the objectives of the Forestry

Code, which aims at ensuring the protection, conservation and rational exploitation of forest resources and also to guarantee users the lawful exercise of their rights.

- WMO 15 (Awareness campaign and learning) and WMO 16 (Improved decision making) related to Sensitization of civil society**:** Challenge E (Bundle 5) have a high priority and may facilitate the implementation of all other water management options identified.
- WMO19: Developing skills for young people related to Human and Resources Employment (Challenge F) has a high priority according to stakeholders. This option will facilitate the integration of young people into working life and to create a generation of skilled technicians in the use of sustainable and innovative techniques. So this option will allow the better implementation of other options such as encouraging investments (WMO18), reducing pressure on forest (WMO 11)...etc.

In order to assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial. Therefore, the suggestions made in Chapter 4.3 regarding the alignment of existing monitoring plans with the needs of the water management options specified in this plan should be considered. This includes finding synergies with existing monitoring schemes regarding the identification of suitable indicators for measuring the output.

4.5.2 Next steps

The synthesis of experiences on development projects in Tunisia and the conducted interviews with experts on their visions for the implementation of the Rmel river basin adaptation plan has led to the proposal of the following approach. (Figure 10)

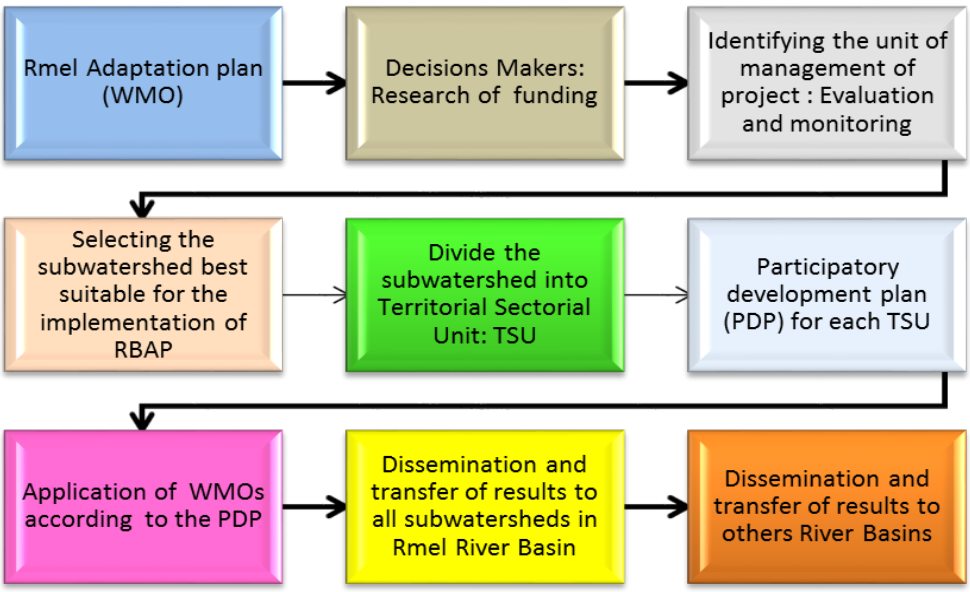


Figure 10: Suggestion of next steps of implementation of Rmel River Basin Adaptation plan

The flowchart in Figure 10 presents a proposed sequence of steps to follow the development of the river basin adaptation plan. These detailed steps are as follows:

1. Presentation of the adaptation plan to the authorities as a project file to grant the necessary funding and budgeting of the project.
2. Identification of a project management unit: represented by experts in the field of agriculture, water and soil conservation techniques, forests, soil...
3. Specify a pilot area whose characteristics meet the main challenges identified for Rmel river basin and encompasses (in which we can apply) the majority of water management options defined by the BeWater project.
4. Divide the pilot sub-basin into units by territorial sector by prioritization for example: Bundle 4: Forest Resources in the area of Jebel Zaghaouan, Bundle 2: Water Quality in the delegation of Zriba since there is a wastewater treatment station, and Bundle 3: Agriculture in the delegation of Bouachir where most irrigated areas are located.
5. Develop a participatory development plan that shows the actions for each territorial sector indicating the objectives, monitoring indicators (budget, time, goal) taking into account the opinion of the population.
6. Application of water management options in the selected pilot sub basin to ensure the evaluation of results achieved compared to targets.
7. Dissemination of the used model for the pilot area to other areas of the Rmel river basin.
8. Apply the approach of the BeWater project to other river basins in Tunisia

PART 2

4.6 Water management options

WMO 1: Promote new water and soil conservation techniques

Description	The first option aims to promote new water and soil conservation techniques to harvest runoff water. These techniques are placed on agricultural landscape (upstream) and are based on traditional, technological and engineering solutions (waterway development techniques and watershed development techniques). Moreover, from now on, this option should consider the participatory approaches.
Addressed challenges	This measure will directly participate in the quantitative water management of the basin and in the reduction of the risk related to droughts and flooding. Indirectly, the measure will contribute in improving the water quality and promote a sustainable agriculture.
Target locations and water uses	In order to choose priority sub-basins for the development of water and soil conservation, a prioritization study is carried out based on multi-criteria analysis and taking into account the sensitivity criteria for soil erosion, water resources saving measures, existing development, and agricultural and socio-economic enhancement. The selected sub-basins are those that obtained the highest weight. Within the framework of the project funded by the African Development Bank, the selected sub basins are as follows; Wadi sbayhia, Wadi Jouf and Wadi Ain batteria.
Benefits	This measure offers several benefits including: maximizing the use of runoff water on agricultural parcels; Maintaining the fertility and productivity of agricultural land; the reduction of solid transportation at the level of Rmel dam; approximation of water points to operators; Job creation as well as associated investments.
Potential negative impacts	This measure involves several risks, including: reduction of agricultural land; constraint on direct grazing of animals during the execution of works (ref).
Timeline of implementation	This option will be applied in the medium term.
Feasibility	For several years, the water and soil conservation measures have been a political object. There is therefore a good technical understanding to facilitate their implementation, which calls for a reinforcement of awareness-raising and training for operators. These actions can help overcome the problems due to lack of transparency on land tenure and the absence of up-to-date registry of properties.
Robustness	The conservation techniques of water and soil will contribute to reducing the risk of desertification regardless of the impacts of future global change (e.g. climate.). However, it is possible that an increase in the availability of water in the short term (in particular via the hill lakes) increases the dependence of economic activities to water and their vulnerability to drought.
Flexibility	Most preservation techniques of water and soil require little initial investment, and are easy to edit (e.g. plowing, grass strips). Some measures, however, like the tracks of technical development, may request a larger investment and result in an infrastructure that is difficult to change in the future (e.g. Threshold, lakes).

Costs	Taking account of the costs over a period of 15 years, the cost required for this measure is which 3 billion TD.
Synergies and conflicts with policy objectives	Currently, this option is mainly supported by Conservation Code of Water and Soil which prohibits the use of any tool or technique that can lead to the destruction of soil structure in areas threatened by water or wind erosion. The Code also prohibits any action that may damage the conservation of water and soil works declared for public utilities or executed in accordance with the provisions of the Water Code and existing on their lands. The code finances and compensates owners who carry out conservation work in order to ensure the sustainability of productivity the agricultural land. The option is also synergistic with the goals of the Water and Soil Conservation Strategy, of which one of the objectives is the conservation and rational use of natural resources. The investment code gives rise to specific bonuses for achieving conservation work of water and soil. The option is also reinforced by the 11th Plan for Agricultural Development Policy (2007-2011) as a minimum condition that requires the application of Water and Soil Conservation Code. However, the option is confronted with a national policy of production-oriented agriculture, which can lead to intensive agricultural practices. It also lacks appropriate funding mechanisms to a broader natural resources management.
Acceptance	The key stakeholders of this option are farmers, civil society (non-institutional actors) and the Ministry of Agriculture (public authorities). This option is generally little intrusive and will have direct beneficial impacts on the operator (e.g. Farmer). It promotes an environmental protection which will be perceived positively by environmental groups. In addition, it is actively supported by the Ministry of Agriculture through legislation and regulations in place. However, there exists certain barriers; Some benefits of this option are poorly quantifiable and difficult to be perceived (e.g. Fertility improvement) while there will be a loss of productive land. At the same time, this measure is voluntarily applied upon the operators' request (who will receive financial compensation). Currently, there is a lack of interest and participation from the farmers' part. The establishment of associations to counter the fragmentation of the problem is also confronted with long administrative procedures.
Suggested stakeholder involvement	It will be necessary to increase the awareness and involvement of farmers and local communities in the design and implementation of all proposed actions. The option can depend in part on the National Strategy for Conservation of Water and Soil that focuses on the popularization and awareness of erosion problems and appropriate responses.
Preconditions for success	Raising the awareness of operators - Financial compensation for loss of agricultural land - Involvement of operators in all the programs and projects carried out in their lands - A collaborative approach among owners to counter land fragmentation problems)
Examples	Current water and soil conservation projects undertaken within the Rmel river basin/ each year the CRDA programs 300 ha of manual work of CES in the regions of Oued Rmel, Zriba, Oued Jouf, Oued zit

