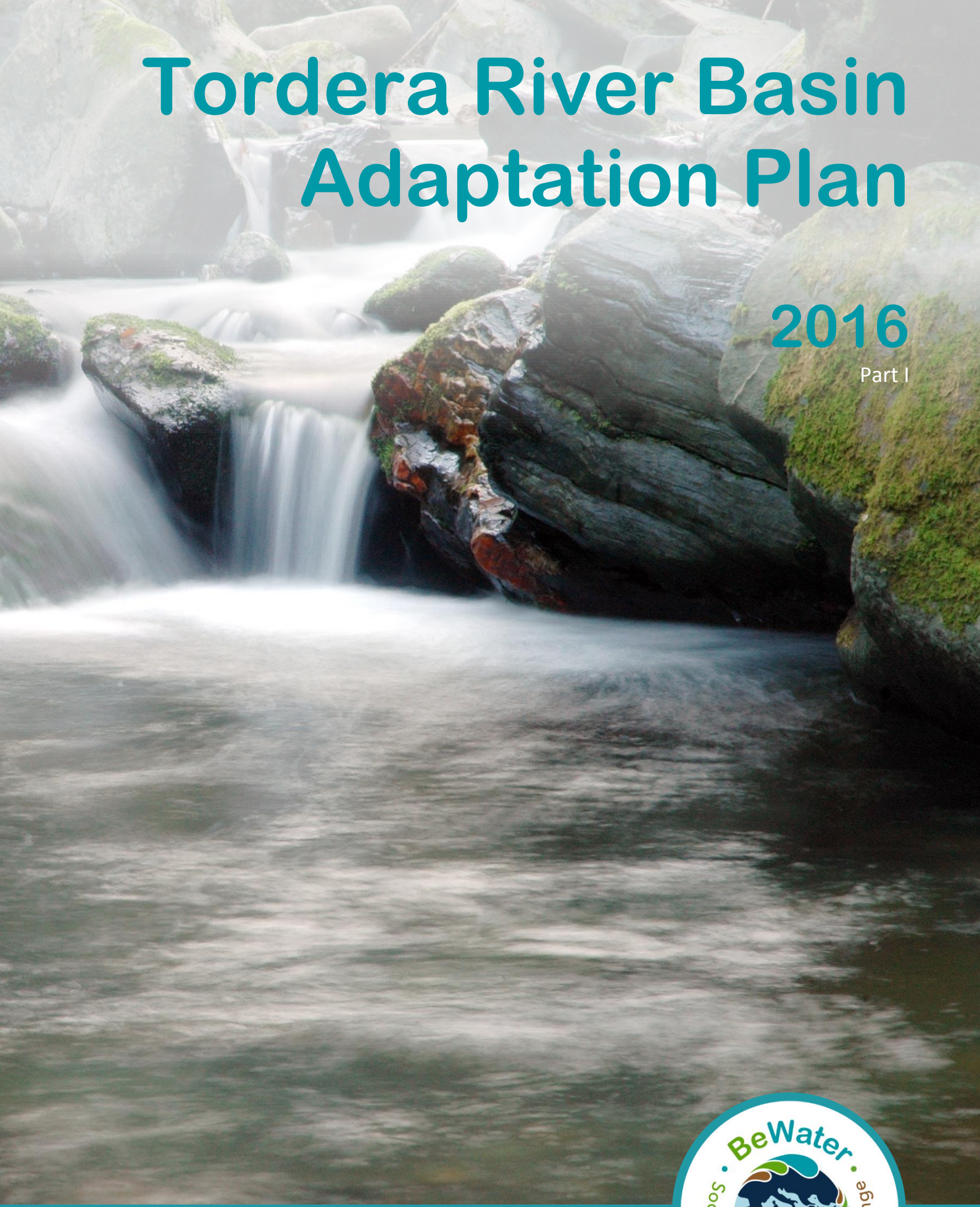
Tordera River Basin Adaptation Plan

2016

Part I



Tordera River Basin Adaptation Plan

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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
October–December
Stakeholder interviews on the river basin context and challenges
2nd general project meeting in Nicosia
July–September
October–December
Finalisation of water management options
Impact assessment, multi-criteria analysis and economic assessment of water management options
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
Water 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.

