Pedieos River Basin Adaptation Plan

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Part I & II

BeWater
Society Adapting to Global Change

Pedieos River Basin Adaptation Plan

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Preface

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

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

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

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

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

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Executive Summary

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

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

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

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

Περίληψη

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

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

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

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

Glossary of key terms

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

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

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

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

PART 1

1 Introduction

1.1 Contextualization of the plan

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

Box 1.1. Definition of River Basin Adaptation Plan

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

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

1.2 Objectives and Vision

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

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

The objectives of the Pedieos River Basin Adaptation Plan are:

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

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

1.3 Overview of Contents

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

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

2 The Pedieos River Basin

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

2.1 Current state and dynamics

2.1.1 Current state of the basin

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

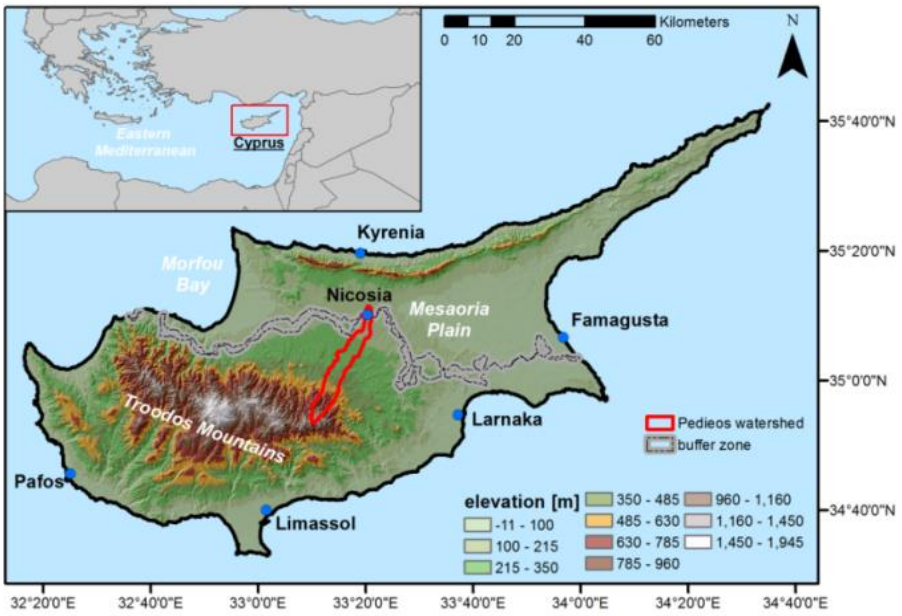


Figure 2.1. Location of the Pedieos River Basin in Cyprus.

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

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

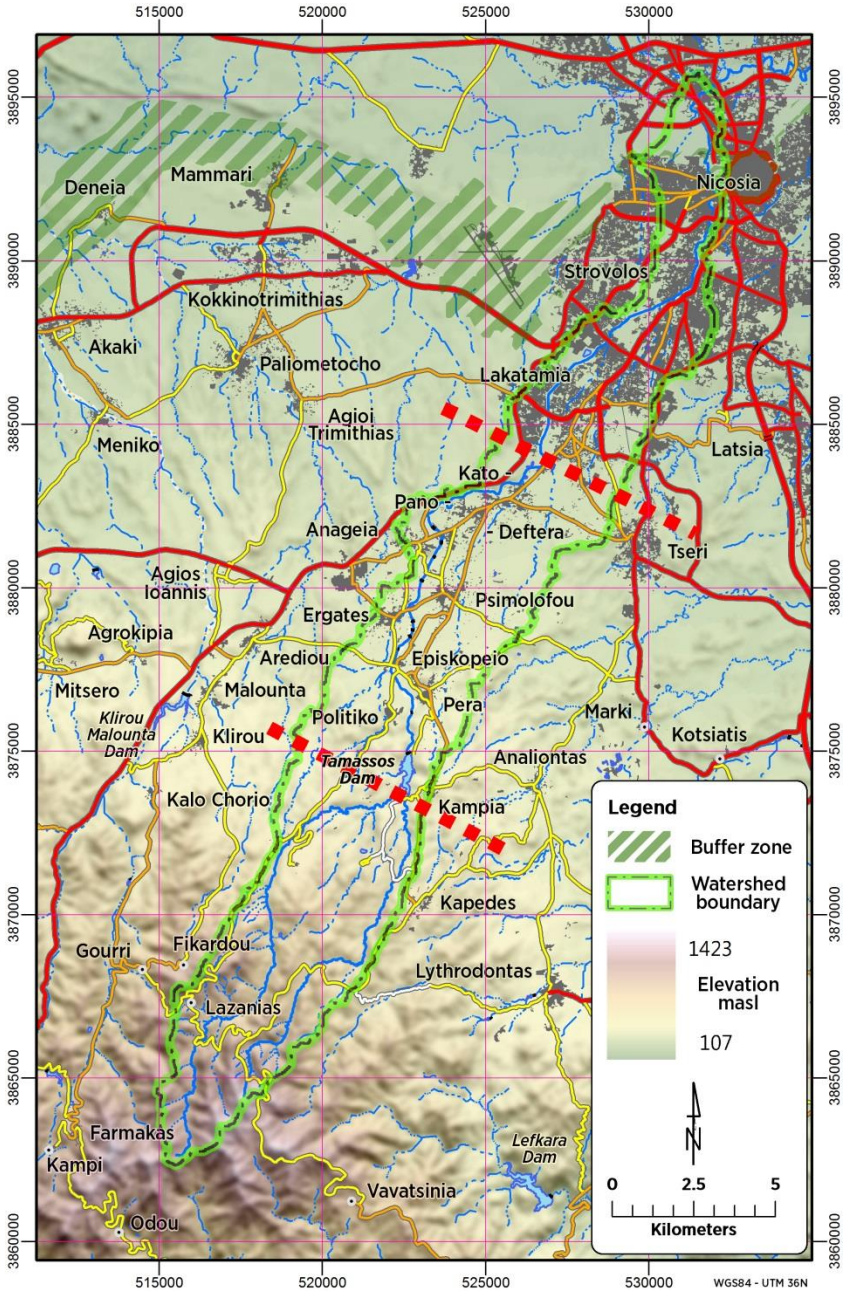


Figure 2.2. The Pedieos river basin; the build-up areas are shown in dark-grey; the red dotted lines indicate upstream, midstream and downstream (North) areas

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

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

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

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

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

2.1.2 Future climate change impacts and water demand

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

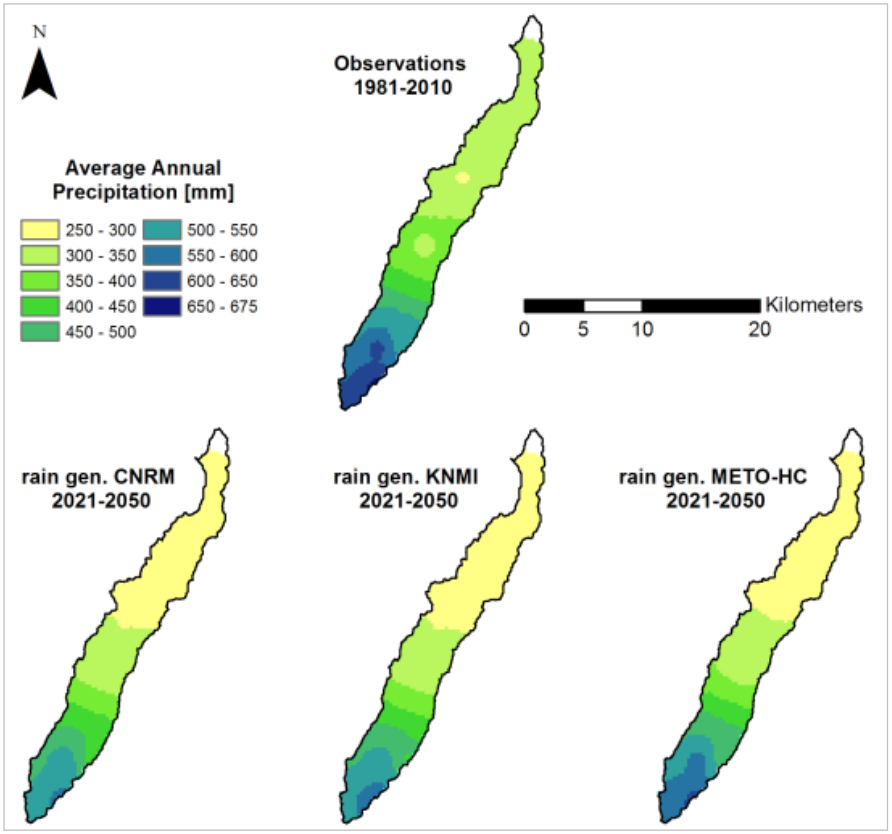


Figure 2.3. Precipitation projections for the period 2021-2050 indicate a drier Pedieos Watershed in the future [xli].

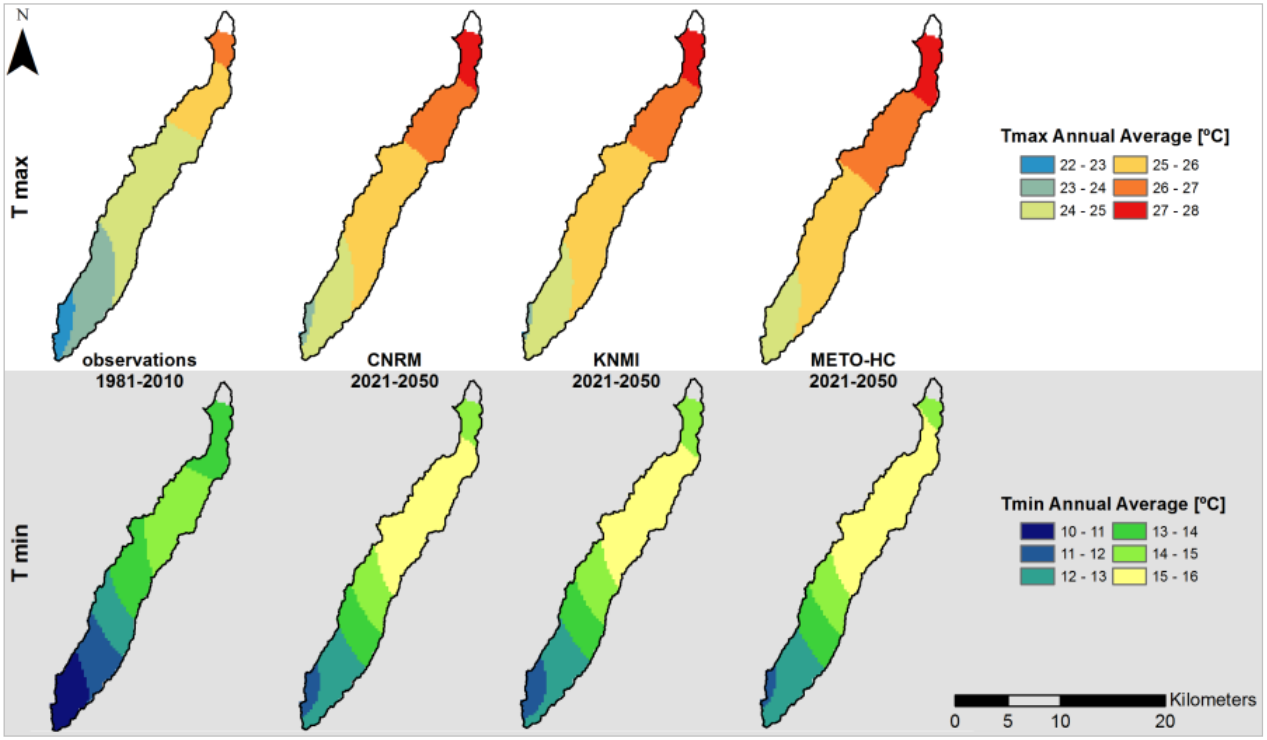


Figure 2.4. Average maximum and minimum temperature projections for the period 2021-2050 show a warmer future for Pedieos Watershed [xxxix].

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

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

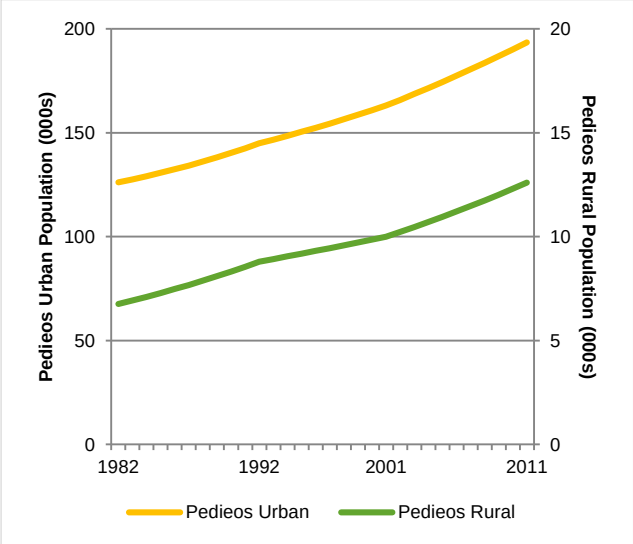


Figure 2.5. Urban and rural population in Pedieos watershed, 1982-2011 [xxxi]

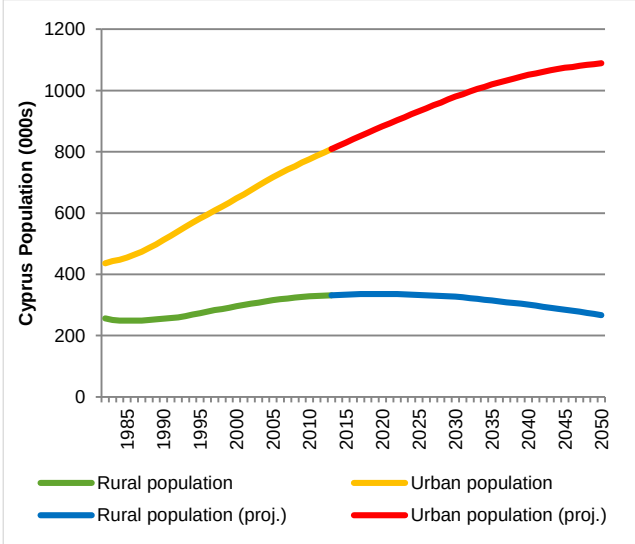


Figure 2.6. Past and projected total urban and rural population in Cyprus [xlii]

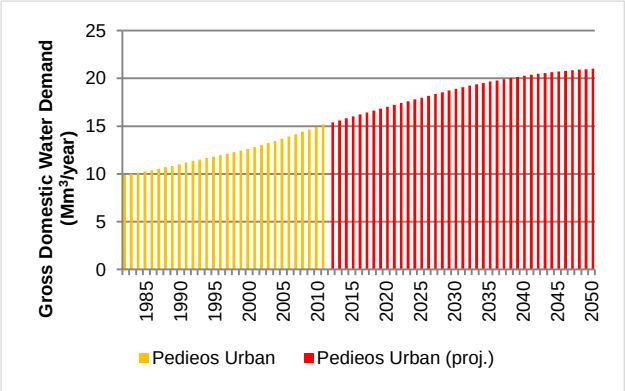


Figure 2.7. Estimated gross domestic water demand in the urban communities of Pedieos watershed (computed by authors, based on [xlii, xliii]).

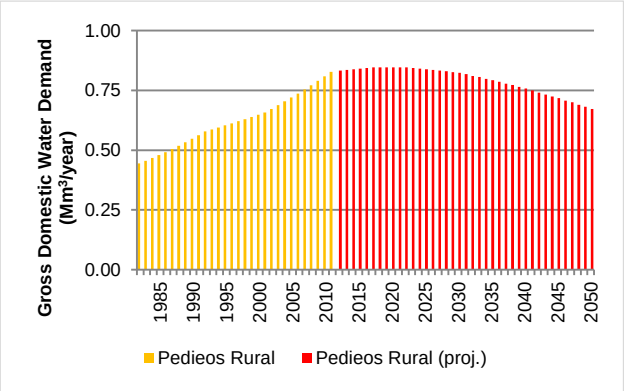


Figure 2.8. Estimated gross domestic water demand in the rural communities of Pedieos watershed (computed by authors, based on [xlii, xliii]).