WMO 2: Consolidation of existing water and soil conservation techniques

Description	The second option aims to improve the function of existing soil and water conservation techniques based on ecological solutions. It is based on the strengthening of these techniques by plantations. The implication of Rural Development firms (e.g., SMVDA) and the setting for incentive context become crucial.
Addressed challenges	This measure will directly participate in the quantitative water management of the basin and in the reduction of the risk related to droughts and flooding. Indirectly, the measure will contribute in improving the water quality and promote a sustainable agriculture.
Target locations and water uses	In order to choose priority sub-basins for the development of water and soil conservation, a prioritization study is carried out based on multi-criteria analysis and taking into account the sensitivity criteria for soil erosion, water resources saving measures, existing development, agricultural promotion and socio-economic enhancement. The selected sub-basins are those that obtained the highest weight. Within the framework of the project funded by the African Development Bank, the selected sub basins are as follows; Wadi sbayhia, Wadi Jouf and Wadi Ain batteria.
Benefits	This measure offers several benefits including: maximizing the use of runoff water on agricultural parcels; Maintaining the fertility and productivity of agricultural land; the reduction of solid transportation at the level of Rmel dam; approximation of water points to operators; Job creation as well as associated investments.
Potential negative impacts	This measure involves several risks, including: reduction of agricultural land; constraint on direct grazing of animals during the execution of works (ref).
Timeline of implementation	The consolidation of technical conservation of existing water and soil are to be applied in the short term.
Feasibility	For several years, the water and soil conservation measures have been a political object. There is therefore a good technical understanding to facilitate their implementation, which calls for a reinforcement of awareness-raising and training for operators. These actions can help overcome the problems due to lack of transparency on land tenure and the absence of up-to-date registry of properties.
Robustness	The conservation techniques of water and soil will contribute to reducing the risk of desertification regardless of the impacts of future global change (e.g. climate.). However, it is possible that an increase in the availability of water in the short term (in particular via the hill lakes) increases the dependence of economic activities to water and their vulnerability to drought.
Flexibility	Most preservation techniques of water and soil require little initial investment, and are easy to edit (e.g. plowing, grass strips). Some measures, however, like the tracks of technical development, may request a larger investment and result in an infrastructure that is difficult to change in the future (e.g. Threshold, lakes).
Costs	Taking account of the costs over a period of 15 years, the fees required to consolidate the existing water and soil conservation devices are about 2 billion TD.

Synergies and conflicts with policy objectives	Currently, this option is mainly supported by Conservation Code of Water and Soil which prohibits the use of any tool or technique that can lead to the destruction of soil structure in areas threatened by water or wind erosion. The Code also prohibits any action that may damage the conservation of water and soil works declared for public utilities or executed in accordance with the provisions of the Water Code and existing on their lands. The code, finances and compensates owners who carry out conservation work in order to ensure the sustainability of productivity of agricultural land. The option is also synergistic with the goals of the Water and Soil Conservation Strategy, of which one of the objectives is the conservation and rational use of natural resources. The investment code gives rise to specific bonuses for achieving conservation work of water and soil. The option is also reinforced by the 11th Plan for Agricultural Development Policy (2007-2011) as a minimum condition that requires the application of Water and Soil Conservation Code. However, the option is confronted with a national policy of production-oriented agriculture, which can lead to intensive agricultural practices. It also lacks appropriate funding mechanisms to a broader natural resources management.
Acceptance	The key stakeholders of this option are farmers, civil society (non-institutional actors) and the Ministry of Agriculture (public authorities). This option is generally little intrusive and will have direct beneficial impacts on the operator (e.g. Farmer). It promotes an environmental protection which will be perceived positively by environmental groups. In addition, it is actively supported by the Ministry of Agriculture through legislation and regulations in place. However, there exists certain barriers; Some benefits of this option are poorly quantifiable and difficult to be perceived (e.g. Fertility improvement) while there will be a loss of productive land. At the same time, this measure is voluntarily applied upon the operators' request (who will receive financial compensation). Currently, there is a lack of interest and participation from the farmers' part. The establishment of associations to counter the fragmentation of the problem is also confronted with long administrative procedures.
Suggested stakeholder involvement	It will be necessary to increase the awareness and involvement of farmers and local communities in the design and implementation of all proposed actions. The option can depend in part on the National Strategy for Conservation of Water and Soil that focuses on the popularization and awareness of erosion problems and appropriate responses.
Preconditions for success	Raising the awareness of operators - Financial compensation for loss of agricultural land - Involvement of operators in all the programs and projects carried out in their lands - A collaborative approach among owners to counter land fragmentation problems)
Examples	As an example, the mechanical benches at Ain El Battriya which are consolidated with Acacia by the ROAD in 1990

WMO 3: Creation and rehabilitation of hydraulic infrastructure

Description	Hydraulic structures will be improved to meet the demands of the population (rehabilitation and upgrading of existing networks, construction cisterns and lifting stations, etc.) while maintaining the balance between demand and distribution.
Addressed challenges	This will allow the quantitative management of water by reducing losses and water leaks in distribution pipes and adduction whether for agriculture and drinking water.
Target locations and water uses	All areas of the basin are affected by this option. The management of AEP systems (drinking water supply) in rural areas is found satisfactory for 20% of GDAP (agricultural development group for drinking water), average for 55% of GDAP and low for the rest of GDAP, which is still suffering some management shortcomings. Despite the specific technical assistance and training programs that have been implemented by the Administration in favor of GDAP to improve their knowledge in the field of management, several problems still persist and hinder the development of certain GDAP. As an illustration, we refer to the low level of education among Board members who are volunteers, project complexity with successive extensions and development of Individual connections; the proliferation of illicit individual connections; free interventions support of the Authority; the virtual absence of preventive maintenance of infrastructure and equipment; the low cover rates of operating and maintenance costs; response times during breaks and breakdowns is slow; and the limited involvement of women in the management of water supply systems (AEP).
Benefits	Rehabilitation and modernization of existing drinking water and irrigation systems, construction of cisterns to increase the number of hours of access to water, creation of artificial recharge wells of groundwater, creating shallow wells in areas with surplus water balance and improved pumping conditions, creating discharge stations to cover water demand of rural populations, electrification of existing water points established in areas covered by the groundwater of wadi Rmel.
Potential negative impacts	The creation and rehabilitation of existing water infrastructure require significant funding. This option requires human and technical capacities.
Timeline of implementation	The application of this option should be in the short term.
Feasibility	The high dispersion of population and access constraints to mountain sites limit the execution of projects at reasonable costs. The supply of household water is made through cans or tanks towed over distances that don't exceed 3 km. But given the evolution of living standards in rural areas, people are starting to look for more comfort and the service mode by individual connection that characterizes the SONEDE (The Tunisian drinkable Water supply Authority) began to gain ground especially in rural areas previously served collectively and its implementation is done in the framework of a coherent approach integrating all technical, institutional, economic and financial aspects. Starting from 2007, all new and rehabilitation projects are designed on the basis of individual service.
Robustness	The savings in water, the reduction in demand and rationalization of the drinking water distribution will help to address the impacts of future change whatever their future development.

