

Rmel River Basin Adaptation Plan

2016

Part I & II



Rmel River Basin Adaptation Plan

Authors:

Siheem Jebari, Hamed Daly, Ines Saidi, Hédia Ezzeddine and Dalel Oussaifi – INRGREF

Contributors:

John Tarpey, Josselin Rouillard – Ecologic Institute

Hans Verkerk, Nicolas Robert – EFI

Steven Libbrecht, Roxana Dude, Valérie Boiten – PROSPEX

Georgia Angelopoulou – GWP-MED

Cover photo credit: Siheem Jebari



Disclaimer: This river basin adaptation plan was developed within the BeWater project, based on funding received from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 612385. Views expressed are those of the authors only.

Preface

Climate change projections for the Mediterranean region estimate an increase in water scarcity and drought episodes, as well as more frequent floods and other extreme events [1]. There is a high likelihood that these events will evoke substantial socio-economic losses and negative environmental impacts if no action is taken to support territories' adaptation efforts. Furthermore, changes in population and land use, such as urban expansion or the abandonment or intensification of agriculture, also affect the response of territories to these events. In this context, sustainable water management strategies are urgently needed as they will enhance the resilience of socio-ecological systems, referring both to society and the environment.

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

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

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

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

Acknowledgements

The authors would like to extend a special thank you to all stakeholders and experts who participated in and contributed to the process of developing Rmel's River Basin Adaptation Plan. It has been a real privilege to work with the Ministry of Agriculture Cabinet that facilitated the collaboration between the different national institutions. The involvement of the technical staff from the CRDA of Zaghouan as well as the ones from the DG/ACTA, DG/BGTH, DG/RE, DG/PA, DG/EDA and ESA-Mograne is acknowledged.

The Rmel project team, very much enjoyed the collaboration conducted with the Ministries of Environment, Education, Industry and Tourism. Many thanks go to the representatives of the civil society (e.g., *UTAP Zaghouan*, *GFDA WadiSbaihia*, *J.L. association*, *ASAD*, *ATPNE*). Their contribution is gratefully acknowledged.

The authors are especially thankful to Mr. A. Rabhi (*currently Secretary of State for Water Resources*), Mr.H. Chourabi (*Head of the Water and Soil Conservation Department*), Mr. N. Ben Haha (*Planning and catchment program coordinator*) and Mr. A. Ben Mohamed (*Water resources management director*), for sharing their professional experiences.

The invaluable advices from Prof. A. Ben Alaya, Prof. L. Ghezal, Prof. S. Khelifi, Prof. R.Majdoub and Prof. N. Boussaidi, are gratefully acknowledged.

Deepest appreciation goes to K. Jemmali, B. Reguez, N. Khalfoun, B. Jebali, B. Tarchi, H. Trabelsi, F. Rouissi, D. Zamel, H. Hammami, A. Kallali, A. Miled, M. Boussami, H. Mourad, S. Laouini, R. Ben Salah, N. Ben Ali, S. Mezgheni, N. H. Bayou, M. Trabelsi, and S. Zribi. They have been invaluable supporters.

Table of contents

Preface	1
Acknowledgements	2
Executive summary	5
خلاصة	6
Glossary of key terms	7
List of acronyms	11
PART 1	12
1 Introduction	12
1.1 Context of the plan	12
1.2 Objectives and vision	12
1.3 Overview of content	13
2 Rmel River Basin	14
2.1 Current status and dynamics	14
2.2 Policy context	19
2.3 Main challenges	22
3 Participatory development of River Basin Adaptation Plan	25
3.1 Development process of Rmel River Basin Adaptation Plan	25
3.2 Methodological overview	29
3.3 Methodological description	31
4 Adaptation actions	34
4.1 Overview of Water Management Options	34
4.2 Bundle factsheets	40
4.3 Monitoring	58
5 BeWater recommendations for Rmel River Basin	61
5.1 From planning to action: Recommendations for implementation	61
5.2 Next steps	63
PART 2	65
6 Water management options	65
WMO 1: Promote new water and soil conservation techniques	65
WMO 2: Consolidation of existing water and soil conservation techniques	67
WMO 3: Creation and rehabilitation of hydraulic infrastructure	69
WMO 4: Application of taxes	72
WMO 5: Developing agricultural cooperatives	74
WMO 6: Good use of agricultural land	76
WMO 7: Developing financial awareness tools	78
WMO 8: Use of water irrigation technologies	80
WMO 9: Improvement of the treatment of waste water	82
WMO 10: Water discharge control	84
WMO 11: Reduction of society pressure on forests	86
WMO 12: Protection against forest fire	88
WMO 13: Introduction of new agro forestry species and enrichment of existing forest	90