2.2 Policy Context

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

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

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

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

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

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

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

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

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

(a) Art. 14 *Knowledge transfer and information actions*: soil management; training activities on energy efficiency; reducing greenhouse gas (GHG) emissions; climate change impacts and adaptation

(b) Art. 17 *Investments*: irrigation water use efficiency; green infrastructure; infrastructure for using renewable energy (e.g. biogas); manure storage facilities; energy-efficient equipment and buildings

(c) Art. 20 *Basic services and village renewal*: climate proofing of local development plans

(d) Art. 21 *Investments in forest area development and improvement of the viability of forests*: afforestation; investments

(e) Art. 28 *Agri-environmental measures*: input intensity reduction; manure management; soil management practices; diversified crop rotations; climate-resilient crops

(f) Art. 29 *Organic farming:* reducing energy-intensive production inputs and N_2O emissions from soils

(g) Art. 42-44 *Leader*: climate change mitigation and adaptation as integral element of Local Development Strategies

The Department of Environment of the Ministry of Agriculture, Rural Development and Environment is responsible for implementing and enforcing the environmental legislation in Cyprus. The Department has a legally-binding long-term framework to reduce greenhouse gas emissions and a framework for building Cyprus' ability to adapt to a changing climate. A draft National Adaptation Plan has been developed based on a multi-sectoral climate change vulnerability analysis after an extensive consultation process with the relevant stakeholders [(liii)]. The harmonisation of the European environmental acquis, namely, the Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora, and the Council Directive 79/409/EEC on the conservation of wild birds, through the Republic of Cyprus' Protection and Management of Nature and Wildlife Law 153(I)/2003 and the Republic of Cyprus' Protection and Management of Wild Birds and Game Law 152(I)/2003 [(liv, lv)], forms the cornerstone of Cyprus' environmental policy.

2.3 Main Challenges

Water scarcity and drought are major challenges in Cyprus and in particular in Pedieos River Basin. Agricultural and natural ecosystems are strongly affected by the high annual and inter-annual rainfall variability. The driest September-October hydrologic years in the past 35 years were 1990-1991 and 2007-2008, when the rainfall at the Athalassa station in the downstream area was just 132 and 133 mm, respectively (Fig 2.9). Average reference evapotranspiration for this station, computed with the FAO Penman-Monteith equation [lvi], was 1520 mm (1980-2010). This gives the downstream area an aridity index (Precipitation/Evapotranspiration) of 0.21, which classifies it on the driest edge of the semi-arid climate zone [lvii]. On the other hand, the most extreme daily rainfall event in the past 30 years was 92.6 mm at Athalassa station (27.11.2000) downstream and 196 mm at Kionia (2.12.2001) on the upstream end of the watershed.

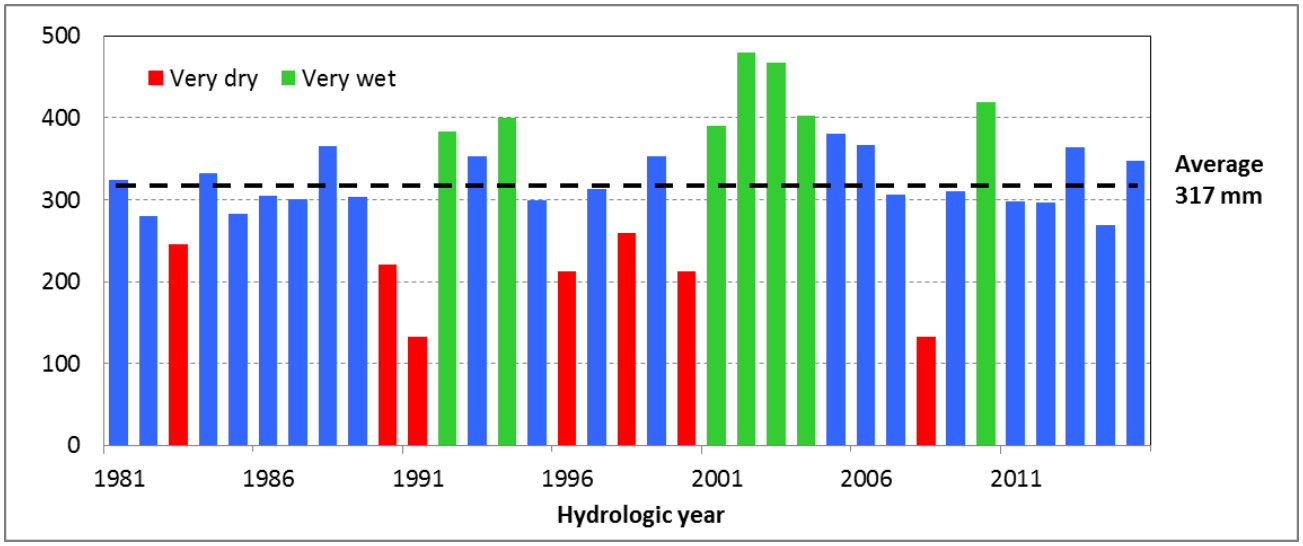


Fig 2.9. Annual rainfall for the past 35 hydrologic years (October 1980 to September 2015) at Athalassa station in the downstream area.

Future climate projections indicate higher temperatures, reduced precipitation volumes and more extreme precipitation events [xxxix]. These projections imply increased water demand for irrigation and domestic water use, potential deterioration of water quality and more severe and frequent flooding events in Pedieos River Basin. Stakeholders identified a wide range of challenges for the Pedieos River Basin. For more details see Section 3.2.2.

3 Participatory Development of Pedieos River Basin Adaptation Plan

3.1 Development process

Stakeholder engagement has gained prominence in the water sector as a principle of good governance in the last years [lviii]. The formulation of the Pedieos River Adaptation Plan is the result of a public participation process. The stakeholder engagement process used comprises several steps of a participatory process, where stakeholders actively participated and provide concrete input in the formulation of the adaptation plan (Figure 3.1).

More precisely, various stakeholders representing several sectors (agriculture, infrastructure, water, environment, energy, forest) and organizational affiliations (business, government authorities, civil society, environmental management practitioners, media, youth and education) were involved through workshops, expert-consultations and face-to-face interviews to: (a) exchange ideas and identify the major challenges for the Pedieos River Basin; (b) identify, formulate and evaluate adaptation options to tackle these challenges. The methodological framework of the adaptation plan is based on the active engagement of stakeholders throughout the different steps of the adaptation plan development (see Figure 3.2).

In parallel to the stakeholder engagement, a comprehensive review of existing river basin adaptation plans and strategies was conducted [lix]. The description of best practice examples provided valuable input for the design of the Pedieos River Basin Adaptation Plan. Figure 3.1 analytically presents the preparatory steps for developing the Pedieos River Basin Adaptation Plan, with indications of when the main events took place. The list of all engagement activities held in Pedieos River Basin is presented in the Annex I.

Figure 3.1. Development process of Pedieos River Basin Adaptation Plan


adaptation plan
BeWater
Society Adapting to Global Change
July–September
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

3.2 Methodological steps followed

This section presents the main methodological steps followed for the development of the Pedieos River Basin Plan (Figure 3.2). Further information on the methodology and results introduced within this adaptation plan, as well as the BeWater Project in general, can be found on the project website (www.bewaterproject.eu).

3.2.1 Identifying and inviting stakeholders

The first step in the formulation of the adaptation plan was to identify the relevant stakeholders within key sectors: (a) water, (b) agriculture, (c) environment, (d) ecology, (e) urban planning and management, (f) forest and (g) education. For the invitation of stakeholders to participatory workshops, a balanced representation across various criteria (e.g. gender, age, organisational affiliation and sector) was aimed for.

3.2.2 Identifying challenges and water management options with stakeholders

During the first stakeholder workshop (July 2014), the participants identified a wide range of medium-to-long term challenges for the Pedieos River Basin and proposed several options to address these challenges. The information from the first workshop was further explored and complemented with 10 additional face-to-face interviews with policy officials. The interviews revealed additional river basin-relevant considerations, such as the current status of adaptation in the region, their experience with public participation in the design of policies and potential conflicts that may appear. The challenges identified by the stakeholders during the first Pedieos stakeholder workshop and the subsequent interviews were consolidated into three overarching challenges (Box 3.1). In order to tackle these challenges, 30 water management options were formulated (see Section 4.1 & Part 2).

Box 3.1. Identified main challenges for the Pedieos River Basin

Challenge A: Quantitative and qualitative status of groundwater

A major challenge identified in the Pedieos River Basin is groundwater quantity and quality. The high temperatures and the increased variability of precipitation leads to increased irrigation water demand that will exacerbate the already high pressures on groundwater resources. A reduction in groundwater quantities will affect irrigated crop production and livestock farms, as well as some of the communities in the midstream area of the Basin that pump groundwater for domestic supply. Over-pumping of groundwater lowers the water table and alters how water moves between the aquifers and the stream. Furthermore, over-pumping of groundwater can also affect the groundwater quality.

The completion of the Tamassos dam at the foothills of the forested Troodos mountains in 2004, has reduced the recharge of the downstream river aquifer. The results of monitoring activities for the European Water Framework Directive have been summarized in the Cyprus River Basin Management Plan and its Annexes [xliii]. The Central and Western Mesaoria groundwater body, which includes the alluvial Pedieos Riverbed aquifer, has been qualified as having a bad quantitative status for the European Water Framework Directive, with dropping groundwater levels [xliii].

Non-point source pollution from agriculture could affect groundwater quality, especially in the rural midstream area of river basin. Croplands are a primary non-point source of contamination to groundwater due to the applications of agricultural chemicals such as fertilizers, pesticides and manure. Excess irrigation water applications may also leach

	agricultural chemicals into groundwater. As a whole, the chemical status of the Central and Western Mesaoria groundwater body has been qualified as good, even though high concentrations of ammonium (NH4) have been found [xliii].
	**Challenge B: Quantitative and qualitative status of surface water** The adverse climatic conditions (increase of temperature & precipitation decrease) will result in diminished surface water supplies. These changes affect the services and the functions of the Tamassos dam water body. The Tamassos dam provides water supply for the nearby rural communities, but has also created a new aquatic ecosystem and recreational area. Surface water flows downstream from the dam are controlled by the release of water from the dam for downstream groundwater recharge. During wet years water flows over the dam spillway and continue downstream. A few small recharge checkdams and diversion structures have been constructed in the midstream area to increase groundwater recharge or divert surface water for irrigation. The reduction in surface water quantities will affect the riparian vegetation and biodiversity habitats of the streams as well as irrigated farming. Similarly to groundwater qualitative status, during peak precipitation events, agro-chemicals from irrigated agriculture and livestock manure are carried away to the river. Urban development has led to the degradation of the riverbed and riparian area. Solid and liquid waste dumping has detrimental effects on the quality of the surface water. Urban sprawl also results in soil sealing in suburban areas of Pedieos River Basin. Pollutants from paved areas can degrade river water quality when washed into the stream.
	**Challenge C: Flooding** The urban area along the Pedieos River has been identified as an area of potentially significant flood risk. Although the Pedieos River in its downstream part is dry most of the year, heavy rainfall events may lead to significant floods, as indicated by the latest flood risk assessment [lx]. Natural vegetation across the riverbed impedes the flow of the water, while illegal dumping of garbage is often blocking waterways and causes localised floods and spill overs of water in the roads. The restoration and maintenance of the riverbed was emphasized by the stakeholders [lxi]. The forests in the upstream area of the River Basin help to regulate relatively minor floods although they are not able to prevent major floods. Crop fields in good state have also a positive contribution to flood prevention in the midstream parts of the river basin. Tamassos dam provides significant flood protection to the midstream and downstream areas of the river basin. The dam modifies the volume of water flowing downstream and alters the natural rates at which river rise and fall during extreme runoff events. The high urban sprawl intensifies soil sealing, which increases the risk of flooding. Flooding is also caused by problems in the rainwater drainage systems in the urban area. Sustainable urban drainage systems are necessary to capture and store surface water runoff and control its release into Pedieos River.

Figure 3.2. Methodological framework of the Pedieos River Basin Adaptation Plan


BeWater
Society Adapting to Global Change
EVALUATING OPTIONS
To evaluate the water management options, the stakeholders select the criteria on which the options will be evaluated, as well as the relative weight of each criterion. The information from the multi-criteria analysis is combined by scientific experts with the outcome of the options' impact assessment. This results in the identification of options that have a desirable impact on the river basin, according to the perceptions of local stakeholders.
Which options have desirable impacts on the river basin?
Assess the impacts of the options through the conceptual 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 evaluating whether the policy objectives, targets and timescales are in line with those of the options, what funding is available, and if eligibility or selection criteria create barriers to adopting the options. This evaluation is then presented to the stakeholders.
How do the options fit within the relevant policy and decision-making frameworks?
Evaluate the options based on multiple decision criteria
IDENTIFYING POLICY ACTORS
As local stakeholders and policy actors will be directly involved in or affected by the implementation and maintenance of the options, their willingness and capabilities to support implementation are important to inform the selection and design of options.
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 stakeholders' expertise and knowledge. Using these outcomes and the results of the multi-criteria analysis, the options are grouped into bundles.
Which synergies or conflicts arise between the options and how can they be grouped together?
Identify key stakeholders and their potential roles in implementing the options
DEVELOPING AN IMPLEMENTATION TIMELINE
The timeline for implementing each of the options within a bundle is based on their effectiveness over time, local stakeholder preferences and the policy framework. Developing the timeline for implementation takes into account factors such as the time lag between implementation and effectiveness, feasibility, acceptability, the policy cycle, associated costs, and the availability of funding. The initial scientific expert assessments were verified by the local stakeholders.
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
The content and design of the river basin adaptation plan is tailored based on an open dialogue between stakeholders and academics, considering local realities and existing examples of adaptation plans in other river basins.
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

3.2.3 Developing a conceptual model for the basin

The information on challenges was used in a next step to develop a conceptual model (fuzzy cognitive map) for the river basin (Box 3.2; Figure 3.3).

Box 3.2. Description of fuzzy cognitive map

A fuzzy cognitive map is a graphical representation of a system - in this case a river basin - where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the sign and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system based on the understanding of individuals. Fuzzy cognitive map allows all the information available on the basin to be organized in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them and their relationships in the system. The map was constructed with inputs from a group of expert stakeholders with different environmental and water management expertise.

The conceptual model was used to qualitatively assess the impact of the 30 water management options on the Pedieos River Basin. The impact of changes in drivers on the dynamics of the river basin was estimated by iteratively multiplying the initial values of all factors with the strength of the relationships. A sigmoid function was used to normalize all factors within the 0-1 range for each multiplication. The impact assessment results were used as input to a multi-criteria analysis that was conducted during the second stakeholder workshop (Section 3.2.4).

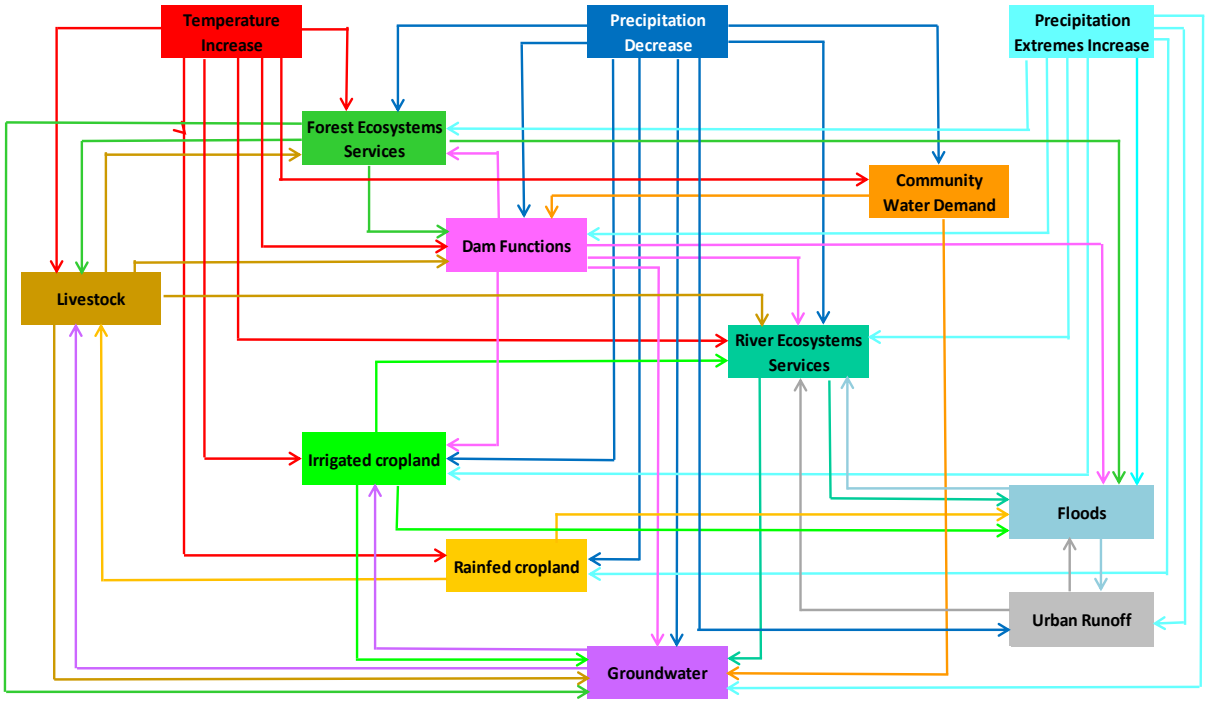


Figure 3.3. Pedieos River Basin conceptual model

3.2.4 Evaluating water management options

Water management options have quite different characteristics and impacts on the river basin and the local communities. To evaluate the specific options that should be included in the river basin adaptation plan, a participatory multi-criteria analysis was conducted (Box 3.3).