Flexibility	This option requires significant funding and significant human and technical capacities, as well as large investments. Thus, this option is considered very flexible.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 1 110 253 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	Water is a national asset that must be developed, protected and used in a manner that ensures the sustainability of satisfying all the needs of citizens as well as the economic sectors. The water economy is considered one of the most important means for development, reservation and rational use of water resources. The work aiming at the development, the economy, improving the quality and the protection of national water resources are of public utility. The management of rural drinking water supply systems is ensured either by the National Company of Exploitation and Distribution of Water (SONEDE) through its own network or by user associations called Agricultural Development Group (GDAP) through AEPR systems made by the Office of Rural Engineering. Nationally, the number of GDAP groups approximates 1400 at the end of 2009. These groupings, amongst other things, take charge of the management of AEPR systems (water sales, servicing and maintenance of systems, etc.). They benefit from the continued support of the State which has set up a national strategy to promote associations since 1992 in order to develop their capacities in the technical, financial and organizational domains.
Acceptance	The Ministry of Agriculture is working notably with its decentralized services in rural engineering Districts in the ROAD (24 Districts, one for each regional department). In particular the DGGREE deals with defining strategic directions in the field of AEPR, project planning and technical assistance to the Rural Engineering Districts to improve the quality of studies and work as well as training, mentoring and support for GDAPs. The studies, direct monitoring of works, supervision, training and development of GDAPs are provided by the Agricultural Engineering District services in each ROAD as follows: 1- The service of AEPR studies whose role is the realization and supervision of out sourced studies to private consulting firms, and which incorporate the participation of beneficiaries in all phases of the study. 2- The AEPR (Rural drinking water supply) works department is responsible for supervising the work done by private companies. 3- The control of works is assured by previously trained technicians in the field. But, given the very limited human and material resources at the level of the ROAD, some of them have begun to outsource this task to private consulting firms.4- The supervision services, training and improvement of GDAP takes charge of monitoring and technical assistance of GDAP in technical, financial and social fields, and that, as part of a promotion strategy of GDAP implemented nationwide since 1992. The SONEDE intervenes in urban and rural areas regrouped and bordering its distribution network using the same approach applied in cities. Through its regional districts and its own means, the SONEDE means assures the realization of studies, monitoring of work entrusted to private companies as well as supervision, training and improvement. The Agricultural Development Groups (GDA) is created at the request of the majority of owners, farmers and fishermen concerned. Their creation is done by order of the governor of the region. Each GDAP has a Board of Directors consisting of 3 or 6 members, including a president elected by the beneficiaries for a period of 3 years. Under Decree 2004-24, their responsibilities have expanded to include other activities related to the protection of natural resources and rationalizing their use, development of rural areas, coaching and training.
Suggested stakeholder involvement	Organizing training sessions and coaching for farmers

Preconditions for success	- Organize training sessions and coaching for local people and farmers. -Organization Of meetings bringing together leaders in the field to discuss the importance of the implementation of this option.
Examples	-

WMO 4: Application of taxes

Description	The option proposes to strengthen the application of taxes on discharges of wastewater caused by factories. This taxation preserves the quality of water for agriculture and drinking water.
Addressed challenges	This option will contribute to the protection of the quality of ground and surface water.
Target locations and water uses	The industrial Zone of Hammam Zriba, the industrial zone of Zaghouan.
Benefits	The benefits of this measure are: strengthening existing laws and regulations, protection of water resources.
Potential negative impacts	Taxes can impose additional costs on people and the concerned activities.
Timeline of implementation	This option should be applied in the short term.
Feasibility	The strengthening of tax implementation primarily requires reinforced administrative capacity, and therefore greater financial resources.
Robustness	The option is primarily administrative and of organizational nature, which means that it can be maintained regardless of future conditions (in different forms if necessary).
Flexibility	The option is primarily of administrative and organizational nature, which means that it can be adapted to societal, economic or environmental changes.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 8 367 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The environmental policy acknowledges the industrial pollution as one of the most important sources of quality degradation of natural resources as well as health and environmental situation. Therefore, It aims to develop the means and prevention methods of industrial pollution. In this regard, the legal aspect was supported and developed through the preparation of the Environmental Code and the publication of numerous legislative and regulatory texts.
Acceptance	The Ministry of Environment is responsible for the coordination and animation of the state's policy in terms of sustainable development, taking all options that could improve the quality and efficiency of the action of the state in environmental domains, as well as options that may be required by the need to inform relevant sectors.
Suggested stakeholder involvement	This management is based on support to communication efforts, awareness and environmental education considered as a basic element of any strategy aiming the change of behavior. The option may be accompanied by awareness campaigns for the public and the private sector. Similarly, the strengthening of controls and incentives to be paid (e.g. the introduction of heavy fines if the tax is not paid) are necessary.
Preconditions for success	Update Study of environmental standards to be compatible with the technological and economic development.

Examples	A tax that varies between 50 TND and 50 000 TND is applied.

WMO 5: Developing agricultural cooperatives

Description	Agricultural cooperatives are companies freely organized by farmers to ensure supply of their operations, improve production conditions and facilitate the flow of products. These companies organized under the principle cooperative do not pursue profit. Their exclusive mission is to promote the development of their members' holdings (cost reduction, improved irrigation systems and facilitating the agricultural flow products).The option aims to favor in particular cooperatives which have a clear objective to develop sustainable agricultural products that are coherent with available water resources.
Addressed challenges	The grouping of farmers in cooperatives will facilitate several actions (having inputs, flow of products after harvest) and thus the development of agriculture.
Target locations and water uses	The option mainly focuses on the farmers of Wadi Sbayhia.
Benefits	The option will secure agricultural activities in a context of low yields and financial vulnerability, and thereby increase the ability of farmers to deal with future global changes.
Potential negative impacts	If they're uncontrolled, intensification of farming practices can result in negative environmental impacts (e.g. water Pollution, water use), increasing the risk of conflicts between uses.
Timeline of implementation	This option should be applied in the medium term.
Feasibility	No major technical obstacles identified.
Robustness	The measure favours strengthening the agricultural sector and thus participate in immediate benefits for the local population (low regret Measures).
Flexibility	The option is hardly intrusive and promotes voluntary cooperation of farmers. It can thus be adjusted to better take into account future challenges.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 170 380 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is synergistic with the goals of most of the relevant state programs advocating a stronger structuring of the agricultural sector and collaboration between farmers. This option is based on the Law on Agricultural Services Corporation. The objective would be to strengthen the application of the law in Rmel watershed.
Acceptance	The option should be well received by farmers via the associated benefits (e.g. Purchase of inputs, increased access to distribution channels). However, experience shows a lack of farmer participation due in part to difficulties encountered during the implementation of the association, the lack of trust between members and the lack of collective financing. Moreover cooperatives do not necessarily imply integration of all concerned farmers.
Suggested stakeholder involvement	Raising awareness amongst farmers of the importance to be part of a cooperative.

Preconditions for success	Information and coaching for farmers for a good management of cooperatives. To facilitate Legislative actions regarding the creation of cooperatives (possible revision of the law and financing)
Examples	URAP Zaghouan: Regional Union of Agriculture and fisheries of Zaghouan (www.facebook.com/URAP-zaghouan-1575727276046309/info/?tab=page_info)