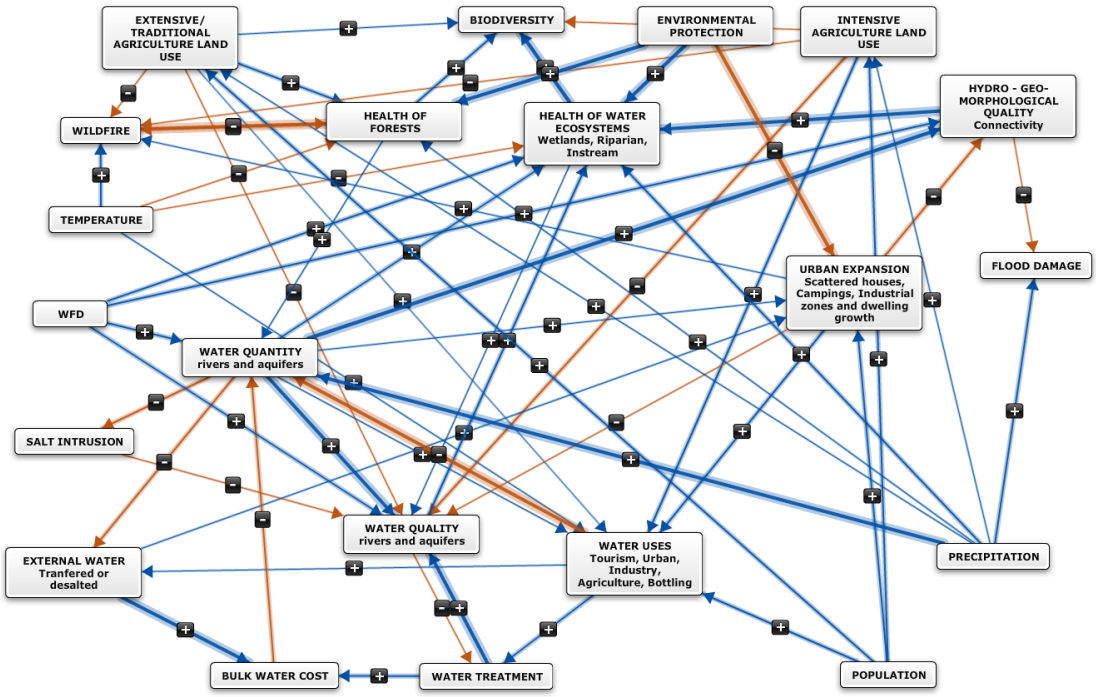


Figure 2: Fuzzy cognitive map of the Tordera river basin

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.