Box 3.3. Description of multi-criteria analysis

During the second workshop (1 July 2015), 19 stakeholders were asked to select evaluation criteria and to express their opinion on the performance of water management options. The scores and weights of the criteria given by the stakeholders were combined with the characterization of the water management options and the outcomes of the impact assessment (as explained in the section 3.2.3) to evaluate the water management options prepared by experts and scientists. The evaluation results are presented on a scale of 0-100 with 0 indicating the least preferred evaluation outcome and 100 the most preferred evaluation outcome.

According to the multi-criteria analysis results (Figure 3.4), *farm education* (WMO6) was highly preferable among stakeholders to address the quantitative and qualitative status of groundwater (Challenge A) followed by the *awareness campaign for local society* (WMO9). The enforcement of the *Code of Good Agricultural Practices* (WMO13) and *volunteerism* (WMO20) were similarly the highest ranked options for the quantitative and qualitative status of surface water (Challenge B). Finally, *improved stakeholders' cooperation* (WMO25) and *sustainable urban drainage systems* (WMO28) received the highest scores for Challenge C (flooding from the river). The least preferable options were the *construction of flood protection works* (WMO29), *agrotourism development* (WMO10), *use of treated sewage water for irrigation and green infrastructure* (WMO4) and *improved irrigation technologies* (WMO1).

However, the use of multi-criteria analysis for evaluating adaptation options requires careful consideration of normalization, weighting and the combination of continuous and categorical criteria. Thus, an additional evaluation of the water management options was conducted through the direct scoring of the options by the stakeholders. The results suggested that *dynamic dam water management* (WMO8) and *borehole licences and water meters* (WMO2) were highly preferable among stakeholders to address the quantitative and qualitative status of groundwater (Challenge A). The enforcement of the *Code of Good Agricultural Practices* (WMO13) was the highest ranked option for the quantitative and qualitative status of surface water (Challenge B), while the *restoration and maintenance of riverbed* (WMO26) was the most preferable option for the Challenge C (flooding from the river).

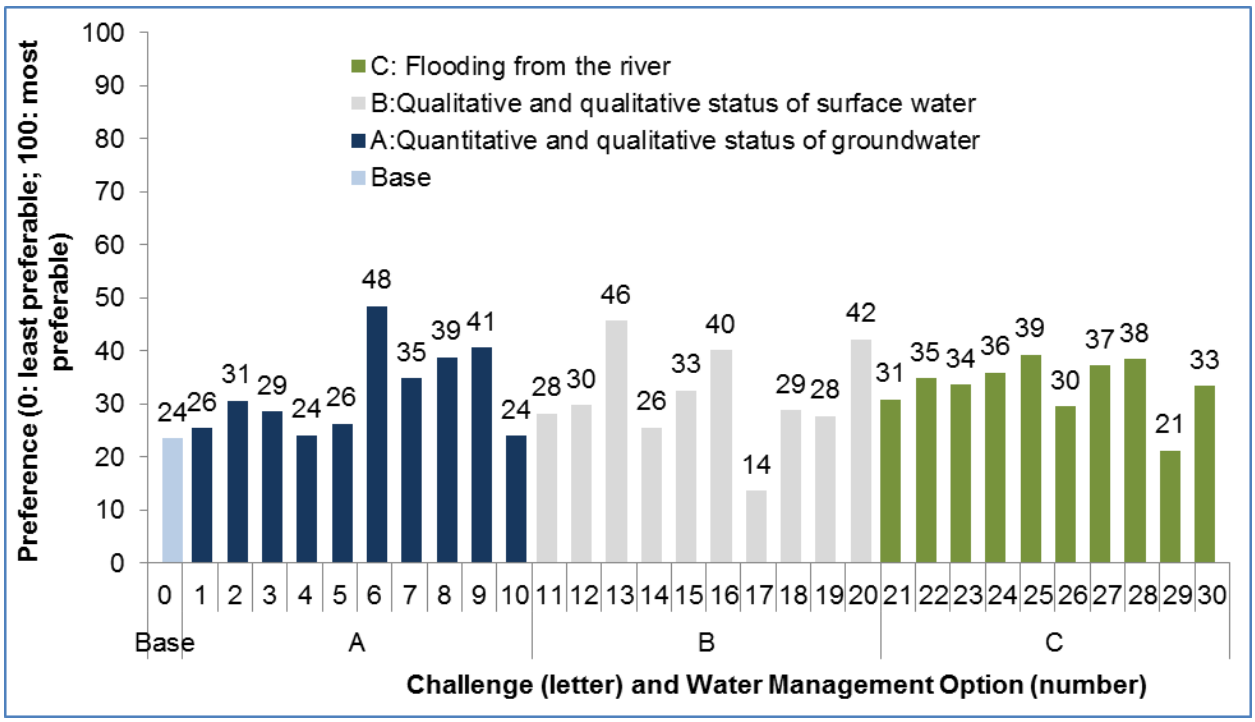


Figure 3.4. Multi-criteria analysis results based on the 15 criteria derived from the conceptual model of the river basin and the characterization of the water management options. Numbers on the x-axis refer to the water management options in Table 4.1; number 0 is the baseline.

Multi-criteria analysis results were used for the development of the bundles of water management options in the Pedieos River Basin Adaptation Plan. In addition, a cost assessment of the selected water management options was conducted from the beginning of their implementation plan (2016) towards 2030. The cost assessment included both capital and operational costs of the required actions for the implementation and maintenance of the options (see Section 4.1.1).

3.2.5 Bundling of adaptation options

Stakeholders assessed the potential synergies and conflicts between the adaptation options. More precisely, they compared the impact of different combinations of options with the implementation of individual options. The bundling process was based on the normalised co-benefit scores, the results of the multi-criteria analysis and the time implementation scores. Stakeholders highlighted the effectiveness of implementing bundles of adaptation options compared to implementing individual options. The formulated bundles of adaptation options are presented in Section 4.2.

3.2.6 Implementation timeline of bundles of adaptation options

The next step in the bundling of the adaptation options includes the identification of options for implementation in the short, medium or long term. Stakeholders developed the implementation timeline and the priority of the individual adaptation options within the proposed bundles based on their preferences and the effectiveness of the options over time (see Section 4.2).

3.2.7 Designing an Adaptation Plan for the Pedieos River Basin

Stakeholders provided valuable feedback regarding the structure of the River Basin Adaptation Plan and acknowledged the contribution of the adaptation plan in mitigating the challenges of the Pedieos River Basin. They also expressed their views on potential barriers and opportunities for the implementation of the adaptation options.

4 Adaptation actions

4.1 Context

4.1.1 Water management options for the Pedieos River Basin

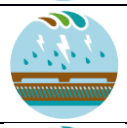
In total 30 water management options for Pedieos River Basin were formulated based on input collected from stakeholders during the first stakeholder workshop, as well as through face-to-face interviews with policy officials. In addition, information from a review of policy documents including the national strategy for adaptation to climate change [(liii)] and other international river basin adaptation plans and strategies, were taken into account. The options range from nature-based to technical and managerial and are listed in Table 4.1; a detailed description of the water management options is provided in Part 2. While the options are grouped together in **bundles** in Chapter 4 according to their synergistic interactions with one another and a common objective they contribute to, this table provides an overview of information that is specific to an option. This information can be used by decision-makers when determining which single option(s) would be most appropriate to achieve targeted objectives.

More specifically, each option is associated with one or more of the challenges identified for the Pedieos River Basin, i.e., 25 options address the quantitative and qualitative status of groundwater (**challenge A**), 24 options address the quantitative and qualitative status of surface water (**challenge B**), and 14 options address the flooding from the river (**challenge C**). Thus, several options address more than one challenge (Table 4.1). However, to facilitate the evaluation of the options, the key challenge that each option addresses was identified (see Table 4.1). Each option is further characterized by a set of additional implementation-oriented factors, such as its acceptability and synergies. These factors help to determine whether there will be barriers to the implementation of an option, or conversely, if there are opportunities that facilitate its implementation.

Considering the 15-year implementation period of the plan (2016-2030), the cost assessment of the selected water management options revealed that the technical options (grey approaches to adaptation) are the most expensive, e.g., *rainwater harvesting systems* (WMO21), *use of treated sewage water for irrigation and green infrastructure* (WMO4) and *sustainable urban drainage systems* (WMO28). On the contrary, managerial and policy oriented approaches to adaptation have low cost, e.g., *volunteerism* (WMO20), *improvement of stakeholders' cooperation* (WMO25) and *improvement of plant genetic resources bank and use of drought tolerant agricultural crops* (WMO7). The acceptability of the adaptation options among the local actors of the river basin is high for 67% of the options, while only for two adaptation options there were serious obstacles (physical, regulatory or organisational) that would be difficult to overcome within the time horizon of the project. These two options refer to *water pricing enforcement* (WMO3) and *dam demolition* (WMO17). Half of the adaptation options create high co-benefits and synergies with the other options, while only two options, i.e., *fire safety measures* (WMO23) and *construction of flood protection works* (WMO29), seem to create low co-benefits.

Table 4.1. Overview of the water management options for the Pedieos River Basin

		Water Management Options	Challenges Addressed	Key Challenge Addressed	Cost[1]	Co-benefits[2]	Acceptability[3]
1		Improved irrigation technologies	A-B	A	€€	+++	++
2		Borehole licences and water meters	A	A	€€€	+++	++
3		Water pricing enforcement	A-B	A	€€	+++	+
4		Use of treated sewage water for irrigation and green infrastructure	A-B	A	€€€	++	+++
5		Water desalination	A-B	A	€€€	++	+++
6		Farm education	A-B	A	€€	+++	+++
7		Improve plant genetic resources bank and use of drought tolerant agricultural crops	A-B	A	€	++	+++
8		Dynamic dam water management	A-B-C	A	€€	++	+++
9		Awareness campaign for local society	A-B	A	€€	+++	+++
10		Agrotourism development	A-B-C	A	€€€	++	++
11		Domestic water saving equipment	A-B	B	€€€	+++	+++
12		Maintenance and repair of water distribution networks	A-B	B	€€€	++	+++
13		Code of Good Agricultural Practices enforcement	A-B	B	€€	+++	++
14		Grazing control	A-B	B	€€	+++	++
15		Improve plant genetic resources bank and use of drought tolerant forest species	A-B	B	€€	++	+++

16		Hydrological studies	A-B	B	€€	+++	+++
17		Dam demolition	A-B-C	B	€€€	++	+
18		Integrated waste management	A-B	B	€€€	+++	+++
19		Construction of multi-purpose cycling/ walking paths across the river	A-B	B	€€€	++	+++
20		Volunteerism	A-B-C	B	€	+++	+++
21		Rainwater harvesting systems	A-B-C	C	€€€	+++	++
22		Improve plant genetic resources bank and use of drought tolerant plants in green infrastructures	A-B-C	C	€€	+++	+++
23		Fire safety measures	A-B-C	C	€€	+	+++
24		Improving land zonation	A-B-C	C	€€	++	++
25		Improve stakeholders' cooperation	A-B-C	C	€	++	+++
26		Restoration and maintenance of riverbed	C	C	€€	+++	+++
27		River runoff retention and groundwater recharge systems	C	C	€€	+++	+++
28		Sustainable urban drainage systems	C	C	€€€	++	+++
29		Construction of flood protection works	C	C	€€€	+	++
30		Cooperation for storm water drainage system	C	C	€€	++	+++

[1] €: low cost (<100,000 euro); €€: medium cost (100,000-1,000,000 euro); €€€: high cost (>1,000,000 euro)
[2] +: low co-benefits; ++: medium co-benefits; +++: high co-benefits
[3] +: low acceptability; ++: medium acceptability; +++: high acceptability

4.2 Bundles of adaptation options

Evidence from studies of adaptation to past and current climate variability indicates that adaptation options are rarely adopted singly [lxii]. Instead, bundles of adaptation options are adopted together in an attempt to address the multiple impacts of climate change on river basins and maximise the co-benefits between different adaptation options. Local stakeholders also stressed the effectiveness of implementing bundles of adaptation options, compared to implementing individual options. The development of complementary bundles of adaptation options enhances synergistic benefits and reduces trade-offs. However, not all adaptation options are necessarily compatible with one another.

The identified adaptation options for Pedieos River Basin Adaptation Plan were bundled with one another based on their co-benefits and conflicts. Scientists and key expert stakeholders assessed the impact of different combinations of adaptation options in relation to the implementation of individual options. Based on this co-benefits analysis, groups of adaptation options with high co-benefits were grouped together. More precisely, the bundling process was based on three key pieces of information: (a) the results of the multi-criteria analysis, (b) co-benefits with other options (the co-benefit scores) and (c) the urgency and synergies for implementation of the options (time implementation scores). The adaptation options could be included in more than one bundle according to the aforementioned criteria.

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

The six bundles of adaptation options are presented in Sections 4.2.1 to 4.2.7. These sections provide summarised information for each bundle, including:

- the focus of each bundle
- the adaptation options per bundle
- the adaptation pathway representing the implementation of the options in different time-oriented phases, i.e. short-term (2018), mid-term (2021) and long-term (2025), and
- the way forward, i.e., implementation avenues.

4.2.1 Sustainable Irrigation Water Management (Bundle 1)

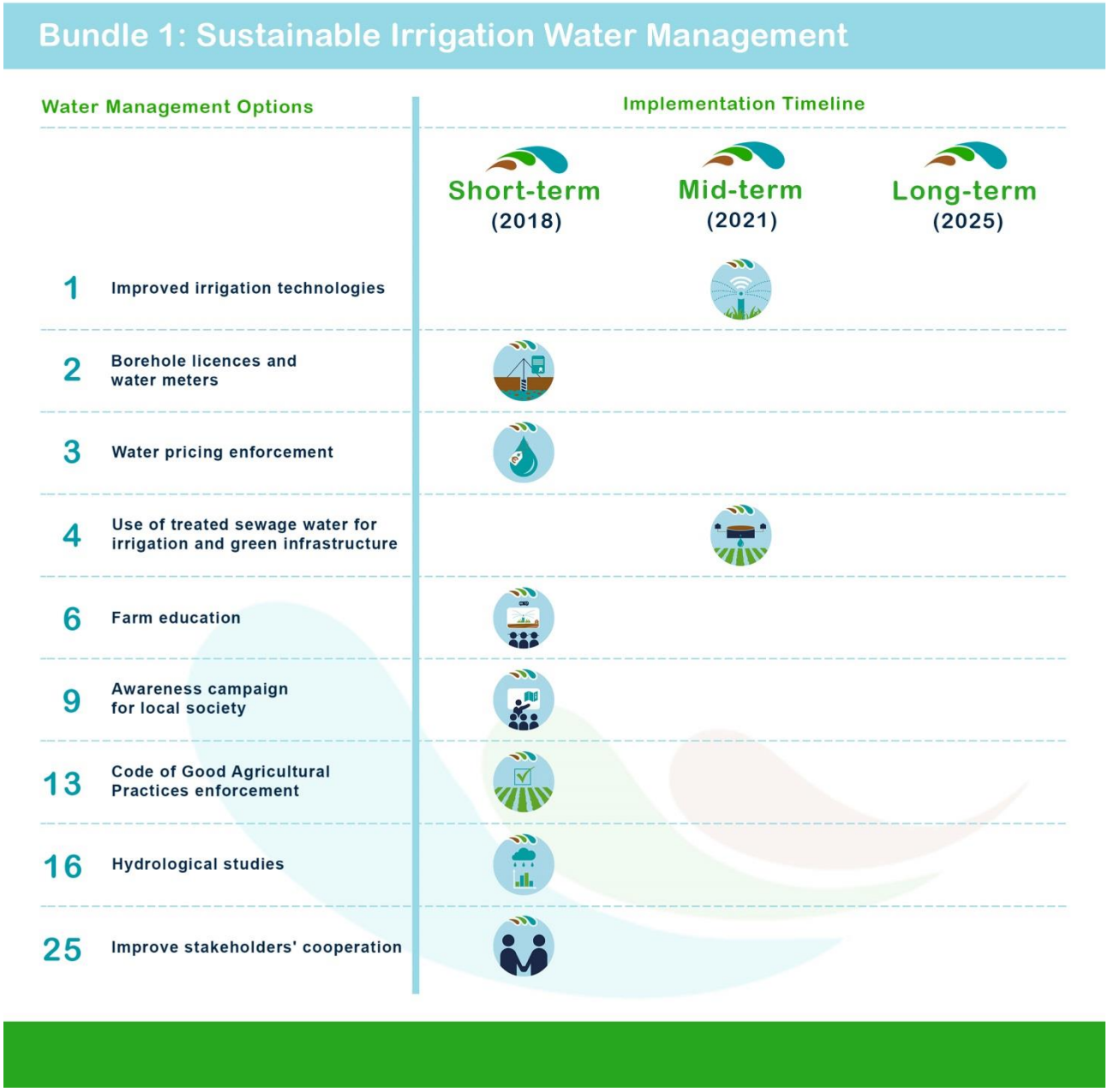
The sustainable irrigation water management bundle aims to match water demand with the sustainable use of water resources. This is achieved through a holistic/integrated approach including farmers' education, training and knowledge transfer regarding sustainable irrigation management. In addition, the adoption of innovative irrigation systems and other managerial options, such as the full cost recovery for water services via water pricing, the installation of water metering equipment and the strict implementation of the Code of Good Agricultural Practices.