WMO 6: Good use of agricultural land

Description	The option aims at the proper use of agricultural land in order to improve productivity and reduce water consumption by introducing adapted crops. It consists of promoting conservation farming techniques, introducing adopted crops (crops that adapt to droughts) and disseminate good practices.
Addressed challenges	This option will contribute to improving and organizing the exploitation at the level of agricultural land.
Target locations and water uses	This option affects all areas of the watershed.
Benefits	This option offers many benefits including: reducing the use of water, reducing pressure on the resource, erosion reduction, reducing vulnerability to droughts.
Potential negative impacts	The option may result in the short term by a reduction in agricultural production and therefore a loss of income. It can also result in installation costs, for example, the need to purchase the right equipment for new crops or the need for training.
Timeline of implementation	The implementation of this option is in the medium term: this option requires: awareness, extension, taxation, resolution of land issues (land clearance), the development of conservation agriculture ...
Feasibility	The option is facing a problem of fragmentation of land and requires certain technical knowledge (e.g. agronomy).
Robustness	The option aims to adopt new farming practices and more adopted crops to drought and therefore respond to the possibility of more frequent extreme weather events in the future.
Flexibility	This option rather flexible because it is based on changes in agricultural practices and not heavy investment. However, some significant changes to the agricultural holding, such as the adoption new cultures can represent a significant investment for the operator and therefore limit the possibility of future changes.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 292 834 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is supported by the Water Code (protection of agricultural land) aiming at the protection of agricultural land against the threats of water erosion of land. The Code specifically prohibits the use of any tools or techniques for the cultivation of the land and may result in the destruction of soil structure in areas threatened by water erosion, which make it difficult to protect these lands. Similarly, the National development strategy of the Ministry of Environment focuses on the implementation of innovations and developments in the field of climate change in order to confront the impact of change that will accentuate the phenomena of degradation of agricultural land.
Acceptance	The option should be well received by farmers. The Ministry of Agriculture in collaboration with the associations must focus on raising awareness of civil society on the importance of the protection of agricultural land and the need to develop crops adapted to climate change.
Suggested	To raise awareness among beneficiaries on the impact of climate change

stakeholder involvement	regarding agricultural production. Involve associations in the organization of awareness campaigns.
Preconditions for success	Revision of the water and soil conservation Code. Introduction of new techniques and plants resilient to climate change.
Examples	The agricultural enhancement and development companies of Ben Cherifa in Zaghouan (year of implementation, 2011)

WMO 7: Developing financial awareness tools

Description	This option aims to improve access to sources of agricultural financing. It consists of setting up counseling programs to help farmers access to agricultural subsidies and reduce taxes. This requires improving the land tenure situation and fragmentation, a better involvement of farmers in the grant process and a reform of financial instruments. It also requires the diversification of funding mechanisms (e.g. Bank, development associations).The option aims to favor in particular farmers who aim to develop sustainable agricultural products that are coherent with available water resources.
Addressed challenges	This option will contribute to the development and expansion of the agricultural sector.
Target locations and water uses	This option affects all areas of the watershed and all its inhabitants.
Benefits	This option offers many benefits including: consolidation of the agricultural sector, improving of production, strengthening of funding sources and income for farmers.
Potential negative impacts	This option may result in the intensification of agricultural production and greater environmental damage.
Timeline of implementation	The implementation of this option is in the medium term.
Feasibility	The option does not require heavy investments. However, it requires administrative and legal changes which can be complicated.
Robustness	The consolidation of the agricultural sector, improving incomes and better access to financial instruments set up by the government will help the agricultural sector cope with different possible futures.
Flexibility	The option requires administrative and legal changes which can be complex and lengthy, and difficult to modify in the future.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 917 555 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is mainly supported by the Encouragement of Investment Code. This code provides land loans which can be granted for the purchase of agricultural land by specialized technicians and young farmers or for the acquisition of the shares of agricultural project promoters an agricultural holding constituting an economic unit. This option is limited by the lack of land titles (Fragmentation of land tenure systems) that prevent the obtaining loans.
Acceptance	Local operators are not mobilized given the failures of the articles concerning the financing mechanism in the investment code.
Suggested stakeholder involvement	Raising awareness and involvement of farmers in cooperatives.

Preconditions for success	-Revision of the investment code. -Creating an agricultural radiation cell. -Setting up a training program and specific extension to the project zone.
Examples	The Women's Group for Agricultural Development of Oued Sbayhia (WGAD) is an organization gathering small farming women in the area of Wadi Sbayhia in the delegation of Zaghouan. created in the year 2002, it has today approximately 150 members of women divided into 9 territorial units. In recent years the WGAD has been able to grow remarkably thanks to the will, abnegation and courage of its female members. It now has a workshop production in line with international standards, a meeting room to plan trainings and administrative offices. The GFDA today produces a wide range of essential oils and floral waters, extracted from aromatic and medicinal plants collected by member of the Group in the forests of Mount Sidi Salem, which is located in the region of Wadi Sbayhia.

WMO 8: Use of water irrigation technologies

Description	This option targets a proper use of farmland to improve production and reduce the amount of consumed water.
Addressed challenges	The implementation of this measure will be very useful and effective for saving water, thus reducing the amount of water consumed.
Target locations and water uses	Agricultural land in the watershed.
Benefits	The main objective is to rationalize the use of agricultural water in order to make the best economic profit and maintain the demand for irrigation at a compatible level with the available water resources.
Potential negative impacts	The option requires financial means to use modern techniques in agriculture. Training users for better management of irrigated water is crucial.
Timeline of implementation	This option must begin in the short term with great support and good technical assistance.In the medium run, this option should continue adapt while considering new technologies in terms of new irrigation techniques.
Feasibility	It lacks technical expertise on servicing and network maintenance.
Robustness	Better control of demand for irrigation water and a more efficient use are beneficial regardless of future global change.
Flexibility	Investments in irrigation techniques are a significant financial effort, which may limit the ability of farmers to invest and adapt their short and medium-term practice.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 2 210 433 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	There is a national strategy for water management. The main objective of water saving programs is to rationalize the use of agricultural water in order to make the best economic profit and maintain the demand for irrigation at a compatible level with the available water resources. The option is synergistic with several articles within the water Code. Chapter 1: Article 19: presenting any proposals concerning the development of a national water saving policy through programs to rationalize water consumption. Chapter VI: Article 86: The water saving is considered one of the most important ways to development, the preservation and rational use of water resources. Work on developing the water saving techniques, improving the quality and the protection of national water resources is of public interest. Likewise, the option is synergistic with the investment code. Article 29: the investments made in the context of the irrigated water saving by groups of common interest are mentioned by the Water Code. It was promulgated by Act No. 75-16 of March 31, 1975 and state the benefit from the advantages granted to category "A". Article 33: the components of agricultural investment given below give rise to the benefit of specific overall premiums excluding all other premiums: the installation of an irrigation system allowing irrigated water saving or replacement of equipment with improved irrigation system; (Decree 2001-2185 du17 September 2001).Article 42a 6: Investments to achieve water

	savings in various sectors, with the exception of the agricultural sector, and investments for the development of research of non-traditional water resources, their production and exploitation accordance with the legislation in force, and audit activities of the waters give entitlement to an overall specific premium whose rate, terms and conditions for issue are provided by decree.
Acceptance	This option is acceptable to citizens. However, lack of knowledge of farmers in respect of the use of water-saving techniques is a problem. The state and the administration are still the main actors in the mobilization, transfer and transport to the user. As for irrigation, the Ministry of Agriculture is organized in the mobilization and management of surface water and groundwater. Similarly, within the ROAD, a development unit shall monitor and provide assistance to farmers and private actors. Low irrigation performance can only reflect a problem of training of users directly in the field. Private actors and Collective Interest Groups supplement the administrative system in the management of agricultural water, and if they are not individuals, they are then grouped into GIC (Groups of collective interest) or agricultural development companies, which directly exploit water resources and hydraulic networks. Training to improve technical efficiency is not sufficient. Technical performance can sometimes be hampered by organizational problems (product marketing, purchase of inputs) and the hydro-agricultural system still fails, despite the technical prowess. The Tunisian Union of Agriculture and Fisheries (UTAP) also supervise farmers. In most irrigated areas, water is poorly managed by farmers and insufficiently valued. This inefficient use of irrigation water can sometimes have a negative impact on certain irrigated areas. The UTAP could encourage the maintenance and rehabilitation of failed irrigation projects to minimize water loss. Companies of studies and infrastructure works involved in the water sector (equipment maintenance, new work and network equipment, outsourcing of maintenance work etc.). The behavior of the farmer regarding the irrigation components, its implementation, the advices, all other information and training services, depends on its economic vision of water. Pricing is therefore one of the tools, which must be wedged in time and space, to improve the sensitivity of the operator to the water economy.Professional agricultural organizations and NGOs play an important role in catalyzing agricultural development in general (groups).
Suggested stakeholder involvement	The series of actions and incentives implemented by the Tunisian State, led on one hand to an awareness of farmers and professional organizations to the principle "Water Economy", by limiting squandering and the rational use of irrigation water. On the other hand, it led to the massive use of water-saving equipment by farmers at the level of the plot. Associations should actively contribute to the public awareness related to the scarcity of water resources, proper management, and its preservation and protection. It should also encourage less water consuming crops.
Preconditions for success	To have significant funding and to carry out an impact study on the environment.
Examples	The drip irrigation system in the nursery of Sidi Zid in Zaghouan