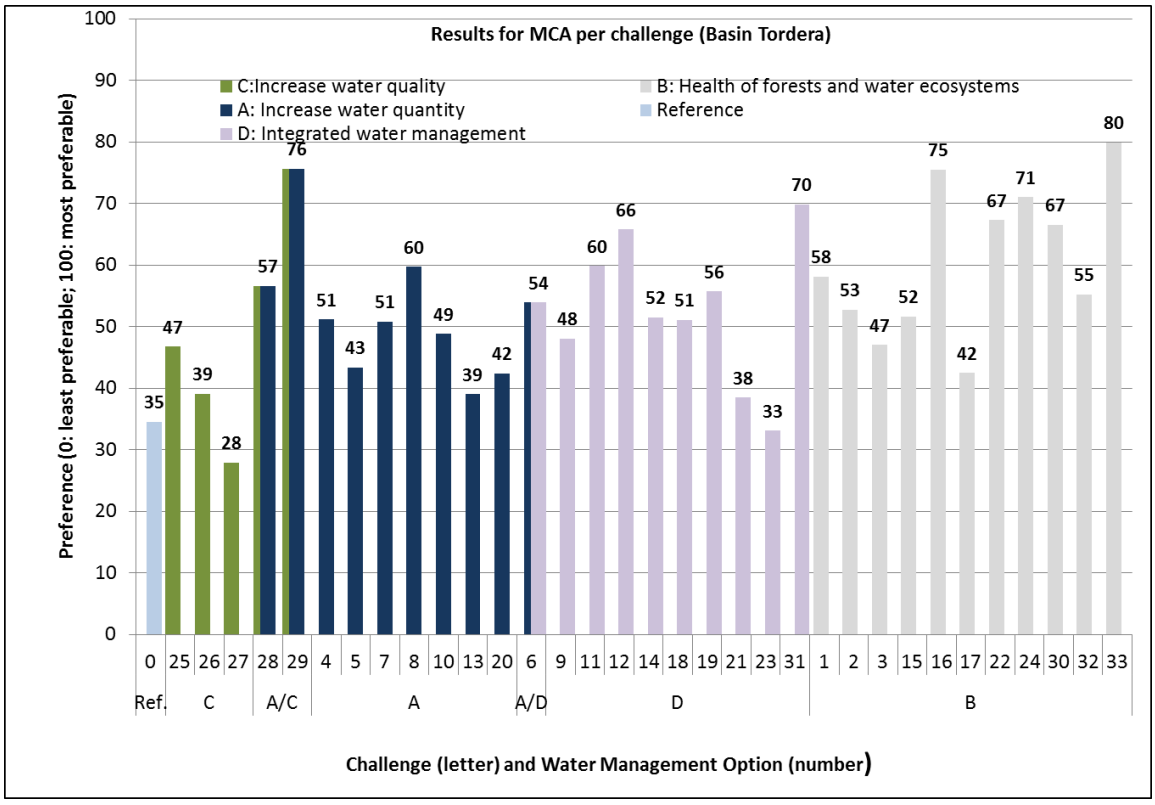


Figure 3: Outcome of the multi-criteria analysis based on criteria (and their changes) derived from the fuzzy cognitive map and the impact assessment. Numbers refer to the water management options in Table 2 and letters to the challenges reported in section 3.3.

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.Palautordera	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).

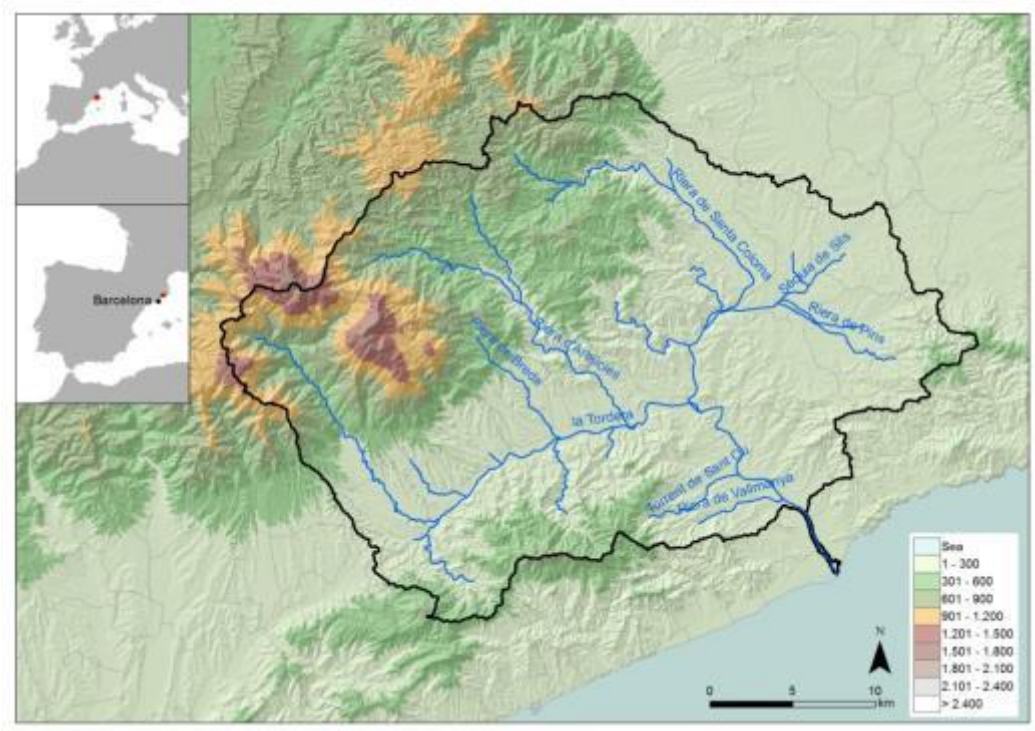


Figure 4: Geolocalisation of the Tordera river basin. Source: CREAF, 2015

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.

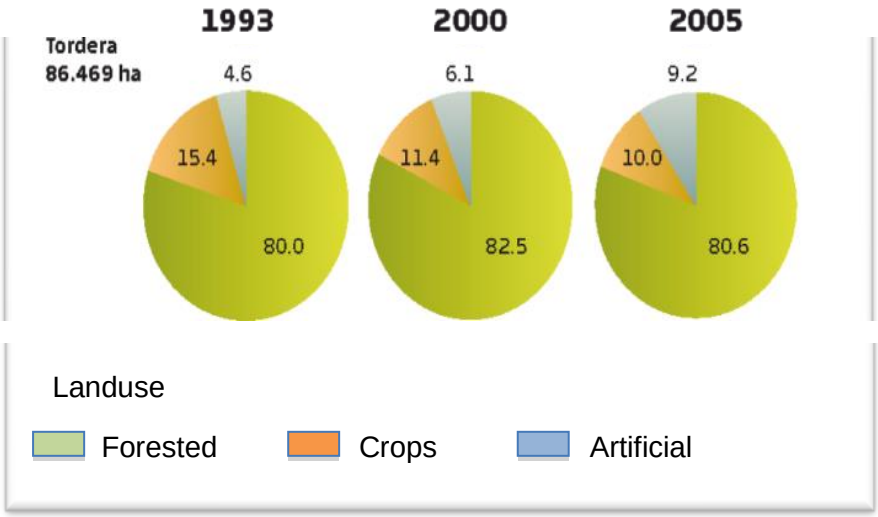


Figure 5: Land use changes in the Tordera Basin [34]

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].