Proposed combination of WMOs

Context	Water Management Options	
The installation of modern irrigation systems and technologies, namely irrigation scheduling decision support systems, including wireless sensor network, results in savings of irrigation water.		**WMO 1: Improved irrigation technologies** • The option aims to establish 100 irrigation blocks in the midstream areas of the river basin (downstream from Tamassos dam), where groundwater-irrigated crops prevail (e.g. vegetables). • The adoption of irrigation scheduling decision support systems will result in the improvement of the quantitative and qualitative status of groundwater. • Positive effects will be created for irrigated agriculture.
Specific law requirements for granting license for borehole drilling and installation of water meters on groundwater pumps.		**WMO 2: Borehole licences and water meters** • The option targets the whole river basin. • The option aims at measuring and controlling groundwater abstraction and reducing its overexploitation. It aims to install groundwater meters on 10,000 wells • Positive indirect effects will be created for irrigated agriculture and livestock.
The enforcement of a water pricing policy that ensures the full cost recovery of water services and takes into account the polluter pays principle provide adequate incentives for users to use water resources efficiently.		**WMO 3: Water pricing enforcement** • The option targets the whole river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects will be created for irrigated agriculture
The use of non-conventional water resources such as treated sewage water increase water availability for agriculture and amenity use (green spaces) and can substantially alleviate the pressures on water resources which are very high in Cyprus.		**WMO 4: Use of treated sewage water for irrigation and green infrastructure** • The option targets the midstream and downstream areas of the river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive effects will be created for irrigated agriculture and livestock
Global change related farm education. The training of local farmers on the rational use of water resources and agrochemical inputs will improve the resilience of agricultural ecosystems		**WMO 6: Farm education** • The option targets the upstream and midstream areas of the river basin • The improvement of farm education will create significant positive effects to agriculture (both irrigated and rainfed) and livestock. • The ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization and provision of habitat for biodiversity) will be improved as well as the quantitative and qualitative status of groundwater.
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly		**WMO 9: Awareness campaign for local society** • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including

younger generation about challenges related to water resources and global change and the importance of water conservation.		sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
The strict implementation of the Code of Good Agricultural Practices reduces the leaching and surface runoff of agrochemicals and livestock waste from crop and livestock farming.		**WMO 13: Code of Good Agricultural Practices enforcement** • The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. • The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The strict implementation of the option slightly reduces flooding from the Pedieos River
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		**WMO 16: Hydrological studies** • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		**WMO 25: Improve stakeholders' cooperation** • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO1 	• The Rural Development Programme 2014-2020 has identified water scarcity as a major challenge and supports investments in irrigation scheduling infrastructure to provide economic and environmental benefits	• Department of Agriculture (MARDE) • Farmers
WMO2 	• Groundwater abstraction control is one of the major requirements of the Water Framework Directive	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO3 	• Within the Water Framework Directive, Cyprus is required to set up a water pricing policy that ensures an adequate cost recovery of water services, taking into account the polluter pays principle	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO4 	• The Department of Agriculture aims to promote the use of treated sewage water in irrigation. • The Water Development Department aims to further promote the use of treated sewage water. Wastewater collection and treatment infrastructure is being significantly expanded and/or upgraded. The lower water prices set for treated water compared to freshwater creates an incentive for farmers to turn to the use of recycled water. • Department of Environment aims to further promote the use of treated sewage water for green spaces	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Farmers • Civil society (NGOs)
WMO6 	• Rural development policy towards 2020 (CAP 'Health Check') extends its intervention domains in the fields of global change, water management and biodiversity. Farmers are urged to be trained on issues such as the integrated and sustainable management of natural resources and the application of farm practices compatible with global change challenges • Cyprus guidelines for urban treated effluents for irrigation requires the training of farmers on the safe and efficient use of treated sewage water	• Department of Agriculture (MARDE) • Farmers
WMO9 	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO13 	• The Department of Agriculture aims to improve the control system related to the guidelines of the Code of Good Agricultural Practices. The enforcement of cross-compliance requirements is mandatory for all farmers receive farm subsidies. • The Department of Environment is very supportive towards the strict implementation of the Code of Good Agricultural Practices as it will strengthen biodiversity conservation	• Department of Environment (MARDE) • Department of Agriculture (MARDE) • Farmers

WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)

4.2.2 Good governance (Bundle 2)

The good governance bundle focuses on policy, social, economic and administrative systems that affect decision-making regarding the water resources management. It includes the manner in which the roles and responsibilities (design, regulation and implementation) by formal and informal institutions are exercised in the water resources management.

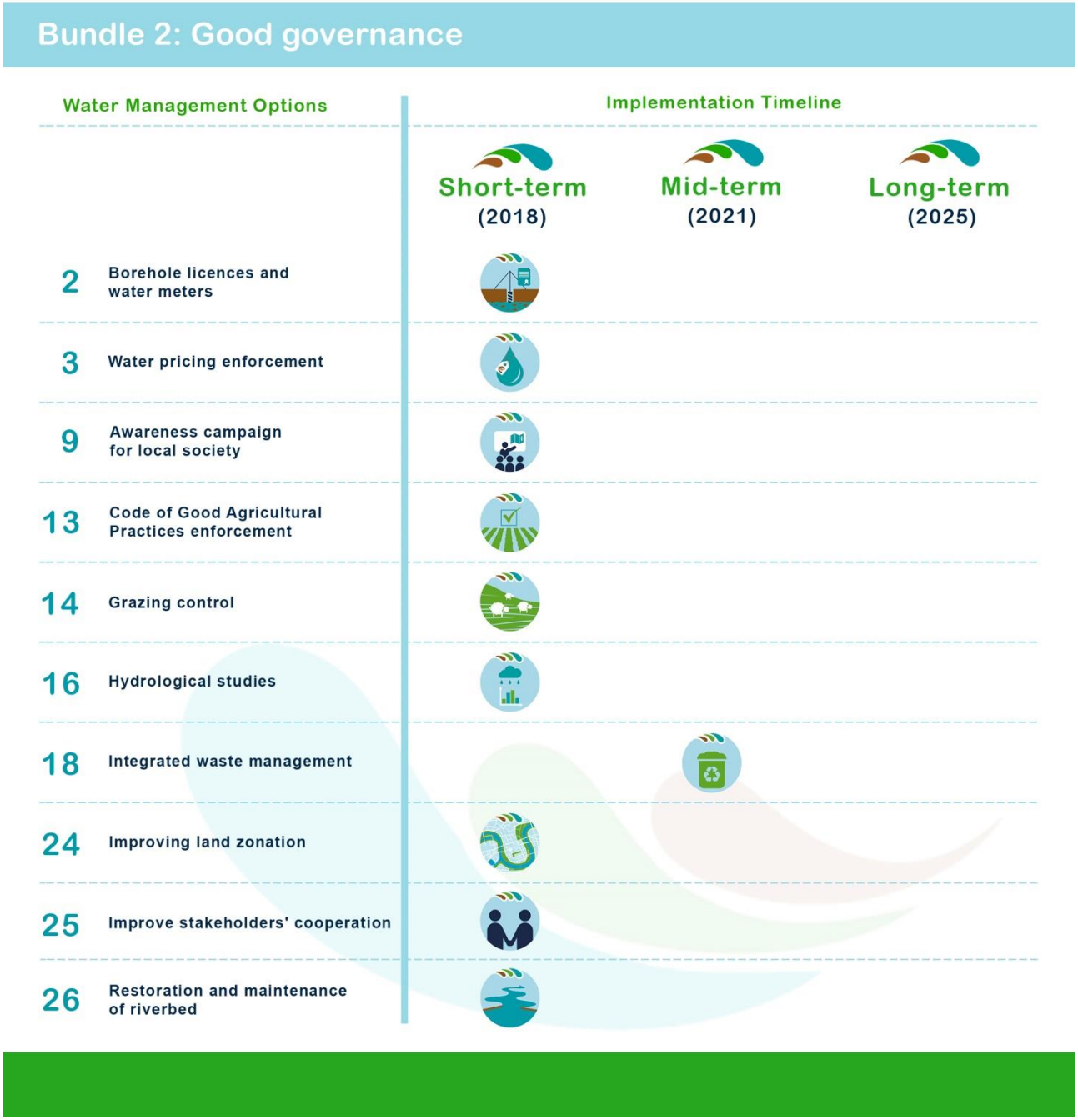
Proposed combination of WMOs

Context	Water Management Options	
Specific law requirements for granting license for borehole drilling and installation of water meters on groundwater pumps.		WMO 2: Borehole licences and water meters • The option targets the whole river basin. • The option aims at measuring and controlling groundwater abstraction and reducing its overexploitation. It aims to install groundwater meters on 10,000 wells • Positive indirect effects will be created for irrigated agriculture and livestock.
The enforcement of a water pricing policy that ensures the full cost recovery of water services and takes into account the polluter pays principle provide adequate incentives for users to use water resources efficiently.		WMO 3: Water pricing enforcement • The option targets the whole river basin • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects will be created for irrigated agriculture
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.

The strict implementation of the Code of Good Agricultural Practices reduces the leaching and surface runoff of agrochemicals and livestock waste from crop and livestock farming.		WMO 13: Code of Good Agricultural Practices enforcement • The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. • The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The strict implementation of the option slightly reduces flooding from the Pedieos River
The control of grazing by permits on the basis of the carrying capacity of the area reduces soil erosion and runoff.		WMO14: Grazing control • The option targets the upstream and midstream areas of the river basin • The grazing control significantly strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. • It is an effective measure for preventing soil erosion reducing thus runoff and the risk of flooding.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
Establishment of protection zones across river basin to control housing development. Land zonation maps and laws need to be improved, widely disseminated and properly enforced.		WMO 24: Improving land zonation • The option targets the whole river basin • The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water • The implementation of the option improves the

		performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River • The implementation of the option improves the qualitative and quantitative status of groundwater.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO2 	• Groundwater abstraction control is one of the major requirements of the Water Framework Directive	• Water Development Department (MARDE) • Farmers • Civil society (NGOs)
WMO3	• Within the Water Framework Directive, Cyprus is required to set up a water pricing policy that ensures an adequate cost recovery of water services, taking into account the polluter	• Water Development Department (MARDE) • Farmers

	pays principle	• Civil society (NGOs)
WMO9 	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO13 	• The Department of Agriculture aims to improve the control system related to the guidelines of the Code of Good Agricultural Practices. The enforcement of cross-compliance requirements is mandatory for all farmers receive farm subsidies. • The Department of Environment is very supportive towards the strict implementation of the Code of Good Agricultural Practices as it will strengthen biodiversity conservation	• Department of Environment (MARDE) • Department of Agriculture (MARDE) • Farmers
WMO 14 	• The control of grazing is one of the major objectives of forest policy in Cyprus	• Department of Environment (MARDE) • Department of Forests (MARDE) • Livestock breeders
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO18 	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO24 	• The Department of Town Planning and Housing aims to properly enforce land zonation laws and plans	• Department of Town Planning and Housing (Ministry of Interior)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26 	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)

4.2.3 Sustainable urban drainage and flood management (Bundle 3)

The sustainable urban drainage and flood management bundle focuses on strategies and systems designed to: (a) efficiently manage the drainage of surface water in the urban environment; (b) reduce runoff by reducing impermeable areas; (c) reduce flooding; (d) recharge groundwater resources.

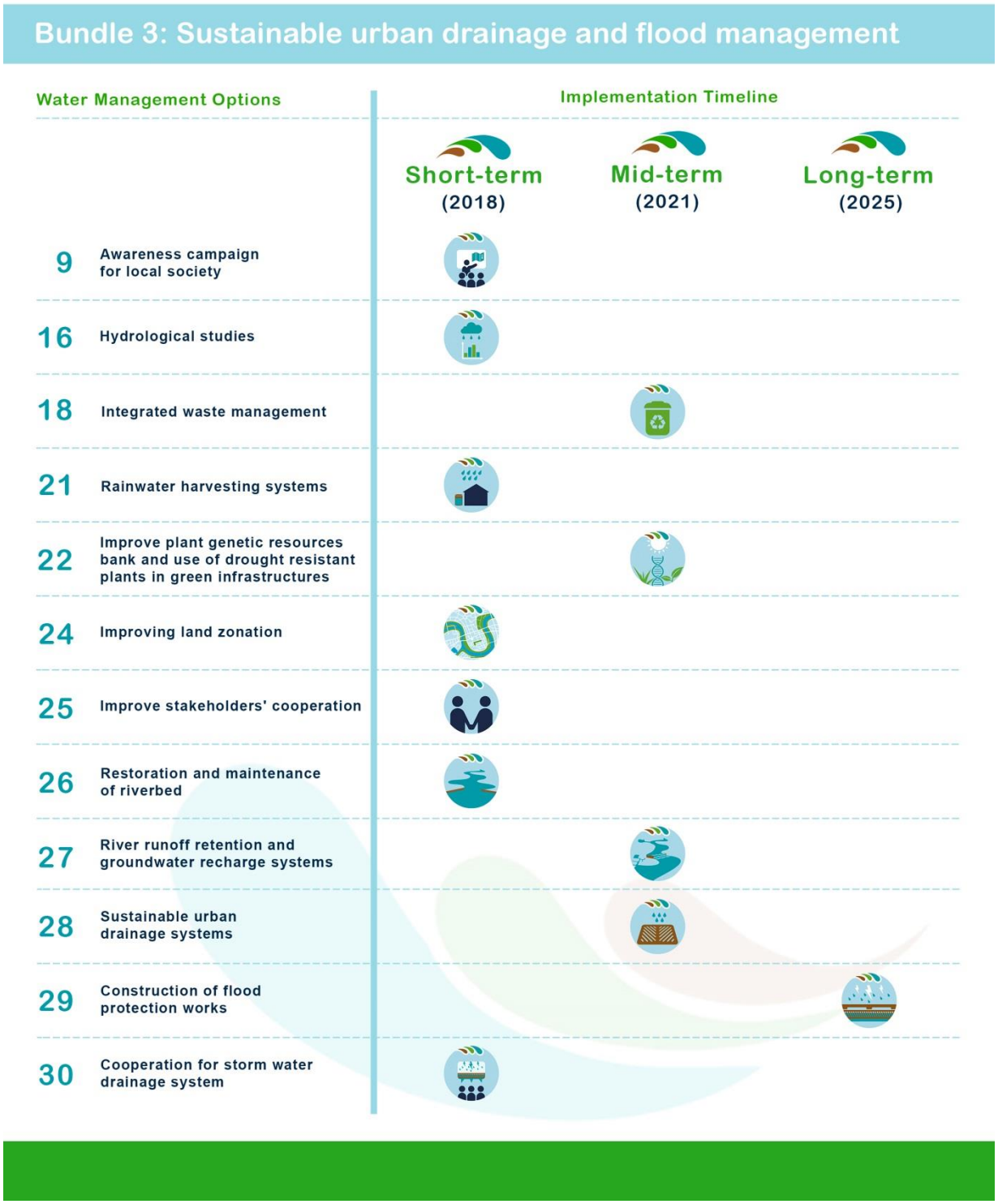
Proposed combination of WMOs

Context	Water Management Options	
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and climate change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
The installation of rainwater harvesting systems will supplement water supply at both household (e.g. collect surface runoff from roofs and paved areas in storage tanks; use of stored water for irrigation of gardens) and farm (e.g. collect surface runoff from roofs of farm buildings and greenhouses; use of stored water for irrigation of agricultural crops) level.		WMO 21: Rainwater harvesting systems • The option targets the whole river basin • The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects are created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos River.
Improvement of green		WMO 22: Improve plant genetic resources bank and use of

infrastructures with drought tolerant plants. Parks, gardens and green areas along roads can be grown with plants that maintain a protective land cover and need little or no irrigation. The option aims to improve the systematisation and organisation of the plant genetic resources bank.		drought tolerant plants in green infrastructures • The option targets the midstream and downstream areas of the river basin • The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on the provision of the river and riparian zone ecosystem services (including sediment and nutrient filtering, bank stabilization) as well as the quantitative and qualitative status of groundwater.
Establishment of protection zones across river basin to control housing development. Land zonation maps and laws need to be improved, widely disseminated and properly enforced		WMO 24: Improving land zonation • The option targets the whole river basin • The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water. • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. • The implementation of the option improves the qualitative and quantitative status of groundwater.
The construction of river runoff retention systems including detention basins, retention ponds and check dams prevents flooding and improves groundwater recharge and water quality		WMO 27: River runoff retention and groundwater recharge systems • The option targets the midstream and downstream areas of the river basin. • The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Systems including green roofs and green ditches that capture surface water runoff through local collection, storage,		WMO 28: Sustainable urban drainage systems • The option targets the midstream and downstream areas of the river basin. • The development of sustainable urban drainage systems

recharge, re-use or release into Pedieos River with low environmental impact		improve the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option also reduces the urban runoff and the flooding from the river.
Technical flood protection through the construction of anti-flooding works such as terraces, rectangular culverts and hydraulically designed bridges.		WMO 29: Construction of flood protection works • The option targets the downstream areas of the river basin • The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.
Cooperation between municipalities for the design of storm water drainage systems at the downstream watershed level. This is a soft measure		WMO 30: Cooperation for storm water drainage system • The option targets the downstream watershed areas • The improvement of cooperation between municipalities significantly reduces urban runoff and the flooding from the Pedieos River, while it improves the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).