WMO 9: Improvement of the treatment of waste water

Description	This option aims to improve wastewater treatment to reduce the impact on the water quality in the natural environment and the reuse of water for other purposes. It consists in increasing the exploitation and development of unconventional water (ex. treating water and then use it for irrigation of specific crops), setting the standard wastewater stations, the extension of sewage networks, and the creation of waste water treatment plants.
Addressed challenges	This option will participate in the improvement of water quality in particular and the water management in general. It has an economical side for farmers who use treated wastewater for their irrigated agriculture.
Target locations and water uses	The administrative departments considering this option are those of Zriba and Zaghouan.
Benefits	This option offers several benefits including: maximizing the use of water resources, improving the water quality and the reduction of the increased pressure on natural resources.
Potential negative impacts	This option requires significant material and investments that could eventually raise the price of water.
Timeline of implementation	This option is to be applied in the medium termbecause technically it is not feasible in the short term.
Feasibility	The implementation of this option requires significant technical capacity and a legislative framework and in particular to secure effective control of wastewater use in agriculture.
Robustness	This option will participate in reducing the risk of degradation of conventional water resources through the use of unconventional water to fight against the global changes in the coming years.
Flexibility	This type of option requires a significant investment.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 546 934 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is mainly supported by the Water Code which aims to fight against all actions that could provoke or increase water degradation by modifying their physical, chemical, biological or bacteriological characteristics, whether it is surface water or groundwater. It prohibits making any surface deposition likely to pollute by infiltration groundwater, or by runoff, surface waters. The Code provides that the use of waste water for agricultural purposes is permitted only after appropriate treatment of the waste water in treatment plants and on the decision of the Minister for Agriculture, taken with the agreement of the Minister of public health. In all cases, the reuse of wastewater, even treated, for irrigation or watering vegetables is prohibited.
Acceptance	This option requires primarily information and sensitization of all industries (public and private), the main actors of the importance of respecting the rules of wastewater discharges. The use of wastewater in agriculture may face opposition

	from farmers.
Suggested stakeholder involvement	Awareness campaigns should be organized for public and private industry on the importance of their roles in the protection of natural resources in general and water resources in particular. This option also requires significant involvement of associations to sensitize farmers.
Preconditions for success	-Have Significant funding -Improving And developing treatment plants according to standards. -Improve awareness raising of industrials
Examples	As an example, the irrigated area of 'Sidi Merayeh' using the treated wastewater from the treatment plant of Zaghouan: the total area is 50 (ha), The number of plots is 24 and the number of farmers 18

WMO 10: Water discharge control

Description	The action aims to promote the control of discharges of pollutants by strengthening the regulatory application and utilization of waste (especially olive presses). This involves creating the implementation of solid waste management systems (collection + transportation + treatment) in rural towns and industrial sites, and the creation of new landfill sites controlled and the use of food waste as fertilizer (spreading).
Addressed challenges	This will direct the water resources protection and indirectly to environmental protection.
Target locations and water uses	The industrial zone of Hammam Zriba, the industrial zone of Zaghouan,
Benefits	The option aims to improve the water quality which will secure its possible use by other applications (e.g. Agriculture, drinking water) and for environmental uses (protection of the aquatic environment).
Potential negative impacts	The option requests a major reorganization of industrial waste treatment and wastewater treatment plants. The creation of landfill site can cause problems for local residents (e.g. Odor).
Timeline of implementation	The option can be performed immediately. Funding is planned via the ADB for 5 years starting from 2016.
Feasibility	The option does not require specific technical capabilities, only a strengthening of existing actions.
Robustness	The option aims to strengthen the capabilities for collecting, storing, processing and use of polluting waste for water resources. The option seems beneficial in the short term (low regret option) And long term (possible performance regardless of impacts of future global changes).
Flexibility	The option consists of institutional arrangements (e.g. Strengthening existing activities) and the establishment of heavier infrastructure (e.g. discharges). Hence its capacity to be adapted over time is average and requires special attention to the sequencing of activities to maximize the immediate and future benefits.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 4 500 000 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	Waste management is a central element of the environmental policy in Tunisia with a National Agency for Waste Management (ANGED). It is a question of National Strategy for Integrated and Sustainable Waste Management, which aims to establish a network of landfills and development of collection and recycling channel. The Water Code requires a systematic treatment of domestic or industrial sewage if it poses a risk to downstream water supply for household and food. However, the implementation is slightly followed by lack of means. In addition the Investment Incentives Code has set up a program that exempts from tax some investment in the collection, processing and treatment of garbage and waste.
Acceptance	The waste treatment should at first glance be a well-accepted activity by the entire society given its central role in the quality of life of citizens. However, the implementation faces many barriers, including a lack of information and awareness

	of citizens, lack of dialogue and communication between actors and the tendency to prioritize other economic development goals. Local authorities and municipalities are particularly affected by the lack of human and financial resources. Also the private sector has a little participation.
Suggested stakeholder involvement	The option may be accompanied by awareness campaigns to the public and the private sector for positive behavior towards the environment. In addition, greater participation of associations can be encouraged (through training, technical and financial assistance) and collaboration between associations and local authorities.
Preconditions for success	Increase funding for waste management Improve awareness of citizens and strengthen pro-environmental attitudes
Examples	This water management measure applies in the industrial area of Zaghouan, discharge area of Jimla. An agreement between the ROAD, the Ministry of Health and the GDA is signed to ensure the control of discharge

WMO 11: Reduction of society pressure on forests

Description	The forest will be protected by implementing prevention and control measures in order to reduce overgrazing. Users will be involved and integrated in the management and protection of forests. The private forest owners will be compensated for the resulting costs or the losses in production. The integration of the local population may go through the establishment of agricultural development groups. Compensation may be required to allow public authorities to take options in order to avoid the overexploitation of forests.
Addressed challenges	The reduction of pressure from civil society on forests contribute to the challenge on the protection and enhancement of forest resources
Target locations and water uses	Selected forests are: the forests of Sidi Zid, the forests of jimla and the forests of Jebel Zaghouan.
Benefits	This measure offers several benefits, including conservation of forest cover, soil protection to a natural hydrological regime, improved grazing conditions, and job creation through the development of income-generating activities for forest users.
Potential negative impacts	This option aims in part to reduce grazing pressure on forests which can cause production losses for farmers and local people.
Timeline of implementation	The measure is a long-term one. It can rely on the programs of the regional department of forests which are valid for 10 years.
Feasibility	The option is based on institutional measures (e.g. control, public participation, compensation) and their strengthening on the risk areas. User involvement implies the establishment of new collective management methods (need of return of existing experience and training).
Robustness	The reduction of pressures on forests contributes to forest resilience to extreme events (e.g. drought, storms, and floods).
Flexibility	The option is based on institutional activities that appear adjustable in time.
Costs	The cost required for this measurement over a period of 15 years is estimated at 350 192 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is based on the Forest Code which sets a number of regulations on users aiming at controlling their impact. In addition, the Forest Code allows users to band together for protection and exploitation actions. However, it is common that users do not respect the rules and the rights of exploitation of forest resources. The lack of financial support and lengthy administrative procedures prevent the creation of an association of forest users.
Acceptance	There is a lack of interest on the part of forest populations to implement (enforce) the Code, in particular the creation of associations.
Suggested	User awareness and participation in collective associations should be

stakeholder involvement	strengthened.
Preconditions for success	User awareness More incentive regulatory framework
Examples	Protection of access to the forest of Zaghouan National Park by fencing in order to reduce pressure on the forest.