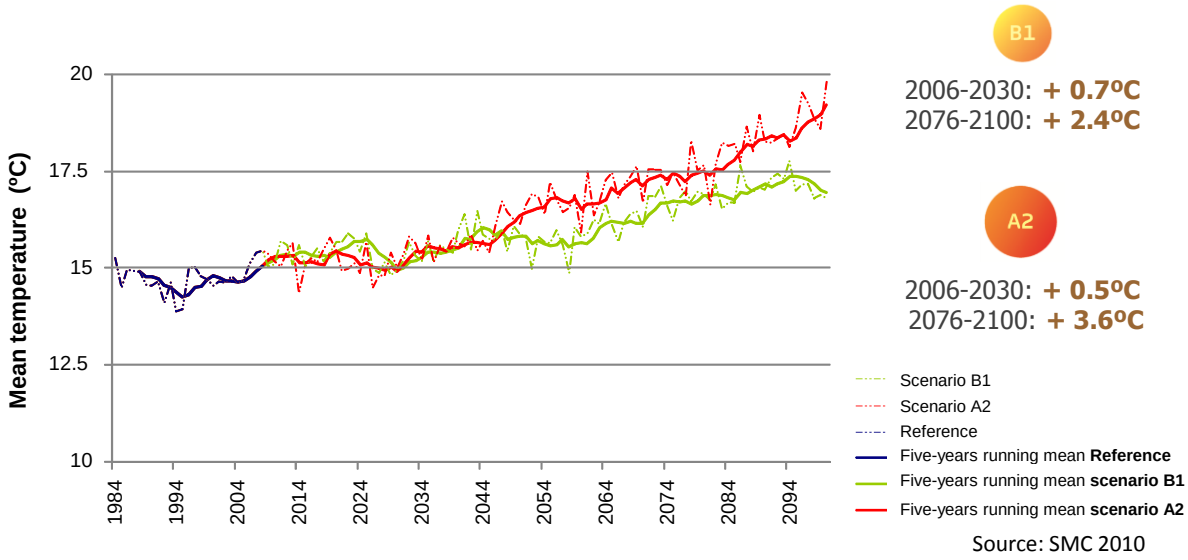


Figure 6 a: Future temperature trends [34]

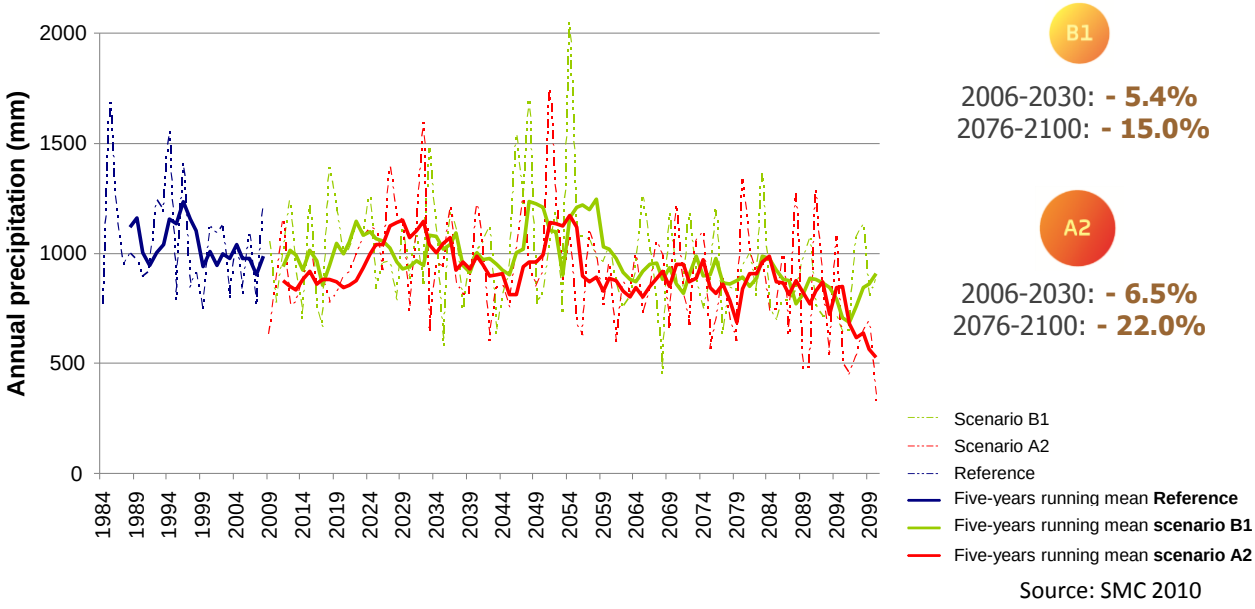


Figure 6 b Future precipitation trends. [34]

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].