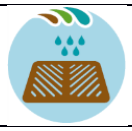
Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO9	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households

		• Civil society (NGOs)
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO18 	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO21 	• The Department of Agriculture aims to promote the installation of rainwater harvesting systems at farm holdings. Efforts will be made these systems to be subsidized under the Rural Development Programme. • The Water Development Department promotes the installation of rainwater harvesting systems	• Department of Agriculture (MARDE) • Water Development Department (MARDE) • Farmers
WMO22 	• The Agricultural Research Institute of Cyprus is involved in the conservation of genetic resources (including collection, conservation and utilisation of the genetic variability existing in local germplasm) and the genetic improvement of plants for adaptation to climate change by increasing their resistance to abiotic and biotic stresses and their adaptability to the warm and dry environment of Cyprus. • Competent authorities, i.e. municipalities, promote native plants that are drought tolerant and low maintenance for green infrastructures	• Agricultural Research Institute (MARDE) • Municipalities
WMO24 	• The Department of Town Planning and Housing aims to properly enforce land zonation laws and plans	• Department of Town Planning and Housing (Ministry of Interior)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26 	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)
WMO27 	• River runoff retention systems are of high importance within Water Framework Directive and Floods Directive • Municipalities aim to promote the construction of river runoff retention systems	• Water Development Department (MARDE) • Municipalities
WMO28	• Water Development Department promotes the installation of sustainable urban drainage systems • Municipalities promote the installation of sustainable	• Water Development Department (MARDE) • Civil society (NGOs)

	urban drainage systems	
WMO29 	• Water Development Department promotes the construction of flood protection works including bridges, terraces and retaining walls • Municipalities and communities promote the construction of small flood protection works	• Water Development Department (MARDE) • Municipalities
WMO30 	• Floods Directive encourages cooperation between municipalities within sub-basins • Municipalities aim to strengthen cooperation amongst their competent authorities	• Water Development Department (MARDE) • Municipalities

4.2.4 Hydrological Management (Bundle 4)

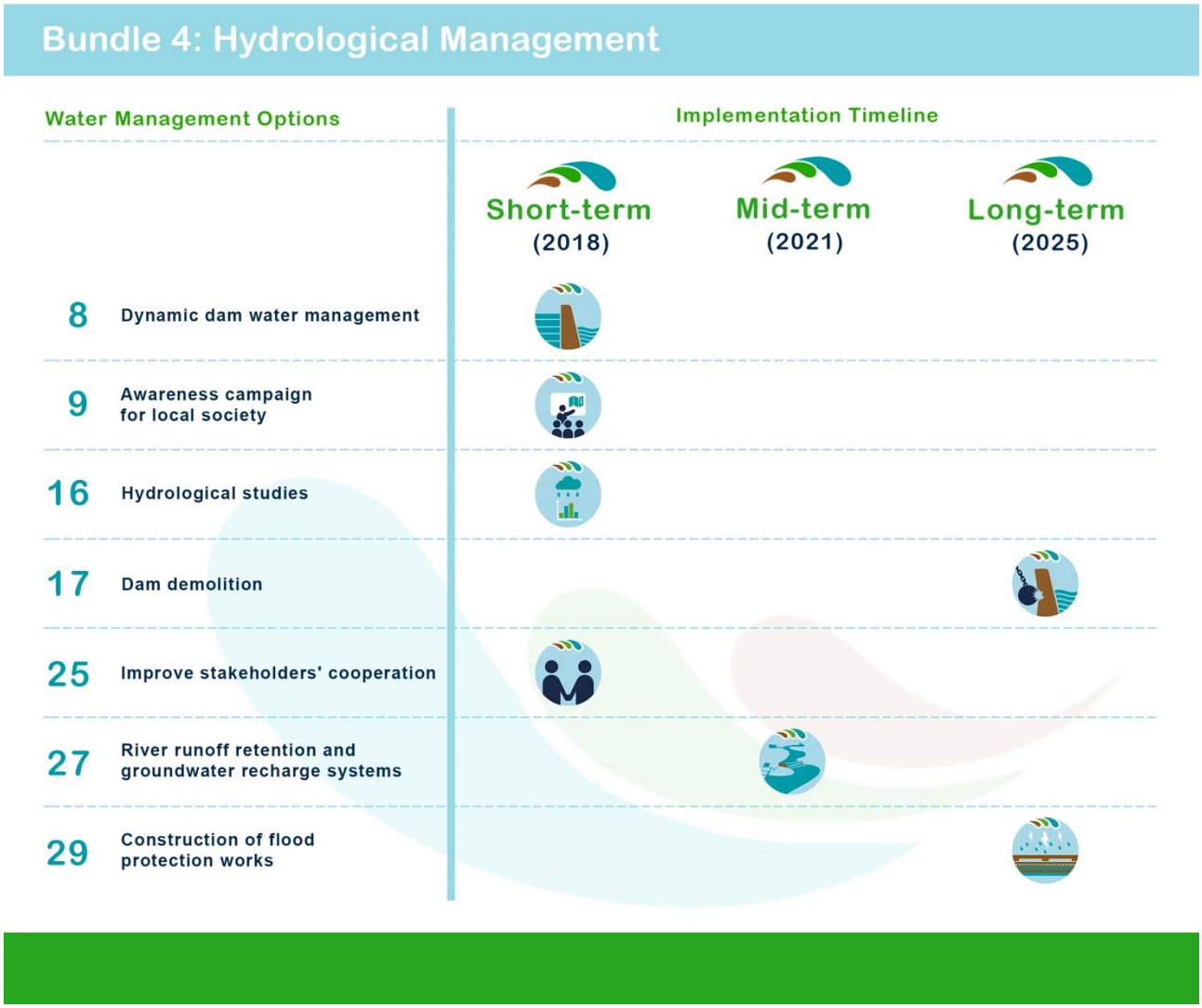
The focus of the hydrological management bundle is to understand the behaviour of hydrologic systems. It aims to improve the quantitative and qualitative status of water resources and to prevent flooding.

Proposed combination of WMOs

Context	Water Management Options	
The dynamic management of the water in the reservoir optimizes environmental services, prevents flooding and improves groundwater resources		WMO 8: Dynamic dam water management • The option targets the midstream and downstream areas of the river basin (downstream from Tamassos dam) • It improves the quantitative and qualitative status of groundwater as well as the performance of irrigated agriculture and livestock. • The provision of river and riparian zones' ecosystem services (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity) also increases, while the risk of flooding from the Pedieos river and the surface runoff of rainwater slightly decrease.
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management		WMO 16: Hydrological studies • The option targets the whole river basin. • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater, (b) the ecosystem

		services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), (c) the performance of irrigated agriculture and livestock, (d) the reduction of urban runoff and flooding from the Pedieos river.
The removal of Tamassos dam can contribute to the restoration of the watershed and the upgrade of river ecosystems		WMO 17: Dam demolition • The option targets the upstream and midstream areas of the river basin. • This radical water management option significantly improves the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as irrigated agriculture.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The construction of river runoff retention systems including detention basins, retention ponds and check dams prevents flooding and improves groundwater recharge and water quality		WMO 27: River runoff retention and groundwater recharge systems • The option targets the midstream and downstream areas of the river basin. • The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Technical flood protection through the construction of anti-flooding works such as terraces, rectangular culverts and hydraulically designed bridges.		WMO 29: Construction of flood protection works • This option targets the downstream areas of the river basin. • The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO8 	• Water Development Department aims to promote the dynamic management of water in Cyprus dams	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO9 	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the	• Department of Environment (MARDE) • Water Development Department (MARDE)

	positive contribution of hydrological studies to biodiversity conservation	
WMO17 		• Water Development Department (MARDE)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO27 	• River runoff retention systems are of high importance within Water Framework Directive and Floods Directive • Municipalities aim to promote the construction of river runoff retention systems	• Water Development Department (MARDE) • Municipalities
WMO29 	• Water Development Department promotes the construction of flood protection works including bridges, terraces and retaining walls. • Municipalities and communities promote the construction of small flood protection works	• Water Development Department (MARDE) • Municipalities

4.2.5 Domestic water supply (Bundle 5)

The domestic water supply bundle focus on both technical and managerial adaptation options that secure the water supply in the households of the river basin.

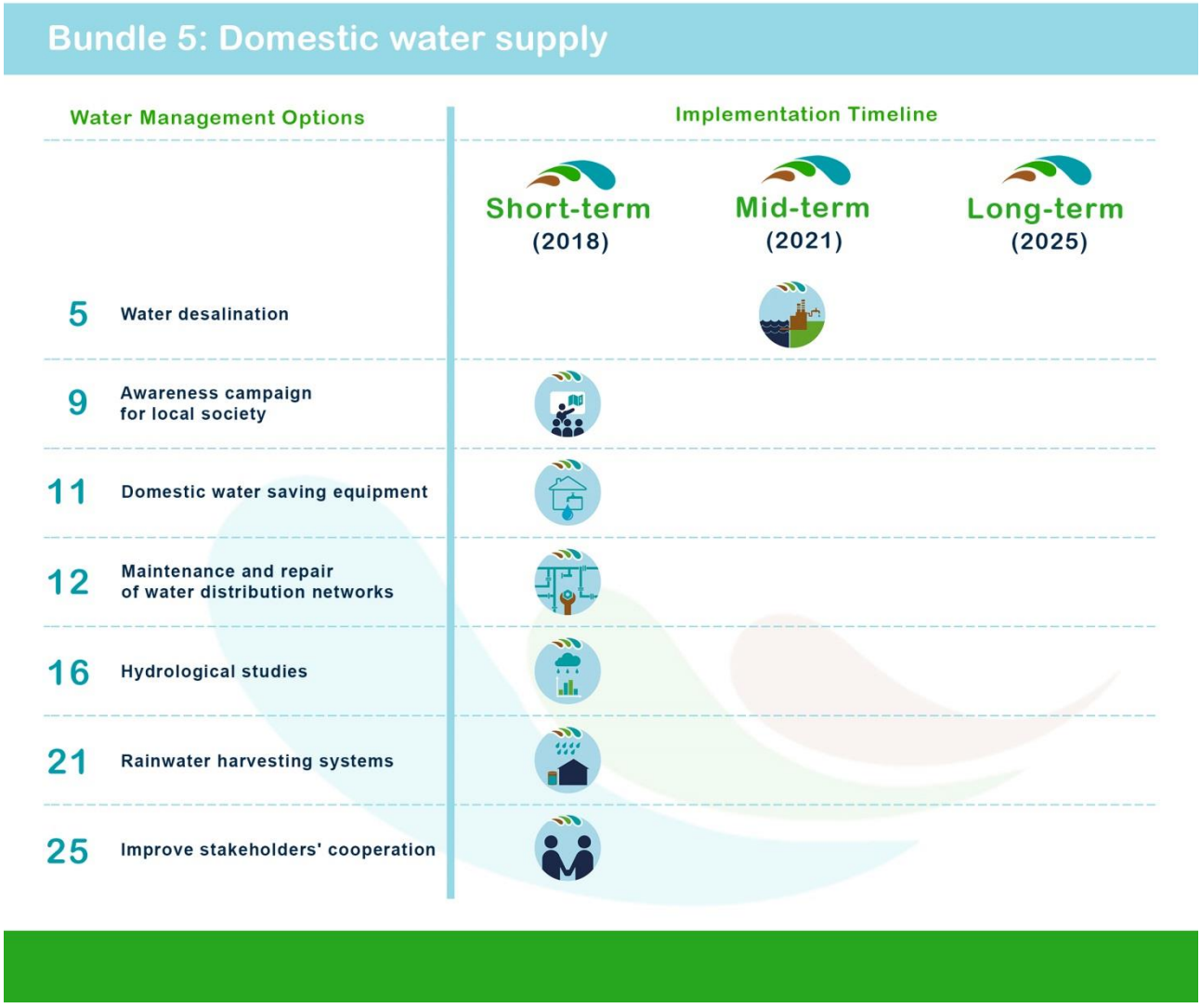
Proposed combination of WMOs

Context	**Water Management Options**	
Expansion of the distribution network to secure domestic water supply in rural communities		WMO 5: Water desalination
		• The option targets the midstream and downstream areas of the river basin. In particular, it aims to expand the desalination up to Tamassos dam communities (Politiko, Pera, Episkopeio, Psimolofou, Anageia) covering extra 5,400 persons. • The adoption of the option will result in the improvement of the quantitative and qualitative status of groundwater, while positive indirect effects will be also created for irrigated agriculture and livestock.
Awareness campaigns including		WMO 9: Awareness campaign for local society

lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and globalchange and the importance of water conservation.		• Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
Installation of water saving technologies and equipment for domestic water use and gardens		WMO 11: Domestic water saving equipment • The option targets the whole river basin. • It aims at least 10% of river basin households (7,740) to adopt such water saving technologies and equipment • The adoption of the option will decrease water demand of households for drinking and gardens' watering purposes. Thus, groundwater quantities will increase. • The quantitative and qualitative status of surface water, related to the ecosystem services provided by the Tamassos dam reservoir (including water supply, provision of habitat for biodiversity and recreation) will also improve. • Land cultivated with irrigated crops (such as vegetables and fruit trees) and livestock (mainly intensive livestock farms with sheep, goats, chickens, cows) will be positively affected
The regular maintenance and repair of the water distribution systems and related infrastructure minimizes leakages and water losses		WMO 12: Maintenance and repair of water distribution networks • The option targets the whole river basin • The option contributes to the decrease of water demand of local households for drinking and garden's watering purposes, while it improves irrigated agriculture and livestock.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The installation of rainwater harvesting systems will supplement water supply at both household (e.g. collect surface runoff from roofs and paved areas in storage tanks; use of stored water for irrigation of gardens) and farm (e.g. collect surface runoff from roofs of farm		WMO 21: Rainwater harvesting systems • The option targets the whole river basin • The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. • Positive indirect effects are created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos River.

buildings and greenhouses; use of stored water for irrigation of agricultural crops) level.		
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO5 	• Desalination is considered by the Republic of Cyprus as a secure option that ensures constant domestic water supply throughout the country • Communities require constant supply of domestic water	• Water Development Department (MARDE) • Communities
WMO9 	• Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Department of Environment (MARDE) • Water Development Department (MARDE) • Households • Civil society (NGOs)
WMO11 	• Water Development Department aims at the reduction of drinking water consumption • Cyprus guidelines for drinking water requires the mandatory installation of water saving technologies and equipment in new buildings	• Water Development Department (MARDE) • Municipalities • Department of Town Planning and Housing (Ministry of Interior)
WMO12 	• Water Development Department aims to minimize water leakages in the urban and rural domestic supply distribution networks. • Nicosia Water Board is responsible for the maintenance and repair of the distribution network for domestic water within the urban and sub-urban areas of the river basin.	• Water Board of Nicosia
WMO16 	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	• Department of Environment (MARDE) • Water Development Department (MARDE)
WMO21 	• Department of Agriculture aims to promote the installation of rainwater harvesting systems at farm holdings. Efforts will be made these systems to be subsidized under the rural development programme. • Water Development Department promotes the installation of rainwater harvesting systems	• Department of Agriculture (MARDE) • Water Development Department (MARDE) • Farmers
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)

4.2.6 Environmental engagement (Bundle 6)

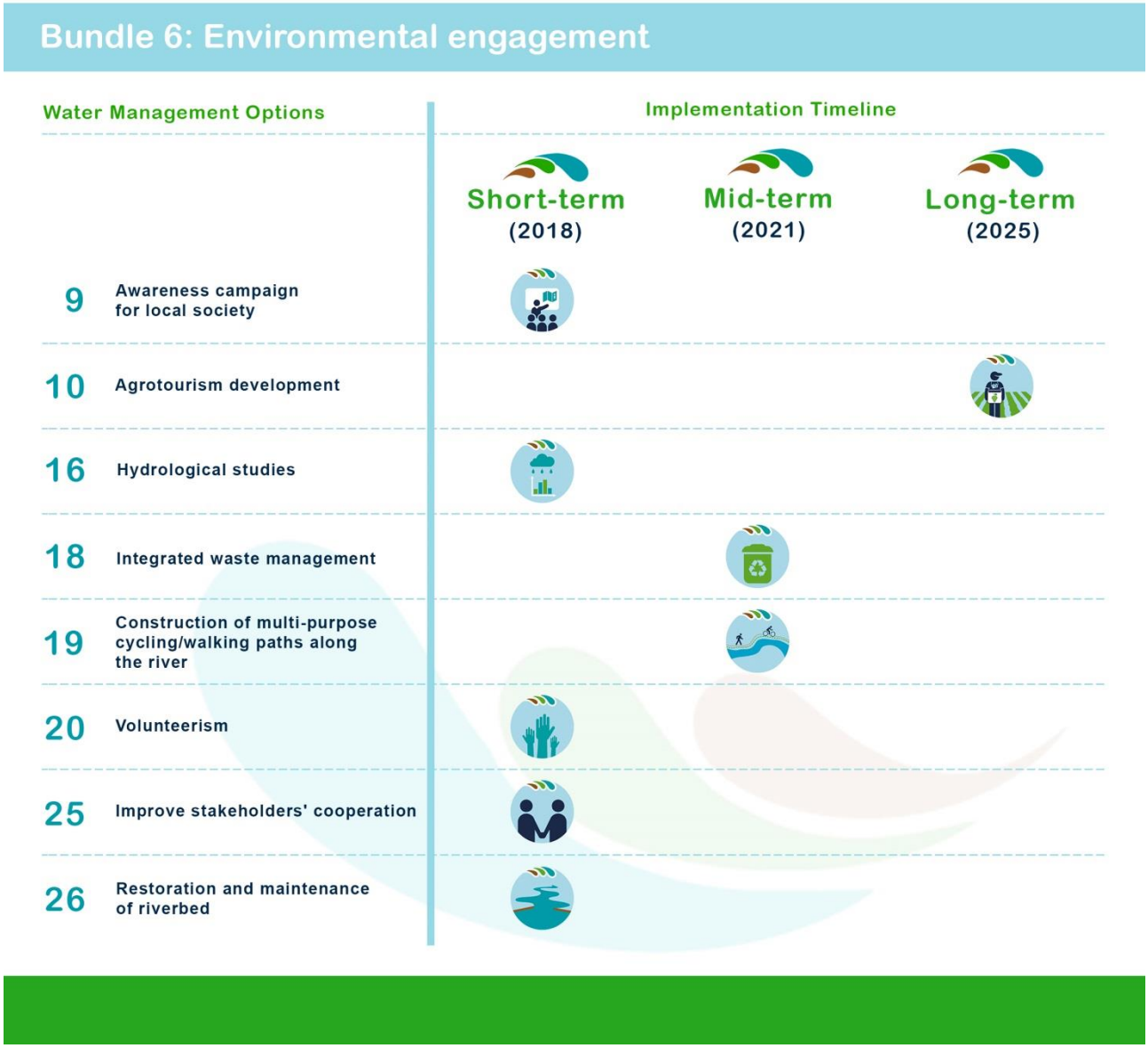
The bundle focuses on engaging civil society in water conservation efforts and in long-term planning for sustainable water resources management.