WMO 12: Protection against forest fire

Description	The protection of forests against fires will be achieved by implementing appropriate techniques and providing the required equipment, as well as by involving users in forest management to make them aware of the importance of managing in a sustainable way these resources while improving their incomes
Addressed challenges	Protection against forest fires contributes to the challenge on the protection and enhancement of forest resources. Moreover, this WMO is having an indirect impact on soil protection and on keeping the natural hydrological regime within the studied river basin.
Target locations and water uses	The forests of Jimla were chosen due to the number of fires
Benefits	This measure offers several benefits, including limiting the number of fires, protecting the forest area, controlling the desertification, protecting he soil fertility and controlling the runoff phenomenon (bare ground).
Potential negative impacts	This can lead to forest loss and forest fragmentation (trenches firewalls, road infrastructure, etc.).
Timeline of implementation	This option can be set up in the short term. It can be based on a 10-year program of the Regional Directorate of Forestry.
Feasibility	The fight against fires via maintenance of undergrowth and the firewall aisles installation is a common practice in Tunisia. Also the equipment of intervention and the establishment of lookout during critical periods are present on the entire territory. Finally, the forest code imposes strict prohibitions on risky behavior. What is essential, therefore, is to strengthen the existing modes of action and develop a public awareness program.
Robustness	The protection of forests against fire reduces the phenomenon of desertification and maintains soil fertility which will have beneficial effects on the ability of forests to adapt to different possible future climate change.
Flexibility	Apart from the installation / expansion of firewall trenches, the proposed activities are institutional and easily adjustable.
Costs	The cost required for this measure over a 15-year period is estimated at 2 600 413 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option can be based on the objectives of the Forest Code and several sections regulating the activities in or near forests to minimize the risk of fire. A major barrier comes from the complexity of legal texts relating to the exploitation of forest resources.
Acceptance	Local people are poorly mobilized on the issue of sustainable forest management.
Suggested stakeholder involvement	An important issue is to increase the interest of local people in forest protection (eg. Forest as a source of revenue) notably through collaborative co-management projects between local residents and land owners and the public authorities. Awareness is also an important line of action.

Preconditions for success	Revision of various articles of the Forestry Code Awareness of local people about the importance of protecting forest resources
Examples	The establishment of a firewall across the forests of the watershed of Wadi Rmel The creation of a center to protect forests against fires, that is equipped with modernized equipment for fire detection

WMO 13: Introduction of new agro forestry species and enrichment of existing forest

Description	Good management of forest resources by introducing new species for agro forestry purposes as well as enriching and preserving existing species in order to preserve and develop the forest
Addressed challenges	The introduction of new species will participate in the development and management of forest resources and thus to improve the standard of living.
Target locations and water uses	Selected forests are: forests of Jimla, and forests of Sidi Zid
Benefits	This measure offers several benefits, including the valuation of forest products and the improvement of the operation of standard of living by sales of forest fruits.
Potential negative impacts	This option aims to improve the management of forest resources, but it is a long term action.
Timeline of implementation	This option is to be applied in the medium term but must be specified and followed by research on the species and varieties to be introduced before starting the plantations. This option considers the short term.
Feasibility	This action is technically feasible. Indeed, the state gives the users the species to be planted.
Robustness	The enrichment of forests contributes to forest resilience to extreme events (e.g. drought, storms, and floods).
Flexibility	The implementation of this measure requires a strengthening of awareness-raising and training for local people. These actions can help overcome the overexploitation of forest resources problems.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 502 001 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The measure is consistent with the objectives of the Forest Code, which aims to ensure the protection, conservation and rational exploitation of forest resources and also to ensure users the lawful exercise of their rights. The protection of national territory against desertification and the development of forestry-pastoral resources are actions of national interest. These actions benefit from the encouragement of the State in the form of grants, loans, aid in kind or any form of encouragement. The incentive measures taken by the State under this Act are designed to encourage the participation of individuals, communities or any other legal person, to carry out actions aimed at increasing timber and fodder production. These incentive measures also aim at improving the economic and social life of forest populations. A major challenge, however, is to increase the application of the Forest Code. Moreover, the low contribution of the owners to carry out the work is a problem. The measure is consistent with the objective of the 11th Plan of Agricultural Policy (2007-2011) which aims at the "Sustainable development of natural resources" among other things, and in particular the protection and development of forest resources.
Acceptance	The Ministry of Agriculture (Forestry Department) encourages the promotion of forestry-pastoral activities. However, the contribution of the local population to carry out the work is low. There is a lack of interest on the part of forest

	populations to implement this type of action, because of the long time required for the operation of the introduced products. Moreover, the forest population mainly aims to improve production as well as their income.
Suggested stakeholder involvement	It will be necessary to raise awareness and enhance the involvement of forest populations in the design and realization of this long-term action.
Preconditions for success	Organization of the local population / valuation of non-timber forest products.
Examples	The introduction of new species (carob, capers, Eglantine ....) in the demonstration plot of Ain El Batteria and forest of Wadi Sbaihiya of the Rmel watershed.

WMO 14: Better governance of forest resources

Description	The option aims to improve the governance of forest resources. It consists of better enforcement of existing forest laws and the regulations of the lease situation of forest communities.
Addressed challenges	Good governance of forest resources contributes to the protection and proper management of these resources.
Target locations and water uses	This action concerns all forest resources in the basin: forests of Sidi Zid, forests of Jimla and the forests of Jebel Zaghouan.
Benefits	This option provides several positive aspects, including the conservation of forest cover, soil protection and improvement of pastoral conditions.
Potential negative impacts	-
Timeline of implementation	This WMO must be applied in the medium term because it must proceed by an identification of failuresand accurate action to take. Then comes to the application of remedies and improvements.
Feasibility	The option is based on legislative options aimed at improving and strengthening existing laws and regulations. Strengthening agricultural development groups will also be necessary in order to ensure the development of the forestry sector.
Robustness	This option reduces the degradation of this richness and preserves soil fertility which will have beneficial effects on the ability of forests to adapt to different possible future climate change.
Flexibility	The option is based on legislative activities that appear hardly adjustable over time.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 100 000 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The creation of an institutional and regulatory environment as well as favorable capacity for sustainable engagement of stakeholders (users, institutional partners) is a central component of the National Strategy Development and Sustainable Management of Forests and Range. However, this action is limited by the absence of texts governing the relationships between regional and central departments in the Ministry, the lack of formal processes between the forestry administration and its institutional partners and potential partners in other sectors as well as the absence of synergy between development structures, research and higher education structures.
Acceptance	The key players of this option are the Ministry of Agriculture and more specifically the Regional Directorate of Forestry (public bodies) and forest population (non-institutional actors). This option will have direct positive impacts on the forest administration. It promotes the strengthening of its capabilities. In addition, it allows the forest to have judicious population access to resources and appropriate sharing of efforts and benefits. Some barriers do exist. The fact that the Forest Code remains too focused on heritage conservation without suitable opening to development problems and the participation of other stakeholders. Organizations

Suggested stakeholder involvement	(GDA, associations, etc.) have not achieved the desired objectives. Indeed, it was not possible to involve communities benefit in the management of programs where the role of these organizations remained passive with no real power. An important issue is to give greater prominence to the existing legislation in the forestry sector through building institutional and individual capacities of the sector and get coordination between regional and central departments within the ministry and between ministries, research and civil society.
Preconditions for success	-Revision of the various articles of the forestry code - Creating A national mechanism of sector financing through the development and implementation of a payment scheme for ecosystem services and the revision / adaptation of the investment code. - Focus on the role of associations for the management of forest resources
Examples	-

WMO 15: Awareness campaign and learning

Description	This option aims to improve the exploitation and management of natural resources by sensitizing civil society about the importance of natural resources and their protection. It consists in particular to facilitate the work of associations and organize awareness campaigns.
Addressed challenges	Raising awareness and progressive involvement of the relevant civil society. This society will participate in achieving the objectives of protection of natural resources to ensure sustainable management of these resources.
Target locations and water uses	This option is very advantageous for all areas of the basin.
Benefits	This option offers many benefits including: collaboration among development agents, researchers and civil society. Moreover, it will facilitate the implementation of the various actions in relation to civil society.
Potential negative impacts	-
Timeline of implementation	This option must begin immediately in the short term
Feasibility	This action mainly depends on the flexibility of the civil society.
Robustness	This option will contribute to reducing the risk of degradation of natural resources regardless of the impacts of future global changes (climate, increased demand, etc.).
Flexibility	This option is of an institutional nature and therefore is easy to change based on future global changes.
Costs	Based on the costs over a period of 15 years as stated in the WP3, the cost required for this option is 70 856 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The different future strategies (water resources, forest resources, conservation of water and soil) emphasize the importance of civil society for the conduct of such a project. Indeed the awareness and training of the operators will therefore become a necessity.
Acceptance	This option essentially requires the integration of associations. However the lack of coordination between different actors makes the acceptability of civil society in such action quite difficult.
Suggested stakeholder involvement	It will be necessary to progressively and gradually introduce new forms of partnership (NGOs) to promote self-development of the population and ensure the sustainability of the actions of a project in the area. Furthermore the organization of awareness campaigns that include all possible decision levels and all implementation phases to improve the understanding of the environment to properly identify constraints and optimal solutions to major problems of the area.
Preconditions	Give more importance to awareness campaigns by increasing the number of

for success	sessions.
Examples	An annual budget is devoted to plan and organize conferences and training sessions in different specialties and aimed at different categories (organic farming, agricultural extension, personal training ....)