[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

[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).

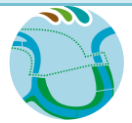
A priori, **most options are considered feasible and acceptable**, even if minor obstacles for implementation need to be overcome. Where serious obstacles are envisioned, these mostly refer to changes in legislation or institutional structures. Low acceptability, where that is the assessment, mostly 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	Acceptability	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.	

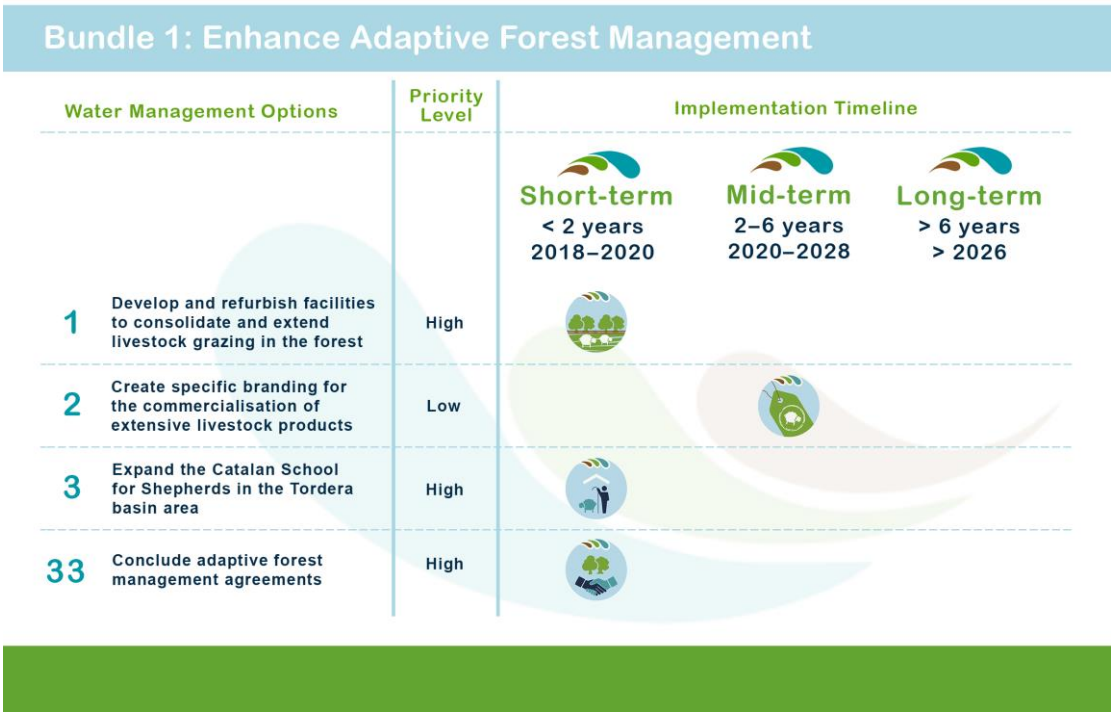
[12] Escola de pastors de Catalunya

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.

Issues Tackled by Options in Bundle 2	**Description of WMOs**	**Type of Action**
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.	**WMO5. Revise the Extractions Master Plan.**	**INFORMATION MANAGEMENT**
	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.	
Investments in water-saving	**WMO6. Establish water use**	**PARTICIPATION &**

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.	**entitlement conditions.**	**AGREEMENT**
	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.	
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.	**WMO7. Promote knowledge transfer on irrigation with reclaimed water.**	**STUDY & DISSEMINATION**
	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.	
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.	**WMO8. Integrate water-saving solutions in construction protocols.**	**STUDY & DISSEMINATION**
	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.	
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.	**WMO10. Promote water recycling in production processes.**	**PILOT & DISSEMINATION**
	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.	
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	**WMO11. Create Water User Associations (WUA).**	**ASSOCIATION**
	This option is intended to promote 1) a study to evaluate the barriers and opportunities to setting up a	

<table>
<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>
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<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>

<table>
<tr><td></td><td colspan="2">systems
• Enforcement of public hydraulic domain legislation</td></tr>
<tr><td rowspan="2">Given the high number of outdated entitlements, many containing important irregularities, it is urgent to update water extraction rights.</td><td>WMO31. Revise and update water entitlements.</td><td>INFORMATION MANAGEMENT</td></tr>
<tr><td colspan="2">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.</td></tr>
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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.