Proposed combination of WMOs

Context	Water Management Options	
Awareness campaigns including lectures in schools, distribution of informative leaflets and other informative initiatives, aim to educate local society and mainly younger generation about challenges related to water resources and global change and the importance of water conservation.		WMO 9: Awareness campaign for local society • Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones, including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity • Positive indirect effects will be created in irrigated agriculture and livestock • The risk of flooding from the Pedieos River and the surface runoff of rainwater will slightly decrease.
Agrotourism could maintain agricultural land in good condition and increase environmental awareness.		WMO 10: Agrotourism development • Agrotourism will be developed in the upstream and midstream areas of the river basin. • Four new agrotourism hotels will be constructed • The development of agrotourism will improve the quantitative and qualitative status of groundwater through the increase of environmental awareness. • The option will create positive impacts on agriculture and livestock through the increase of environmental awareness and the use of local agricultural products by the agrotourism hotels.
This option aims to develop hydrological studies including risk assessment to combat desertification and improve water management.		WMO 16: Hydrological studies • The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) (c) the performance of irrigated agriculture and livestock (d) the reduction of urban runoff and flooding from the Pedieos river.
The option promotes the strict enforcement of regulations regarding solid waste dumping at or near river. Moreover, it provides incentives for waste reuse and recycling.		WMO 18: Integrated waste management • The option targets the whole river basin • The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding
The expansion of walking and		WMO 19: Construction of multi-purpose cycling/walking

cycling paths up to Tamassos dam area can raise environmental awareness and discourage people dumping in the riverbed.		paths along the river • The option targets the whole river basin. • The implementation of the option includes the maintenance and improvement of infrastructure across the river, which can potentially reduce urban runoff and flooding.
Strengthening volunteerism movement improves awareness raising for the importance of water conservation and helps to restore and clean river bed. It is a private initiative.		WMO 20: Volunteerism • The option targets the whole river basin. • The volunteerism movement strengthening contributes to the restoration and cleaning of the riverbed, therefore improving the quantitative and qualitative status of groundwater as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The restoration of the riverbed also reduces urban runoff and flooding from Pedieos River.
Cooperation between stakeholders and competent authorities is key element for effective water resources management. Lack of such cooperation may lead to conflicts that aggravate existing problems		WMO 25: Improve stakeholders' cooperation • The option targets the whole river basin • The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). • The implementation of the option improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including the removal of illegal constructions, allows undisturbed river flow and reduces flooding.		WMO 26: Restoration and maintenance of riverbed • The option targets the whole river basin. • The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. • The implementation of the option improves the qualitative and quantitative status of groundwater.

Adaptation pathway



Way forward/implementation avenues

WMOs	Opportunities for implementation	Actors to be involved
WMO9	• The Water Development Department aims to further expand awareness campaigns to local society within Water Framework Directive	• Water Development Department (MARDE) • Department of Agriculture (MARDE) • Households • Civil society (NGOs)
WMO10	• Rural Development Programme 2014-2020 promotes the development of agrotourism as a means of employment diversification in rural areas. • Agrotourism create significant backward and forward linkages within regional economies.	• Department of Agriculture (MARDE) • Farmers • Cyprus Tourism Organization
WMO16	• The preparation of hydrological studies is necessary to meet the requirements of the Water Framework	• Department of Environment (MARDE) • Water Development Department

	Directive • The Department of Environment recognises the positive contribution of hydrological studies to biodiversity conservation	(MARDE)
WMO18 	• The Department of Environment aims to apply an environmentally rational management of waste in Cyprus	• Department of Environment (MARDE)
WMO19 	• The expansion of walking/bicycling paths up to Tamassos dam areas has been already designed by the Department of Town Planning and Housing	• Department of Town Planning and Housing (Ministry of Interior)
WMO20 		• Civil society (NGOs)
WMO25 	• Common Agricultural Policy promotes a transparent, well-targeted and coherent stakeholder consultation • A transparent, well-targeted and coherent stakeholder consultation is currently promoted within Water Framework Directive • Municipalities and communities aim to promote a transparent, well-targeted and coherent stakeholder consultation	• Department of Agriculture (MARDE) • Water Development Department (MARDE)
WMO26 	• One of the major priorities of the Water Development Department is the regular cleaning and maintenance of all riverbeds in Cyprus	• Water Development Department (MARDE) • Civil society (NGOs)

4.3 Monitoring

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

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

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

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

- *financial input indicators that are used to monitor progress in terms of the annual payment of the funds available for any operation,*
- *output indicators that measure activities directly realised within options (e.g. number of training sessions organised),*
- *result indicators that measure the direct and immediate effects of the intervention (e.g. successful training outcomes),*
- *impact indicators that refer to the benefits of the option beyond the immediate effects on its direct beneficiaries at river basin level.*

When developing the water management options for this plan, a review of and comparison with existing management plans focussing on the river basin was undertaken (see Part 2). These existing plans, such as the River Basin Management Plans developed in compliance with the European Water Framework Directive, have a monitoring and evaluation network in place where the presented water management options can be integrated.

More precisely, the Water Framework Directive distinguishes three types of monitoring [lxv]: (a) surveillance monitoring, to assess long-term changes resulting from widespread anthropogenic activity; (b) operational monitoring, to establish the status of those water bodies identified as being at risk of failing to meet their environmental objectives; (c) investigative monitoring, carried out where the reason of any exceedance for ecological and chemical status is unknown.

The Water Framework Directive has put aquatic ecology (biological quality elements) at the base of management decisions. However, the linkage between data on biotic communities and the designation of measures has not yet been fully established [lxvi]. These authors found that the links between ecological status and restoration measures were obscure in many of the first European River Basin Management Plans. Reyjol et al. [lxvii] also point to the need for resolving uncertainties resulting from current monitoring approaches and those related to global change and for investigating the usefulness of top-down prediction-based assessments for local decision-making. Thus, it is important to combine long-term, surveillance monitoring with modelling analyses to be able to obtain a better understanding of the effects of natural variability versus the effects of human interventions. Herring et al. [lxvi] also suggest to establish more sampling sites and higher sampling frequency, both before and after the implementation of measures.

The Water Development Department's surveillance monitoring of biological quality elements (e.g., DO, EC, NH_4-N, TP, pH, As, B, Cr, Cu, Fe) in the Tamassos reservoir [lxviii] can be used to assess in more detail the ecosystem services provided by the Tamassos dam, which is one of the factors of the Pedieos River Basin conceptual map (see Section 3.2.3). In addition, some water management options, namely, *improved irrigation technologies* (WMO1), *farm education* (WMO6), *agrotourism development* (WMO10) and *Code of Good Agricultural Practices enforcement* (WMO13) can be monitored under the monitoring system of the Managing Authority of the Rural Development Programme 2014-2020. This monitoring framework within the Rural Development Programme 2014-2020 enables the responsible actors to guide and monitor the implementation of the selected options in a structured way and maximizes the impact of the programme. Other water management options, such as the *improvement of genetic resources banks for drought tolerant species* (WMO7, WMO15, WMO22), *rooftop water harvesting* (WMO21), *fire safety measures* (WMO23), *restoration and maintenance of the riverbed* (WMO26), *river runoff retention and groundwater recharge*

systems (WMO 27), and *sustainable urban drainage systems* (WMO28) could be incorporated in potential future LIFE projects, which include dedicated monitoring and evaluation actions.

5 From planning to action: Recommendations for implementation

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

5.1 Implementation of all options within a given bundle

The six bundles presented in Chapter 4 are sets of options, which have been grouped together on the basis of their foreseen abilities to collectively address the identified challenges within the Pedieos River Basin and to react to additional local opportunities (e.g. increasing sustainable tourism in the area). Implementation of an entire bundle ensures a high occurrence of synergies between the options and the pursuit of one or more common objectives. Two water management options that are strongly aligned may decrease the implementation or maintenance costs if they are implemented together. Other combinations may lead to an increased impact with regards to addressing an existing threat.

In the bundle factsheets in Chapter 4, a wealth of information is provided on the interaction of the water management options to support decision-making processes. This includes, for example, indications of the objectives which may be reached by choosing to implement a given bundle, the costs involved and the potential phasing of the options in time. If an entire bundle is to be implemented, the 'adaptation pathway' provides further information about which options are critical to implement before other water management options in the bundle.

5.2 Implementation of individual water management options

The existence of very specific objectives, resource or capacity limitations or other considerations may make the implementation of an entire bundle unfeasible. In this case, deciding instead to implement one or more individual options will not necessarily have a negative impact on the performance of these options. While all of the water management options presented are suitable for implementation in the river basin, the decision to implement individual options on their own requires a check that the option is not dependent on any other water management option. Information on the relationship between the options is outlined in the bundle factsheets in Chapter 4.2 and should be consulted in order to reach such conclusions.

Here, a particular focus should be given to prioritised water management options, which have been identified based on suggestions of the stakeholders engaged in the process and taking into account implementation-oriented factors, which were assessed in the multi-criteria analysis, and policy synergies. As such, these options are strongly aligned with community interests and are foreseen to offer large potential in addressing the targeted challenges identified within the basin (see Section 3.2.4 and Table 4.1). In order to assess the best implementation timing, the adaptation pathways as presented in Chapter 4.2 should be consulted.

5.3 General recommendations

The recommendations are based on the experience developed in the project in close cooperation with local stakeholders and international project partners:

- Participatory approaches can contribute to a more holistic consideration of climate change related challenges and potential adaptation pathways.
- The bottom-up participatory approach followed for the development of the adaptation plan could be useful for the design of public consultations of environmental policies.
- The use of multi-criteria analysis for prioritizing options requires careful consideration of normalization, weighting and the combination of continuous and categorical criteria.
- Bundles of adaptation options better address the multiple impacts of climate change on river basins than the implementation of individual options. Therefore, priority should be given to bundles with high synergies.
- The successful implementation of individual water management options or bundles of options requires the development and execution of a monitoring plan with sound indicators. The alignment of the monitoring needs of the water management options with existing monitoring plans, i.e. River Basin Adaptation Plan and Rural Development Programme, should be strongly considered (Section 4.3).
- There is a need to establish a legislative framework in the Pedieos River Basin that will strengthen the consultations among all involved actors and increase societal awareness.
- Strengthening of institutional partnerships can enhance the adaptation process. A better coordination between competent authorities and stakeholders would be beneficial for assessing the potential impacts of climate change and for implementing the most appropriate options to tackle these changes.
- The adaptation plan is a dynamic document and it should be updated periodically, to incorporate new knowledge on key issues that are directly or indirectly linked with the river basin. The establishment of a steering committee or a coordinating actor could ensure the continuation of the collaboration and the validity of the plan.
- Strong commitment for the adoption of the adaptation options is needed from all involved actors and authorities.

PART 2

6 Analytical description of the water management options

	Improved irrigation technologies (WMO1)
Short explanation	Installation of irrigation scheduling decision support systems, including wireless sensor network, could result in savings of irrigation water.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option aims to establish 100 irrigation blocks in the midstream areas of the river basin (downstream from Tamassos dam), where groundwater-irrigated crops prevail (e.g. vegetables).
Benefits	The adoption of irrigation scheduling decision support systems will result in the improvement of the quantitative and qualitative status of groundwater. Positive effects will be also created for irrigated agriculture.
Potential negative impacts	Increase of farm production cost
Timeline of implementation	The option can be functioning on very short term (<5 yrs). The expected lifetime of which irrigation scheduling decision support systems are operational without major rehabilitation is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor physical, technical or organisational barriers for the implementation of the option that can easily be overcome. Most significant obstacle is the capital cost of purchasing and setting up the wireless sensors.
Robustness	The option manages to maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option can be complemented with other water management options (e.g. irrigation water pricing) to maximize its efficiency

Costs	The total implementation cost of the option towards 2030 is approximately 700.000€. This cost includes the establishment cost of irrigation blocks, the installation of wireless sensor network and the annual operational costs.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at the protection and management of groundwater resources, water pricing policies and agricultural policies aiming at strengthening the viability of farm holdings.
Acceptance	The acceptability of the option is not very high because local environmental actors support that the adoption of such technologies will lead to the expansion of irrigated agriculture resulting thus to the increase of water use.
Suggested stakeholder involvement	Ministry of Agriculture, Rural Development and Environment (MARDE); Department of Agriculture
Preconditions for success	Awareness raising amongst farmers for the benefits of the proposed technologies; Subsidies for the adoption of irrigation scheduling decision support systems through the Rural Development Programme. The article 17 of the Rural Development Programme 2014-2020 provides financial incentives for increasing irrigation water use efficiency.
Concrete examples where applied	Very few farms are currently using irrigation scheduling decision support systems in the river basin.

Borehole licences and water meters (WMO2)

Short explanation	Enforcement of borehole drilling permits and installation of water meters on groundwater pumps could control groundwater abstraction and reduce its overexploitation.
Addressed challenges	Quantitative and qualitative status of groundwater
Target locations and water uses	This option targets the whole river basin. The specific objective of the option is the installation of groundwater meters on 10,000 wells.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be created for irrigated agriculture and livestock.
Potential negative impacts	The production cost for farmers will increase as well as the water price for the communities' inhabitants.
Timeline of implementation	The option can be implemented in the short run (<5 yrs). The expected lifetime of which water meters are operational without major maintenance is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs)
Feasibility	There are serious barriers for the implementation of the option including the unwillingness of farmers to install water meters and the lack of political will to impose the legislative framework for groundwater abstraction.
Robustness	The option maintains its effectiveness under various climatic and socioeconomic conditions
Flexibility	The option can be complemented with other water management options (e.g. irrigation water pricing) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 2,5 million €. This cost includes transaction costs of policy implementation plus the installment of 10,000 water meters.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at the protection and management of groundwater resources and the pricing policies for efficient water management.

Acceptance	The acceptability of the option is low among local farmers since it increases the production costs. However, other social actors e.g., environmental NGOs are very positive about this option since it contributes to the protection of the groundwater resources.
Suggested stakeholder involvement	MARDE; Water Development Department; Department of Agriculture
Preconditions for success	Consultations between competent authorities and farmers; Improvement of farm training in order farmers better understand their requirements under cross-compliance schemes; Subsidies for the installment of water meters through the rural development programmes
Concrete examples where applied	The option is currently implemented for agricultural water use, but poorly enforced.