WMO 16: Improved decision making

Description	This option aims to improve decision making by involving stakeholders in all stages of the study and the decision process. The government can encourage a reorientation of existing institutions. The financial support and development of awareness can be used to enhance coordination between public authorities and civil society. Moreover, this context can create integrated businesses between graduates and farmers in order to manage the public lands (science + experience). The option may consider co-creation of a link between education, research, society and politics. The research need to adopt interdisciplinary approaches to work with the society to develop solutions and innovations for agriculture and sustainable water use.
Addressed challenges	The involvement of stakeholders in decision making is essential for the development and success of the projects.
Target locations and water uses	The entire Rmel watershed is affected by this option.
Benefits	The main benefits are: the coordination between public authorities and civil society, creating integrated businesses between graduates and farmers, research should adopt transdisciplinary methods to integrate society in development and solution innovations for a better agriculture and sustainable water use. Work towards developing a background incentive for the proper management of natural resources.
Potential negative impacts	The dialogue between the authorities and civil society is not always productive. Similarly, civil society is not always ready to apply new techniques based on science.
Timeline of implementation	This option is to be applied in the medium term after the sensitization of civil society.
Feasibility	The feasibility depends on funding of scientific research (adopt programs that facilitate the integration of graduates in agricultural areas) also the integration of civil society in all stages of decision making.
Robustness	This option will contribute facilitating the acceptance of the operators to the technical measures proposed by the state and thus reducing losses and degradation of natural resources regardless of the impacts of future global changes.
Flexibility	Flexibility can be accelerated by improving academic degree programs and adopt a method to integrate graduates in the development of solution for the management of natural resources as a new start of the civil society in a second stage.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 41 833 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The different future strategies (water resources, forest resources, conservation of water and soil) consider the human factor as the main partner in any operation of development and conservation of natural resources. A participatory approach therefore becomes a necessity. The methods of intervention that were based on

Acceptance	the vertical approach did not allow involving operators at all stages of planning and implementation. Indeed, they do not feel concerned by this problem. This option requires collaboration between development agents, researchers and civil society. In fact, due to lack of coordination, the participatory approach would be a further complication for both the administration and operators, and it maintains an environment of uncertainty that will negatively influence the behavior of operators.
Suggested stakeholder involvement	The organization of awareness campaigns bringing together the various stakeholders (public authorities, private sector, civil society) to discuss the main issues related to the area.
Preconditions for success	Organization committee meetings that bring together those responsible for decision making. Preparation and implementation of participatory management plans
Examples	Development projects in the governorate of Zaghouan: ADB project (African Development Bank) and FMFW project (financing management framework of the watershed)

WMO 17: Promote projects that generate more income

Description	This option aims to improve means of subsistence by encouraging investment in income generating projects and employment. This mainly passes through economic incentives for eco-tourism projects, introducing craft activities for women in rural areas, promotion of new production activities and development of organic agriculture. This option should support projects that take into account impacts on water resources and that aim to develop the river basin in a sustainable way.
Addressed challenges	This option will contribute to encouraging natural-resource-based-projects and characteristics in the area in order to improve the living standards of local people.
Target locations and water uses	The entire Rmel watershed is affected by this option.
Benefits	The benefits of this option are: improving living standards, increasing the access to basic necessities and increasing production, and environmental protection.
Potential negative impacts	-
Timeline of implementation	This option is to be applied in the medium term.
Feasibility	This option requires no special technical capacity.
Robustness	The implementation of this option will participate in the management of the different natural resources that will help reduce the risk of future global change impacts.
Flexibility	Flexibility depends on the motivation of the local population (women and youth) to participate in this type of action.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 1 338 670 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The option is consistent with the incentives code of investment, which encourages the use of natural resources. Incentive options taken by the state are intended to encourage the participation of the local population, mainly women. It tries to promote the execution of actions to increase revenues and improve the conditions of economic and social life.
Acceptance	Public authorities (Ministry of Agriculture, the Ministry of Industry and Trade and Ministry of Environment) encourage the promotion of social and economic activities by identifying specific development options and actions such as training and support for the creation of income generating activities. There is a lack of interest on the part of operators to implement this type of action, due to lack of funding mechanism.
Suggested stakeholder involvement	- Joint awareness of civil society through identifying options and specific development actions on their roles in the use of natural resources and their responsibility for the protection and conservation of these resources.

	- Integration of associations in raising awareness.
Preconditions for success	Encourage the launching of projects that are tolerant to the environment / Work towards creating an incentive background.
Examples	The exploitation of small plots in the Jebel Zaghouan National Park as a botanical garden The production of essential oils by rural women in Wadi Sbaihla,

WMO 18: Encourage investments

Description	This option aims to improve livelihoods through job creation and encouragement of the launch of income generating projects. This option should support investments that take into account impacts on water resources and that aim to develop the river basin in a sustainable way.
Addressed challenges	This option aims at the development of different sectors to create new jobs likely to improve the living standards of the local population.
Target locations and water uses	Sub-basin of wadi Sbaihia / the Rmel watershed
Benefits	To facilitate the obtaining of short-term loans and grants for small farmers and youth, and to facilitate access to information on the opportunities, financing and investment procedures.
Potential negative impacts	Obtaining loans may depend on certain criteria that are usually limiting the beneficiaries / young people are not always motivated by the idea of creating their own projects
Timeline of implementation	- This option must be applied in the medium term
Feasibility	The feasibility depends on the strategy of the country which must provide a budget for beneficiaries and adjust the criteria to the measure.
Robustness	The willingness to invest and create projects.
Flexibility	-Improved knowledge and youth technical capabilities can help boost the capacity of local communities to plan and adapt to future global changes.
Costs	-Based on cost over 15 years in the WP3, the cost required for this option is 1 004 002 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The Investment Incentives Code promotes investments in the sectors of agriculture, industry, tourism, crafts and some service activities. This is achieved in the areas of encouragement of regional development established by the decree referred to in the abovementioned Article 23. These areas benefit from the state's support and the employer's contribution to statutory social security for wages paid to Tunisian officials. However, the procedures are long and the contribution of the state is low.The National Development Strategy is favourable to the measure. In order to boost investment and promote jobs in the field of environment, which represents a growth industry in this regard, Tunisia has organized in 2009, the second International Forum of Investment and Employment in the environmental sector. This approach is considered essential to establish a social climate favorable to the policy of encouraging domestic and foreign investment in various economic sectors, and the strategic choice knowledge-based economy: a dynamic, efficient, innovative, creative of new wealth and self-financing and regulatory mechanisms.
Acceptance	In order to consolidate the achievements in ecological tourism and to better define the role and tasks of different stakeholders in the ecotourism sector, the Ministry of Environment and Sustainable Development has set up a study on