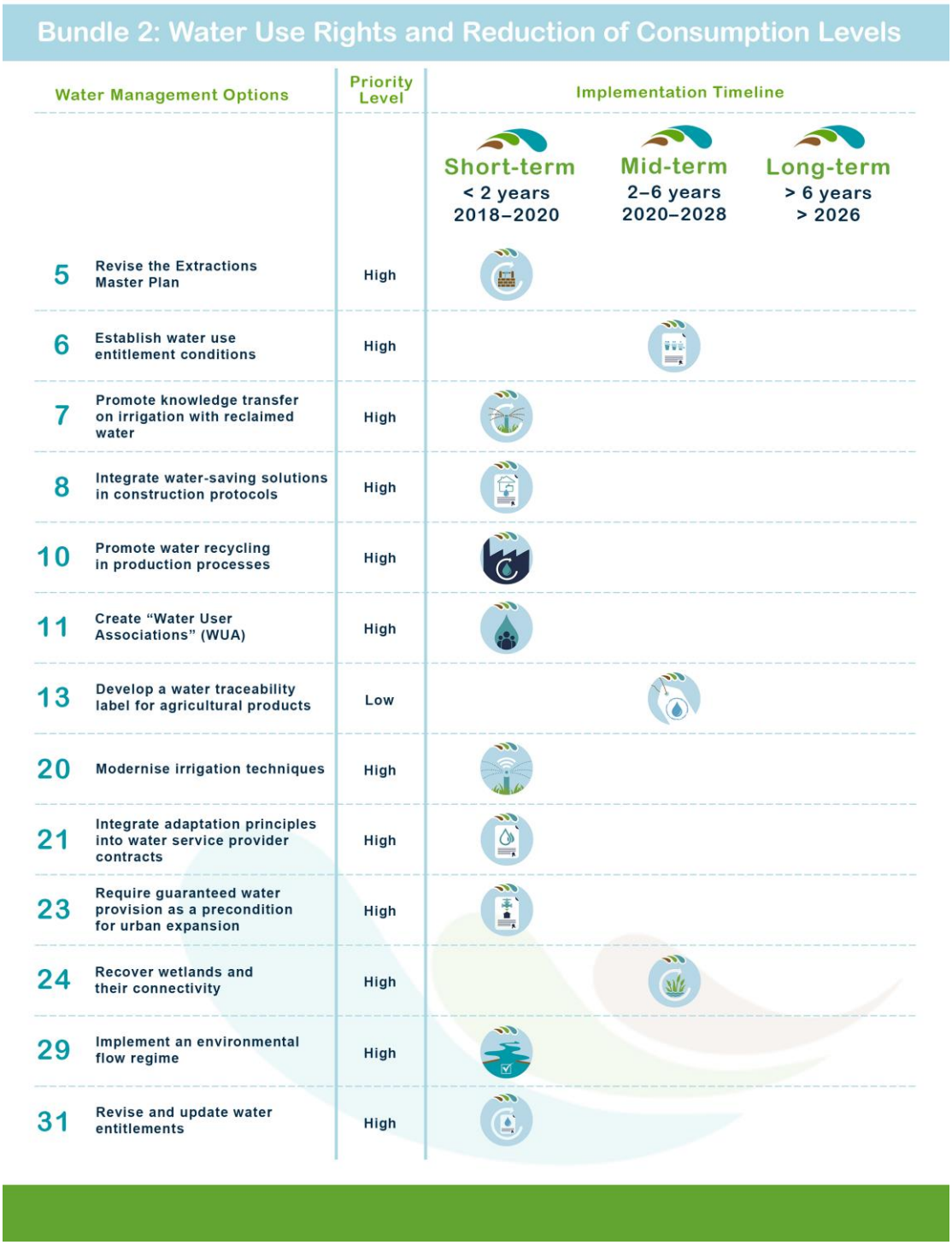
WMO13 (Water traceability label) needs WMO31 to be implemented first, because of the need to clearly identify those who have updated and legalised their entitlements. This option was rated as having a low priority, since stakeholders believe its implementation requires a strong political will.

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.