Water pricing enforcement (WMO3)

Short explanation	Water pricing policy enforcement could provide incentives for using water resources efficiently.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be created for irrigated agriculture.
Potential negative impacts	The production cost of farmers will increase.
Timeline of implementation	The option can be implemented in the short run (<5 yrs) since it is a matter of political will. The expected lifetime of the new water prices is medium (5-20 yrs), while the expected time since the policy is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are serious barriers for the implementation of the option including the lack of political will to impose additional costs to farmers. A precondition to efficient and equitable water pricing is the metering and monitoring of groundwater abstractions.
Robustness	Water pricing setting can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Water pricing setting can be easily adjusted to different climatic and socioeconomic conditions and can be complemented with other water management options (e.g. borehole licenses and water meters) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 376,000€. This cost includes transaction costs of policy implementation plus policy control costs.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resource conservation, e.g. the Water Framework Directive and the Rural Development Programme 2014-2020. Potential conflicts with agricultural policy objectives aiming to maintain and strengthen subsistence farming.
Acceptance	The acceptability of the option is low among local farmers since it increases the production costs. However, other social actors e.g., environmental NGOs are very positive about this option since it contributes to the protection of the groundwater

	and surface water resources.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Strict control of policy implementation; Consultations between competent authorities and farmers
Concrete examples where applied	The option is not implemented in the river basin.

Use of treated sewage water for irrigation and green infrastructure (WMO4)

Short explanation	Treated sewage water use could increase water availability for agriculture and parks and roadsides and alleviate the pressures on water resources
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive effects will be also created for irrigated agriculture and livestock.
Potential negative impacts	The long-term impacts of emerging contaminants such as pharmaceuticals that are present in the treated sewage water on soils, groundwater, ecosystems and human health are not known.
Timeline of implementation	The option can be functioning on short term (<5 yrs) since it refers to the construction of a treated sewage water supply (distribution) network. The expected lifetime of the irrigation network is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor physical and technical obstacles for the implementation of the option. These obstacles include the cost of constructing a treated sewage water supply (distribution) network and any potential unknown effects of treated sewage water on irrigated agriculture.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The use of treated sewage water for irrigation and green infrastructure can be complemented with other water management options (e.g. water pricing) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 14,5 million €. This cost includes the construction of the supply network (for 1,000 ha) and the annual operational costs (including the water price).
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation. Synergies also with agricultural policies that aim to alleviate water scarcity pressures on the agricultural sector. Potential conflicts with the already existing strict guidelines on quality standards regarding the use of treated sewage water for irrigation as well as measures for the protection of public

	health.
Acceptance	High acceptability of the option among local actors since it will contribute to the maintenance of the groundwater and surface water resources.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Awareness raising to farmers and citizens regarding the benefits and constraints of treated sewage water for irrigation.
Concrete examples where applied	The option is currently implemented in some of the green spaces of the downstream areas of the river basin.

Water desalination (WMO5)

Short explanation	The expansion of the water distribution network up to the Tamassos dam could secure domestic water supply in rural communities.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the midstream and downstream areas of the river basin. In particular, it aims to expand the desalination up to Tamassos dam communities (Politiko, Pera, Episkopeio, Psimolofou, Anageia) covering extra 5,400 persons.
Benefits	The adoption of the option will result to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects will be also created for irrigated agriculture and livestock.
Potential negative impacts	Desalination is extremely energy intensive. Desalination plants are run on fossil fuels creating negative effect on climate change. Moreover, the brine of the desalination plants that is returned to the sea has a negative effect on marine biodiversity.
Timeline of implementation	The option can be functioning on short term (<5 yrs) since desalination plants are already in operation. The expected lifetime of the option is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no physical, technical or organisational barriers for the implementation of the option.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The use of water desalination can be easily adjusted to different climatic and socioeconomic conditions and can be complemented with other water management options (e.g. domestic water saving) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 4 million €. This cost includes the expansion of the water supply network and the annual operational costs.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation. Potential conflict with environmental policies since desalination is an energy intensive process the residue of which should be carefully treated.

Acceptance	Medium acceptability of the option among the midstream stakeholders because they don't want an increase in the water price.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Adequate financial resources
Concrete examples where applied	The option is currently implemented in the downstream areas of the river basin, i.e. in the urban and sub-urban areas of Nicosia.

Farm education (WMO6)	
Short explanation	Farm education on the rational use of water resources and agrochemical inputs could improve agricultural ecosystems resilience
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of the river basin
Benefits	The improvement of farm education will create significant positive effects to agriculture (both irrigated and rainfed) and livestock. The ecosystem services of the river and riparian zones (including sediment and nutrient filtering, water storage, bank stabilization and provision of habitat for biodiversity) will be improved as well as the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	Farm education activities can be effectively functioning on short term (<5 yrs). The expected lifetime of the farm education programmes is medium (5-20 yrs), while the expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	No barriers for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Farm education is a rather flexible option and can be easily complemented with other water management options (e.g. improved irrigation technologies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 205,000€. The proposed farm training activities are slightly more costly compared to current farm training courses since they are climate change related.
Synergies and conflicts with policy objectives	Significant synergies with: (a) agricultural policies aiming at the sustainability (economic, environmental, social) of agriculture; (b) policies aiming at water resources conservation.

Acceptance	High acceptability of the option among local actors and mainly farmers.
Suggested stakeholder involvement	MARDE; Department of Agriculture
Preconditions for success	Awareness raising among farmers regarding the benefits of professional training.
Concrete examples where applied	Some local farmers are already participating in farm training schemes through rural development programmes and extension services.

Improve plant genetic resources bank and use of drought tolerant agricultural crops (WMO7)

Short explanation	Agricultural land can be cultivated with drought tolerant crops that need little or no irrigation. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on rainfed agriculture and livestock.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the systematisation and organisation of the plant genetic resources bank is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to the lack of personnel to organise and systematise the plant genetic resources bank. However, these barriers can be easily overcome.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the seed bank): 73,000€
Synergies and conflicts with policy objectives	Significant synergies with cross-compliance requirements and policies aiming at water resources conservation.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Agricultural Research Institute
Preconditions for success	Awareness raising to farmers regarding the benefits of cultivating drought tolerant agricultural crops.
Concrete examples where applied	The plant genetic resources bank is currently operating in the Agricultural Research Institute. However, the systematization and organisation of the seed bank needs to be improved as well as seeds' regeneration.

Dynamic dam water management (WMO8)

Short explanation	Dynamic management of the water in the reservoir could optimize environmental services, prevent downstream flooding and improve recharge of groundwater resources
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	This option targets the midstream and downstream areas of the river basin (downstream from Tamassos dam).
Benefits	The dynamic dam water management will improve the quantitative and qualitative status of groundwater as well as the performance of irrigated agriculture and livestock. The provision of river and riparian zones' ecosystem services (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity) will also increase. Moreover, the risk of flooding from the Pedieos river and the surface runoff of rainwater will slightly decrease.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the proposed dam water management outcome is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option, which can be easily overcome. It mainly includes the cost of preparing a study based on which a dynamic management in the reservoir can be achieved.
Robustness	Quite robust option that can maintain its effectiveness under various climatic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. hydrological studies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the study preparation, equipment purchase and maintenance, salaries of technical personnel): 646,000€.
Synergies and conflicts with	Significant synergies with policies aiming at water resources conservation.

policy objectives	
Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Knowhow transfer regarding the benefits of the dynamic management of the water in the reservoir.
Concrete examples where applied	

Awareness campaign for local society (WMO9)

Short explanation	Lectures in schools, seminars and distribution of informative leaflets could educate local society and youth on climate change and water resources challenges and the importance of water conservation.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water.
Target locations and water uses	This option targets the whole river basin.
Benefits	Awareness raising and participation of local society will improve the quantitative and qualitative status of groundwater as well as the ecosystem services provided by the river and riparian zones (including sediment and nutrient filtering, water storage and release, bank stabilisation, aquifer recharge, habitat for biodiversity). Positive indirect effects will be also created in irrigated agriculture and livestock. Moreover, the risk of flooding from the Pedieos river and the surface runoff of rainwater will slightly decrease.
Potential negative impacts	-
Timeline of implementation	Awareness campaign can occur on short term (<5 yrs), while the expected lifetime of the knowledge acquired is considered medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no barriers (physical, technical or organizational) for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is highly flexible under different climatic and socioeconomic scenarios and can be easily complemented with other water management options either grey or nature-based.
Costs	Total implementation cost of the option towards 2030 is approximately 248,000€. It includes the purchase of equipment and materials (e.g. leaflets) and the annual operational cost.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation.

Acceptance	High acceptability of the option among local actors and competent authorities.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	-
Concrete examples where applied	Awareness campaigns are taking place in the local schools of the river basin to develop a more conscious attitude towards water conservation. Dissemination activities and awareness campaigns take also place within the framework of Water Framework Directive.

Agrotourism development (WMO10)

Short explanation	Agrotourism could support the maintenance of agricultural land in good condition and increase environmental awareness.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water; Flood risk reduction
Target locations and water uses	Agrotourism will be developed in the upstream and midstream areas of the river basin.
Benefits	The development of agrotourism will improve the quantitative and qualitative status of groundwater through the increase of environmental awareness. Moreover, the option will create positive impacts on agriculture and livestock through the increase of environmental awareness and the use of local agricultural products by the agrotourism hotels.
Potential negative impacts	-
Timeline of implementation	The option can be functioning on short term (<5 yrs), while the expected lifetime for which the option is operational without major rehabilitation is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	There are no barriers (physical, technical or organizational) for the implementation of the option.
Robustness	The option is robust to uncertainties and can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	If the implementation of the option in practice is inappropriate, it can be adjusted or reversed very slowly.
Costs	Total implementation cost of the option towards 2030: 2,356,556€.
Synergies and conflicts with policy objectives	Significant synergies with agricultural policies aiming at the viability of agriculture and the protection of environment.
Acceptance	The acceptability of the option is low among environmental actors (e.g. NGOs). Concerns arise with regards the risk of environmental degradation because of touristic infrastructure.
Suggested stakeholder	MARDE; Department of Agriculture

involvement	
Preconditions for success	Preparation of environmental studies
Concrete examples where applied	Very few agrotourism hotels in the river basin

Domestic water saving equipment (WMO11)

Short explanation	Installation of water saving technologies for both domestic water use and gardens could result in water saving
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin. In particular, it aims at least 10% of river basin households (7,740) to adopt such water saving technologies and equipment
Benefits	The adoption of the option will decrease water demand of households for drinking and gardens' watering purposes. Thus, groundwater quantities will increase. The quantitative and qualitative status of surface water, related to the ecosystem services provided by the Tamassos dam reservoir (including water supply, provision of habitat for biodiversity and recreation) will also improve. Furthermore, land cultivated with irrigated crops (such as vegetables and fruit trees) and livestock (mainly intensive livestock farms with sheep, goats, chickens, cows) will be positively affected.
Potential negative impacts	-
Timeline of implementation	The option can be functioning on short term (<5 yrs). The expected lifetime of the relative equipment is around 10 years according to its technical specification. The expected time since the option is implemented until it starts to have the desired effect is very short (< 5 yrs).
Feasibility	Minor technical, physical or organizational barriers for the implementation of the option. Most significant obstacle is the cost of purchase of water saving technologies and equipment.
Robustness	Quite robust option to uncertainties since it manages to maintain its effectiveness under different climatic and socioeconomic development scenarios
Flexibility	Quite flexible option since it can be adapted to different climatic and socioeconomic development scenarios
Costs	Total implementation cost of the option towards 2030: 2,2 million €. This corresponds at a 10% of river basin households adoption rate
Synergies and conflicts with policy objectives	Potential synergies with housing and energy policies for promoting sustainable and environmentally friendly buildings

Acceptance	High acceptability of the option from the local actors
Suggested stakeholder involvement	Water Development Department promotes the adoption of water saving technologies and equipment.
Preconditions for success	Citizens should be further informed about the environmental (water saving) and economic benefits of adopting such technologies.
Concrete examples where applied	The option is currently implemented throughout the river basin for drinking and gardens' watering purposes.

Maintenance and repair of water distribution networks (WMO12)

Short explanation	The maintenance and repair of the water distribution systems could substantially minimize leakages and water losses.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The regular maintenance and repair of water distribution systems improves the qualitative and quantitative status of groundwater and surface water. The option contributes to the decrease of water demand of local households for drinking and garden's watering purposes, while it improves irrigated agriculture and livestock.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of water distribution systems repair is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to limited financial resources.
Robustness	Currently, financial resources for maintaining and repairing the related infrastructure have been decreased resulting in a gradual loss of the effectiveness of the option. However, the option can still be characterized as robust to climatic and socioeconomic changing conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. hydrological studies, sustainable urban systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030, including capital and operational costs, based on average daily repairs of the existing network: 1,3 million €.
Synergies and conflicts with	Significant synergies with policies aiming at water resources conservation.

policy objectives	
Acceptance	High acceptability of the option among local actors and competent authorities.
Suggested stakeholder involvement	Water Board of Nicosia
Preconditions for success	The timely identification and repair of defective pipes is a crucial factor for the effective implementation of the option. Awareness raising for developing a more conscious attitude towards water conservation
Concrete examples where applied	The option is implemented throughout the river basin; around 5 repairs daily.

Code of Good Agricultural Practices enforcement (WMO13)

Short explanation	The strict implementation of the Code of Good Agricultural Practices could reduce the leaching and surface runoff of agrochemicals and livestock waste.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of river basin.
Benefits	The enforcement of the Code of Good Agricultural Practices significantly improves the qualitative and quantitative status of groundwater and surface water due to reduction of nitrate pollution from fertilizer use and livestock waste. The option strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values) as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). Moreover, it slightly reduces flooding from the Pedieos river.
Potential negative impacts	Slight reduction in farm incomes due to additional labour requirements and lower yields.
Timeline of implementation	The enforcement of the Code of Good Agricultural Practices can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is also very short (<5 yrs).
Feasibility	No barriers (physical, technical or organizational) for the implementation of the option.
Robustness	Robust option to uncertainties, which can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education, improved irrigation technologies) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including transaction and policy control costs): 183,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to improve the environmental performance of agriculture (e.g. cross-compliance requirements).

Acceptance	Medium acceptability of the option among local farmers because they consider the guidelines of the Code too strict that may endanger the viability of their farm holdings.
Suggested stakeholder involvement	MARDE; Department of Agriculture
Preconditions for success	The efficiency of the option depends on the systematic control of a representative sample of farm holdings.
Concrete examples where applied	It is implemented throughout the river basin.

Grazing control (WMO14)

Short explanation	Grazing permits, on the basis of the dynamic carrying capacity of the area, could reduce soil erosion and runoff.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the upstream and midstream areas of river basin.
Benefits	The grazing control significantly strengthens the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. Furthermore, it is an effective measure for preventing soil erosion reducing thus runoff and the risk of flooding.
Potential negative impacts	-
Timeline of implementation	The control of grazing can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is also very short (<5 yrs).
Feasibility	Minor obstacles mainly organizational that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. farm education, Code of Good Agricultural Practices) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including transaction and operational costs): 228,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to protect forests (e.g. forest policy). Potential conflicts with agricultural policies aiming at the support of livestock raisers income.
Acceptance	Medium acceptability of the option among local livestock raisers because livestock is already declining in the region and the enforcement of strict requirements may endanger the viability of their holdings.

Suggested stakeholder involvement	MARDE; Department of Forests; Department of Environment
Preconditions for success	The efficiency of the option depends on the systematic and sufficient control of a representative sample of livestock holdings.
Concrete examples where applied	It is implemented throughout the river basin (Forest Law 1913; Statement of Forest Policy 1950, Statement of Forest Policy 2000-2010).

Improve plant genetic resources bank and use of drought tolerant forest species (WMO15)

Short explanation	Forest ecosystems could be improved with drought tolerant species. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater
Target locations and water uses	This option targets the upstream areas of river basin.
Benefits	The systematisation and organisation of the plant genetic resources bank significantly improves the ecosystem services provided by the forest (ecological, sociocultural, scenic and landscape services and values), while it improves the qualitative and quantitative status of groundwater and surface water. The option also improves livestock performance. Moreover, it reduces the flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes is long (> 20 yrs). The expected time since the option is implemented until it starts to have the desired affect is between 5 to 20 years.
Feasibility	Minor organizational obstacles (including limited personnel) that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. fire safety measures) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the seed bank): 131,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to protect forests (e.g. forest policy).

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Forests; Department of Environment
Preconditions for success	Optimal systematisation and organisation of the plant genetic resources bank and the regeneration of seeds.
Concrete examples where applied	

Hydrological studies (WMO16)

Short explanation	The development of hydrological studies, including risk assessments, could combat desertification and improve water resources management.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	This option targets the whole river basin.
Benefits	The preparation of hydrological studies will identify and analyse the factors that improve: (a) the qualitative and quantitative status of groundwater, (b) the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), (c) the performance of irrigated agriculture and livestock, (d) the reduction of urban runoff and flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The preparation of hydrological studies can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	No major obstacles (physical, technical, organizational) for the implementation of the option.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with the majority of the selected water management options.
Costs	Total cost of preparing 3 hydrological studies towards 2030: 479,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming to water resources conservation and flood protection.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Adequate financial resources
Concrete examples where applied	Hydrological studies have been conducted in the river basin in the past.