	"the strategy the revaluation of ecotourism in Tunisia, "and this in collaboration with the German technical cooperation agency. However, it is not automatic that the projects are not harmful to the environment. The Ministry of Agriculture encourages investment in general and investment in agriculture and fisheries. This has been particularly established by Law 93-120 of 27 of December 1993 on the promulgation of the Code of Investment Incentives. The provisions of the Code apply to investment operations concerning the creation, Extension, Renewal, the redevelopment or activities transformation. In Industry, the New Promoters (NP) and Small and Medium Enterprises (PME) that undertake projects in the activities of manufacturing, craft activities and industry-related service activities, enjoy a premium of study and technical assistance set at 70% of the cost with a ceiling of 20 000 DTN.
Suggested stakeholder involvement	Awareness and involvement of beneficiaries in all performed actions. Some non-governmental associations can act as an intermediary to facilitate obtaining loans and grants.
Preconditions for success	The promotion of projects in the sectors of agriculture, industry, economy and crafts and consider youth awareness to invest in the private sector. The latter, is almost deserted compared to the state sector
Examples	The promotion of ecotourism in the town of Zriba and Zaghouan (http://www.darzaghouane.com/)

WMO 19: Developing skills for young people

Description	This options aims to organize training sessions to facilitate the integration of young people into working life and thus a generation of skilled technicians for proper use of different techniques. This option should support the development of skills for water-friendly techniques and thereby support the sustainable development of the river basin.
Addressed challenges	This will give an importance to young people to prepare them to manage projects that will participate in following the development of the area.
Target locations and water uses	Sub-basin of wadi sbaihia
Benefits	Training young people in modern specialty programs, organizing training sessions and internships, improve employability.
Potential negative impacts	These training sessions may not lead to jobs. Young people are sometimes less interested in training if the conditions are not favorable.
Timeline of implementation	This option must be applied in the short term.
Feasibility	The feasibility depends on the financing of these trainings / the availability of training centers.
Robustness	The creation of training centers / training for trainers
Flexibility	-Improved knowledge and youth technical capabilities can help boost the capacity of local communities to plan and adapt to future global changes
Costs	-Based on cost over 15 years in the WP3, the cost required for this option is 131 357 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	Totally exporting service companies established before the promulgation of the Code of Investment Incentives can recruit foreign supervisory and control agents for a transitional period of two years from the date of enactment of this Act. This is considered after informing the Ministry of Vocational Training and Employment. However, trainers or supervisory staff are not always available, hence the ability to schedule training for young people. These training sessions are currently proving to be limited. The National Development Strategy seeks an overall upgrading of the training sector. This sector must be for the benefit of key stakeholders, namely, first and foremost; job seekers, businesses, economic sectors and regions while considering their development needs and investment. The program should thus enable to address the challenges of the next stage in the light of the imperatives of continues economic and technological change, and to open up wider prospects for investment in promising and innovative sectors. However, the support programs are always relative to market demand, of companies in economic and agricultural sector. If no request is made, the trainings are then absent.
Acceptance	This option is acceptable because it is done on the request of the beneficiaries and the market, but it faces some obstacles: there are problems of funding and lack of awareness on the importance of these trainings for the integration of young people

	in the professional life; training may not always be frequent. The civil society sometimes provides the opportunity for young people to train in the areas required by the market. NGOs can allocate necessary funds of budget to support and fund development projects and that, on the basis of competence, the nature of the projects and scheduled activities.
Suggested stakeholder involvement	Civil society and NGOs. Awareness and involvement of beneficiaries in all performed actions.
Preconditions for success	Awareness of the beneficiaries of the importance of the capacity and potential of youth. Address adequate trainers as well as training centres / Offer free training. Similarly to motivate the youth by allowances.
Examples	The Jouggar training center for the training of young people: http://www.avfa.agrinet.tn/fr/detail_centre.php?code=29

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Annex 1. Dissemination Activities Report

Dissemination Activities Report: *P2 April 2014–September 2014*					**BeWater partner:** *INRGREF*			
WP	**Activity**	**Title / Purpose / Topics**	**Date**	**Place**	**Type of audience**	**Size of audience**	**Countries addressed**	**Comments**
5	Popular articles	The impact of climate change on water resources : Expectations of the scientific research project BeWater financed by the European Union Publisher: Al Wamidh Magazine	April 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	5000	TN	The Al wamidh magazine is a local press in the region
5	Press release	BeWater stakeholders preparations to activate the participation of the involved partners in the project Publisher: Al Wamidh Magazine	May 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	5000	TN	The Al wamidh magazine is a local press in the region
3	Flyers	Flyers distributed with invitations for the 1st workshop	June 2014	Zaghouan	☑ SCI ☑ IND ☑ CIV ☑ POM ☑ MDA	80	TN	1st general med banner (29.7*42cm)

3/5	Workshops	Bewater first stakeholder workshop	June 2014	Zaghouan	☑ SCI ☑ IND ☑ CIV ☑ POM ☑ MDA	70	TN	The first workshop was the basic initiative to introduce the project
5	Questionnaire	Bewater survey	June 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	70	TN	This survey helped us to identify the opinions and the expectations of the different stakeholders who attented the 1st workshop
3/5	Popular articles	A research-development project financed by the European Union related to Rmel river basin. Publisher: Al Wamidh Magazine	July 2014	Zaghouan	☑ SCI ☑ IND ☑ CIV ☑ POM ☑ MDA	70	TN	The Al wamidh magazine is a local press in the region
5	Web Sites/Applications	Stakeholders from the Rmel river basin participate in water management	September 2014	The Bewater website	☑ SCI ☑ IND ☐ CIV ☑ POM	The internet users	TN	

					☐ MDA			
5	Web Sites/Applications	Tunisia's Rmel river basin Publisher : Revolve Water Magazine	September 2014	The Revolve magazine website	☑ SCI ☑ IND ☐ CIV ☑ POM ☐ MDA	The internet users	TN	

Dissemination Activities: *October 2014–February 2015*					**BeWater partner:** *INRGREF*			
WP	**Activity**	**Title / Purpose / Topics**	**Date**	**Place**	**Type of audience**	**Size of audience**	**Countries addressed**	**Comments**
5	Interviews	The interviews are intended to complement the information provided by the CSP in the qualitative information	October 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	9	TN	interviews were conducted with policy makers, implementers and stakeholders that did and did not participate in the workshop.

		sheets and the perspectives obtained at the first stakeholder workshops.						
3/5	Workshops	Awareness campaign	December 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	70	TN	This awareness campaign is entitled "The climate change and sustainable management of water resources: interaction between science and society in the Rmel river basin" and aimed to endorse the bewater plateform ,to involve youth this time and to introduce the project tot he large public.
3/5	Posters	8 banners	December 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	70	TN	These banners were mainly depicted during the awareness campaign but they will be exposed on cultural youth centers, water related locals ect. in the next few weeks.

3	Interviews	Interviews conducted by a national radio station and a national press agency	December 2014	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	/	TN	Shems FM TAP (Tunis Afrique press)
3	Press release	The Bewater awareness campaign Publisher: Al-Wamidh magazine	January 2015	Zaghouan	☑ SCI ☐ IND ☑ CIV ☑ POM ☐ MDA	5000	TN	
3/5	Videos	The video is about the awareness campaign	February 2015	Zaghouan	☑ SCI ☑ IND ☑ CIV ☑ POM	70	TN	This video was made by the bewater team

					☑ MDA			
	Youth initiative	The BeWater youth initiative with GWP-Med and Deep Blue	March 2015	Zaghouan -Tunis				
	Worshops	Inrgref with GWP-Med	July 2015	Zaghouan				The workshop aimed to take collective reflection on the current role played by youth in the management of water resources, limitations and challenges faced and there commendations and concrete actions to overcome these challenges.
	Youth initiative	The BeWater youth initiative with GWP-Med	November 2015	Zaghouan				The workshop brought together representatives of the various stakeholders involved in water resources management from different governorates of Tunisia.
	Awareness campaign	The BeWater awareness campaign	December 2015	Jradou - Zaghouan				Primary School of Jradou

	Meetings	Meeting at the DGACTA	January 2016	Tunis				Stakeholders meet to talk about the progress of the project and phases reached so far.
	Workshops	Bewater Third stakeholder workshop	April 2016	Tunis				
	Awareness Compaign	The youth initiative	May 2016	Zaghouan				