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	

	relevant actors.	
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.	**WMO17. Foster selective fishing.**	**INFORMATION & PARTICIPATION**
	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.	
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.	**WMO19. Raise awareness.**	**INFORMATION & PARTICIPATION**
	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.	
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.	**WMO25. Eliminate toxic substances used in municipal parks and gardening practices.**	**INFORMATION & AGREEMENT**
	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.	
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.	**WMO26. Create a catchment agreement to reduce diffuse pollution.**	**AGREEMENT**
	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.	
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	**WMO27. Centralise and facilitate access to relevant data on the basin water bodies' status and uses.**	**INFORMATION**
	This option is intended to promote the creation	

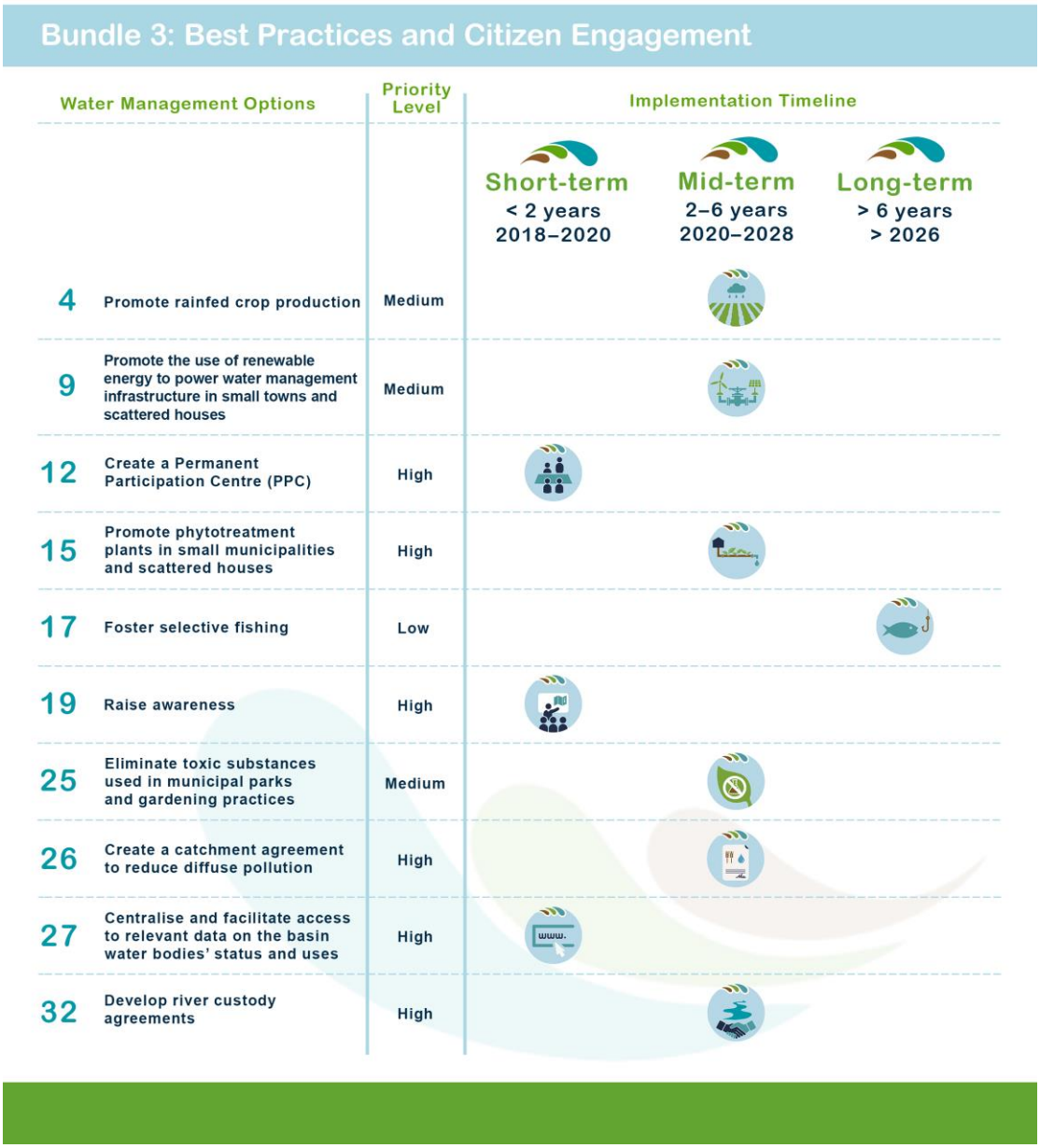
<table>
<tr><td>about the nature, scope, updating and publication of these figures, and their publication format makes them hard to search.</td><td colspan="2">of a webpage in which all the relevant data on the Tordera river basin collected by public authorities, non-governmental organisations or research projects is published in an accessible format.</td></tr>
<tr><td rowspan="2">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.</td><td>WMO32. Develop river custody agreements.</td><td>AGREEMENT</td></tr>
<tr><td colspan="2">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.</td></tr>
</table>

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.



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.	