Dam demolition (WMO17)

Short explanation	The removal of the Tamassos dam could contribute to the restoration of the watershed and the upgrade of river ecosystems. However, it may also increase flooding.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the upstream and midstream areas of the river basin.
Benefits	This radical water management option significantly improves the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as irrigated agriculture.
Potential negative impacts	The removal of dam negatively impacts on the qualitative and quantitative status of groundwater and surface water, while it increases the urban runoff and the flooding from the Pedieos river.
Timeline of implementation	The dam removal can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcome of the option is medium (5-20 yrs). The expected time from dam removal until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Serious physical, technical and organizational obstacles that would be very difficult to overcome within the time horizon of the project.
Robustness	It is difficult to assess the effectiveness of the option under different climatic and socioeconomic conditions.
Flexibility	The option is not flexible under different climatic and socioeconomic scenarios. However, it can be complemented with other water management options to trade-off the negative impacts.
Costs	Total cost of dam demolition (including studies and restoration works) towards 2030: 1,5 million €.
Synergies and conflicts with policy objectives	Potential synergies with environmental policies aiming at river ecosystem services protection. However, significant conflicts with flood protection policies.
Acceptance	Low acceptability of the option among local actors and competent authorities due to the high negative impacts.

Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Conduct of hydrological studies (including ex ante evaluation and risk assessment)
Concrete examples where applied	Neither applied in Pedieos River Basin nor in Cyprus

Integrated waste management (WMO18)

Short explanation	The strict enforcement of regulations regarding solid waste dumping at or near the river could provide incentives for waste reuse and recycling.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option targets the whole river basin.
Benefits	The integrated waste management improves the qualitative and quantitative status of groundwater as well as the performance of irrigated agriculture and livestock. Moreover, solid waste at or near the river may block water flow thus increasing the risk of flooding.
Potential negative impacts	-
Timeline of implementation	The implementation of an integrated waste management can be effectively functioning on short term (<5 yrs), while the expected lifetime of the outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome. The major obstacle is the high construction cost.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. awareness campaign for local society, volunteerism).
Costs	Total cost of the option (including construction cost, i.e., garbage collection, garbage disposal, recycling, yard waste composting, and annual operating costs) towards 2030: 3,8 million €.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming environmental protection and water resources conservation.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Environment
Preconditions for success	Strict regulations for permits and regular inspections of waste treatment facilities and collectors
Concrete examples where applied	The option is applied at the urban areas of the river basin

Construction of multi-purpose cycling/walking paths across the river (WMO19)

Short explanation	The expansion of walking and cycling paths up to Tamassos dam area could raise environmental awareness and discourage people dumping in the riverbed.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water
Target locations and water uses	The option targets the whole river basin.
Benefits	The expansion of walking/cycling paths will increase environmental awareness and discourage people from waste dumping in the riverbed, thus contributing to the improvement of the quantitative and qualitative status of groundwater. The implementation of the option includes the maintenance and improvement of infrastructure across the river, which can potentially reduce urban runoff and flooding from Pedieos river.
Potential negative impacts	-
Timeline of implementation	The construction of multipurpose cycling /walking paths across the river can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome.
Robustness	The option is quite robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. awareness campaign for local society, volunteerism).
Costs	The total cost of expanding the cycling and walking path across the river towards Tamassos dam (14.6 km) (including operational costs) towards 2030 is approximately 8,2 million €
Synergies and conflicts with policy objectives	Significant synergies with policies promoting environmental protection and physical activity.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	Department of Town Planning and Housing
Preconditions for success	Financial resources commitment for the expansion of cycling/walking paths up to Tamassos dam
Concrete examples where applied	Multi-purpose cycling/walking paths (10 km) have been constructed in the urban areas of the Pedieos River Basin (including Lakatamia, Strovolos and Nicosia).

Volunteerism (WMO20)

Short explanation	Volunteer movement can help to restore and clean the riverbed, and improve awareness raising for the importance of water conservation
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the whole river basin.
Benefits	The volunteerism movement strengthening contributes to the restoration and cleaning of the riverbed, therefore improving the quantitative and qualitative status of groundwater as well as the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The restoration of the riverbed also reduces urban runoff and flooding from Pedieos river.
Potential negative impacts	-
Timeline of implementation	Strengthening of volunteerism movement can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (< 5 yrs).
Feasibility	No major obstacles (physical, technical, organizational) for the implementation of the option.
Robustness	The option is very robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is very flexible under different climatic scenarios and can be easily complemented with the majority of the proposed water management options.
Costs	Total cost of the option towards 2030: 36,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies promoting environmental protection and water resources conservation.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	Environmental NGOs (e.g. Let's Do It Cyprus)
Preconditions for success	Willingness of local society to support such movements.
Concrete examples where applied	Environmental NGOs have participated in Pedieos river bed cleaning activities

Rainwater harvesting systems (WMO21)

Short explanation	We can capture surface runoff from roofs and paved areas in storage tanks. We can use the stored water for irrigation of gardens or agricultural crops.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction
Target locations and water uses	The option targets the whole river basin.
Benefits	The installation of rainwater harvesting systems contributes to the improvement of the quantitative and qualitative status of groundwater. Positive indirect effects are also created in irrigated agriculture and livestock, while its implementation reduces flooding of the Pedieos river.
Potential negative impacts	-
Timeline of implementation	Installation of rainwater harvesting systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the desired outcomes of the option is medium (5-20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (< 5 yrs).
Feasibility	Minor obstacles (physical, technical, organizational) for the implementation of the option that can easily be overcome.
Robustness	The option is robust to uncertainties and can maintain its effectiveness under different climatic and socioeconomic conditions.
Flexibility	The option is flexible under different climatic scenarios and can be easily complemented with other water management options (e.g. river runoff retention and groundwater recharge systems; improved irrigation technologies)
Costs	The cost of the option towards 2030 (including plastic water storage tanks and pipes, operational costs) is approximately 26,4 million €.
Synergies and conflicts with policy objectives	Significant synergies with policies promoting water resources conservation and farm viability.

Acceptance	Medium acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	Awareness raising campaigns to local society and farmers regarding the benefits of the rainwater harvesting systems
Concrete examples where applied	Small-scale application of the option throughout the river basin

Improve plant genetic resources bank and use of drought tolerant plants in green infrastructures (WMO22)

Short explanation	Parks, gardens and green areas along roads can be grown with plants that maintain a protective land cover and need little or no irrigation. The strengthening of a plant genetic resources bank can help.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The better systematisation and organisation of the plant genetic resources bank will create significant positive effects on the provision of the river and riparian zone ecosystem services (including sediment and nutrient filtering, bank stabilization) as well as the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the systematisation and organisation of the plant genetic resources bank is long (> 20 yrs). The expected time since the option is implemented until it starts to have the desired affect is very short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option mainly due to the lack of personnel to organise and systematise the plant genetic resources bank. However, these barriers can be easily overcome.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios.
Costs	Total implementation cost of the option towards 2030 (including the equipment purchase and the annual operational costs, namely salaries of scientific and technical personnel of the plant genetic resources bank): 363,000€.
Synergies and conflicts with policy objectives	Significant synergies with policies aiming at water resources conservation.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Agricultural Research Institute
Preconditions for success	Awareness raising to local society and competent authorities (e.g. municipalities) for the benefits of adopting the option.
Concrete examples where applied	The plant genetic resources bank is currently operating in the Agricultural Research Institute. However, the systematization and organisation of the plant genetic resources bank needs to be improved.

Fire safety measures (WMO23)

Short explanation	Construction and maintenance of water reservoirs, firebreaks and forest roads helps to protect our forests against fires. A healthy forest reduces soil erosion and downstream floods.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the upstream areas of the river basin.
Benefits	Fire safety measures improve the forest ecosystem services (including ecological, sociocultural, scenic and landscape services and values) as well as the qualitative and quantitative status of groundwater and surface water. The implementation of the option helps to maintain the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization), while it improves the performance of livestock. Moreover, fire safety constructions reduce the surface runoff and the flooding of the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the fire safety measures outcome is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	No major obstacles (physical, technical or organizational) for the implementation of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	The option is rather flexible under different climatic scenarios and can be complemented with other water management options (e.g. grazing control) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including wood protection constructions, reservoir constructions, maintenance of firebreaks and forest roads): 486,000€.
Synergies and conflicts with policy objectives	Significant synergies with forest policies.

Acceptance	High acceptability of the option among local actors.
Suggested stakeholder involvement	MARDE; Department of Forests
Preconditions for success	Adequate financial resources
Concrete examples where applied	Fire safety measures have been applied in the upstream areas of the river basin.

Improving land zonation (WMO24)

Short explanation	We should not construct buildings along the Pedieos River, along streams and in flood prone areas. Land zonation maps and laws need to be improved, disseminated widely and properly enforced.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The improvement of land zonation laws and plans contributes to the increase of the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization) as well as the qualitative and quantitative status of groundwater and surface water. The implementation of the option also improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the land zonation improvement outcome is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. restoration and maintenance of riverbed) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including the preparation of a study and policy recommendations as well as the operational costs): 496,000€.
Synergies and conflicts with policy objectives	Significant synergies with groundwater conservation and riverbed protection policies.

Acceptance	Medium acceptability of the option among local actors due to the high housing demand.
Suggested stakeholder involvement	Department of Town Planning and Housing
Preconditions for success	Land protection zones across rivers have been already established by laws indicating that no housing development is allowed. However, these laws have not been properly applied due to a lack of effective control.
Concrete examples where applied	Land zonation laws and plans have already been established but they are not properly enforced

Improve stakeholders' cooperation (WMO25)

Short explanation	Public consultation events, environmental impact assessments and other transparency and accountability mechanisms are a key element for effective water resources management.
Addressed challenges	Quantitative and qualitative status of groundwater and surface water and flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The improvement of stakeholders' cooperation improves the qualitative and quantitative status of groundwater as well as the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The implementation of the option also improves the performance of the irrigated agriculture and livestock, while it reduces the surface runoff and the flooding from the Pedieos river.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of stakeholders' cooperation improvement is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. volunteerism) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 50,000€.
Synergies and conflicts with policy objectives	Significant synergies with water resources management policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department; Department of Agriculture
Preconditions for success	The organization of regular consultation events is necessary for the improvement of cooperation between stakeholders and authorities.
Concrete examples where applied	Water Development Department is currently organizing awareness and dissemination events within Water Framework Directive.

Restoration and maintenance of riverbed (WMO26)

Short explanation	The cleaning and maintenance of the riverbed and the embankment of the riparian zone, including removal of illegal constructions, allows undisturbed river flow and reduces flooding.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the whole river basin.
Benefits	The cleaning and the maintenance of the riverbed reduce the surface runoff and the flooding from the Pedieos River. The implementation of the option improves the qualitative and quantitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The option can be effectively functioning on short term (<5 yrs), while the expected lifetime of the riverbed's cleaning and maintenance is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. They mainly relate to the cost of implementing the option.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. improving land zonation, volunteerism) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 545,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department; Volunteer movements
Preconditions for success	Public awareness and participation to foster a sense of individual responsibility and proactive environmental attitude.
Concrete examples where applied	Pedieos riverbed has been cleaned and maintained by Water Development Department actions and NGOs volunteer events.

River runoff retention and groundwater recharge systems (WMO27)

Short explanation	Check dams slow down the river flow and allow water storage in detention ponds in or next to the Pedieos River. This reduces downstream flooding and improves groundwater recharge and water quality.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The construction of river runoff retention and groundwater recharge systems decreases the urban runoff and the flooding from the Pedieos River, while it increases the quantitative and qualitative status of groundwater.
Potential negative impacts	-
Timeline of implementation	The construction of river runoff retention and groundwater recharge systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. They mainly include the high cost of constructing these runoff retention systems.
Robustness	Very robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. restoration and maintenance of riverbed, sustainable urban drainage systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030 (including 20 detention basins & retention ponds plus 20 check dams): 748,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection and water resources conservation policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	MARDE; Water Development Department
Preconditions for success	-
Concrete examples where applied	The option has been implemented in several parts of the midstream and downstream areas of the river basin

Sustainable urban drainage systems (WMO28)

Short explanation	Green roofs, grassed ditches and permeable pavements collect and store runoff water locally. The water will recharge soil and groundwater bodies or could flow slowly to the Pedieos River.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the midstream and downstream areas of the river basin.
Benefits	The development of sustainable urban drainage systems improve the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization). The implementation of the option also reduces the urban runoff and the flooding from the Pedieos River.
Potential negative impacts	-
Timeline of implementation	The development of sustainable urban drainage systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. These obstacles mainly relate to the high implementation cost of the option.
Robustness	Quite robust option that can maintain its effectiveness under various climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with other water management options (e.g. river runoff retention and groundwater recharge systems) to maximize its efficiency
Costs	Total implementation cost of the option towards 2030: 8,6 million €.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among local actors.

Suggested stakeholder involvement	Water Development Department; Individual citizens
Preconditions for success	Awareness raising to local society regarding the benefits of sustainable urban systems
Concrete examples where applied	Small-scale sustainable urban drainage systems have been implemented in the river basin

Construction of flood protection works (WMO29)

Short explanation	Construction of anti-flooding works such as concrete walls, terraces and higher bridges could reduce flooding from the Pedieos River.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the downstream areas of the river basin.
Benefits	The construction of flood protection works significantly decreases urban runoff and the flood from the Pedieos River.
Potential negative impacts	Constructions harm the natural condition and the ecosystem services of the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).
Timeline of implementation	The construction of flood protection works can be effectively functioning on short term (<5 yrs), while the expected lifetime of the option is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (physical, technical or organizational) for the implementation of the option that can easily be overcome. These obstacles mainly include the high cost of implementing the option.
Robustness	This option cannot be characterized as robust since it cannot maintain its effectiveness under changing climatic and socioeconomic conditions.
Flexibility	Similarly, this option is not flexible under different climatic and socioeconomic scenarios.
Costs	Total implementation cost of the option towards 2030: 3,3 million €.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	Medium acceptability of the option among local actors.

Suggested stakeholder involvement	Water Development Department
Preconditions for success	Targeted installation of anti-flooding works
Concrete examples where applied	The option has been implemented throughout the river basin

Cooperation for storm water drainage system (WMO30)

Short explanation	Cooperation between municipalities is needed to make sure that all surface flows can fit through storm water drainage network.
Addressed challenges	Flood risk reduction.
Target locations and water uses	This option targets the downstream watershed areas.
Benefits	The improvement of cooperation between municipalities significantly reduces urban runoff and the flooding from the Pedieos River, while it improves the ecosystem services provided by the river and the riparian zone (including sediment and nutrient filtering, bank stabilization).
Potential negative impacts	-
Timeline of implementation	The improvement of cooperation for storm water drainage systems can be effectively functioning on short term (<5 yrs), while the expected lifetime of cooperation strengthening is medium (5-10 yrs). The expected time since the option is implemented until it starts to have the desired affect is short (<5 yrs).
Feasibility	Minor obstacles (mainly organizational) for the implementation of the option that can easily be overcome.
Robustness	Very robust option since it can maintain its effectiveness under changing climatic and socioeconomic conditions.
Flexibility	Flexible option under different climatic scenarios that can be complemented with the majority of water management options addressing flood protection issues.
Costs	The total implementation cost of the option towards 2030 is approximately 384,000€.
Synergies and conflicts with policy objectives	Significant synergies with flood protection policies.
Acceptance	High acceptability of the option among municipalities.
Suggested stakeholder	River basin municipalities

involvement	
Preconditions for success	The creation of a coordinating center between municipalities for the design and evaluation of storm water drainage systems
Concrete examples where applied	There is cooperation between river basin’s municipalities but it is not effective

Annex I. List of stakeholder engagement activities held in Pedieos River Basin

Engagement Activity	Objectives	Target group	Date(s)
First stakeholder workshop	– to inform stakeholders on the BeWater Project, particularly its case studies, objectives and expected results – to inform stakeholders on what is known about the river basin and what is projected to occur in the following years in the context of global change – to map specific challenges and issues for the river basin – to clarify objectives for the watershed – to discuss water management options to tackle the identified challenges.	20 stakeholders from several thematic areas of activity: – agriculture – infrastructure – water – environment – energy – forest management and various organizational affiliations: – business and economy, – government and public authorities – civil society – practitioners – media – youth – education	2 July 2014
Two meetings with expert stakeholders	– to better understand global change impacts on Pedieos River Basin – to define the steady-state conditions of the fuzzy cognitive map based on stakeholders' views	12 expert stakeholders and the Cyprus Institute researchers with different expertise on: – water – agriculture – biology – climate – infrastructure – energy	24 March 2015 & 31 March 2015
Second stakeholder workshop	– to collect stakeholders' comments on the formulated water management options – to evaluate by stakeholders of the water management options through an on-the-spot multi-criteria analysis.	19 'key stakeholders' representing several thematic areas of activities: – agriculture – infrastructure – water – environment – energy – forest management	1 July 2015

		and various organisational affiliations: – business and economy – government and public authorities – civil society – practitioners	
Outdoor public event along the Pedieos park bike/walking path	– to capture some more general opinions of the suggested water management options from a larger group of stakeholders	84 users of Pedieos linear park	23 October 2015
Third stakeholder workshop	– to identify and discuss potential synergies and conflicts between the identified in previous workshops water management options – to identify the implementation timeline of the options based on their effectiveness over time and stakeholders' preferences – to provide input and feedback for the development of the adaptation plan	13 stakeholders representing several thematic areas of activities including water, environment, agriculture, tourism, energy and forest management.	18 March 2016

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