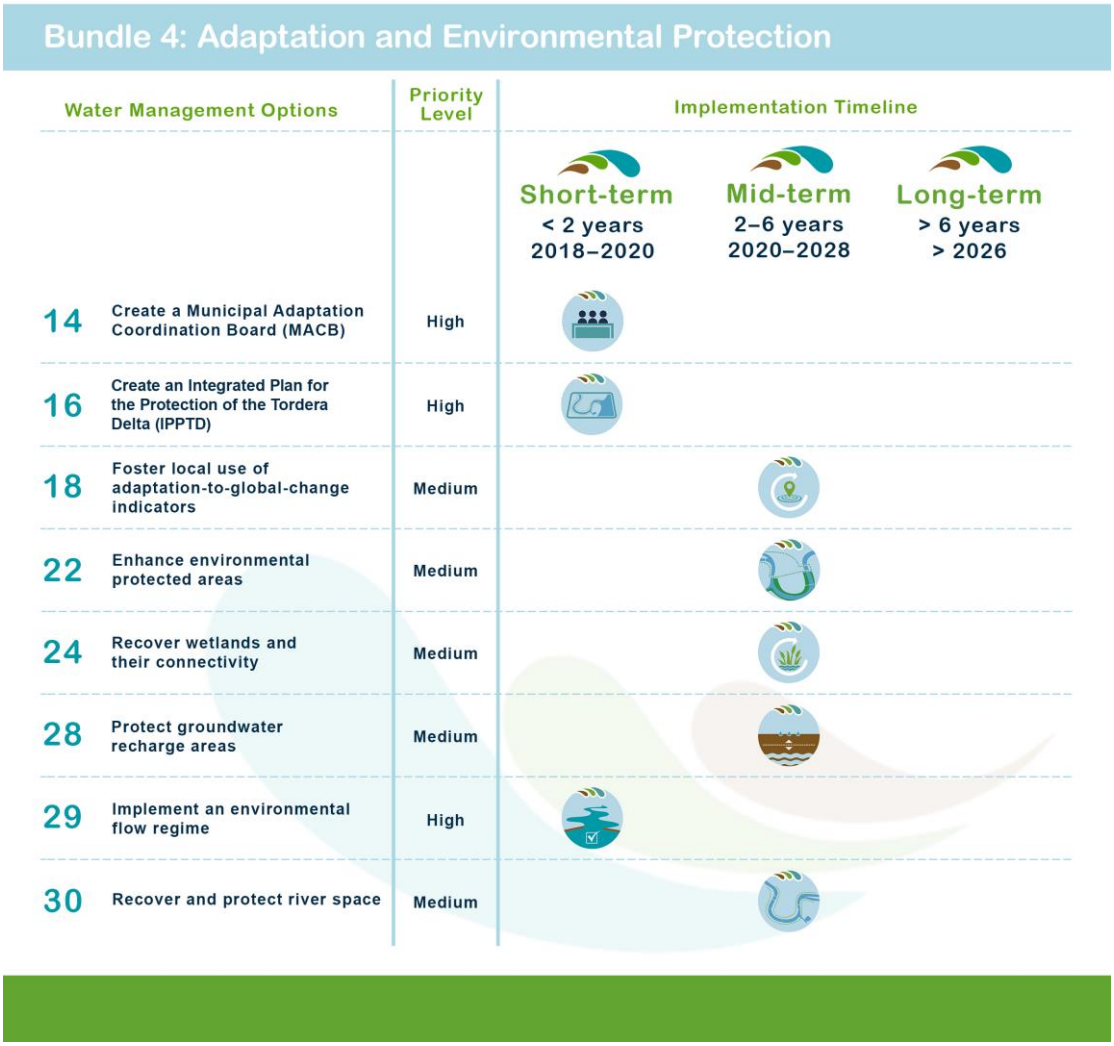
The Tordera delta area is particularly sensitive to the impact of global change and is affected by multiple upstream pressures. Fragmentation of powers among public administration bodies and the different roles of a variety of stakeholders make it difficult to manage the delta in an integrated manner.	**WMO16. Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD).**	**PARTICIPATION**
	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.	
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.	**WMO18. Foster local use of adaptation-to-global-change indicators.**	**STUDY, PILOT & DISSEMINATION**
	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.	
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.	**WMO22. Enhance environmental protected areas.**	**PARTICIPATION**
	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).	
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.	**WMO24. Recovery of wetlands and their connectivity.**	**PILOT & DISSEMINATION**
	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	

<table>
<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.



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 Politècnica 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.

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 media	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
	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
Awareness campaign sessions	Interview on BeWater and adaptation challenges in Tordera	14/04/2016	Radio Tordera, Local broadcast; available on BeWater web page
	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 Politècnica 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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