WMO 14: Better governance of forest resources.....	92
WMO 15: Awareness campaign and learning.....	94
WMO 16: Improved decision making.....	96
WMO 17: Promote projects that generate more income.....	98
WMO 18: Encourage investments.....	100
WMO 19: Developing skills for young people	102
References	104

Executive summary

The development of an adaptive management plan for a watershed requires a good knowledge of the general context (e.g. existing resources, the main problems and issues) and a strong mobilization of stakeholders at both national and local levels.

The main objective of this research-development work was to develop a novel approach to engage society matters related to sustainable water management and adaptation to global change. This document presents the synthesis of the initiative and key recommendations. It deals with climate change and the adapted water management options at the Rmel watershed while considering the six main key challenges: 1- Water quantity, 2- Water quality, 3- Agriculture, 4- Forest and biodiversity management, 5- Awareness of civil society and Human resources, 6- employment.

A science driven approach is combined with a bottom-up participatory approach. In fact, the technicality and neutrality science offers are combined with the benefits of stakeholder participation.

The first step of the BeWater process in the Rmel river basin consisted in collecting scientific information related to climate change, land use, development of population, economic activities and potential future pressures to identify issues, challenges and management options for the above mentioned catchment.

In the second step, a Fuzzy Cognitive Mapping was applied to enable evaluating the water management options against the different challenges expressed by the stakeholders. Following that, a cost effectiveness analysis, and a multi-criteria analysis were conducted through participatory workshops in order to prioritize management options. Finally, the different options were grouped into bundles addressing different challenges based on their co-benefits.

The information provided throughout the plan is thus intended to serve as a tool to help to guide policy and decision makers in selecting appropriate options or sets of options to implement within the basin to address the basin's specific needs. Following this methodology, specific water management options are recommended within the river basin.

In order to insure the successful implementation of individual water management options or bundles of options, the development and execution of monitoring plan including sound indicators is crucial.

Our hope is that this developed step wise approach could be applied to other Tunisian and Mediterranean watersheds.

خلاصة

يعتبر التصرف المستدام في المياه من أهم التحديات المتعلقة بالمنطقة الأورومتوسطية في ظل التغيرات المناخية. إذ من المتوقع أن يؤدي تغير المناخ إلى زيادة ندرة المياه والجفاف في هذه المنطقة، مما سوف يسبب خسائر اجتماعية واقتصادية كبيرة إلى جانب التأثيرات البيئية السلبية. في هذا السياق، هناك حاجة ماسة إلى بذل مزيد من الجهود لتعزيز الشراكة بين العلم و المجتمع وترسيخ الشعور بالمسؤولية في إطار مواكبة الموارد المائية للتغيرات المناخية و العالمية. وتمثل عمليات تبادل المعارف والخبرات، تحسين الوعي إلى جانب الشراكة الفعالة بين المجتمع المدني و البحوث التنموية، المفتاح لضمان استراتيجيات التكيف الناجحة و دراسة سبل تنفيذها. إن العمل على هذا المنوال سوف يؤدي إلى زيادة مرونة النظم الاجتماعية و الإيكولوجية في الأحواض المائية.

في إطار مشروع BeWater تم تطوير خطة لمواجهة التحديات المناخية المستقبلية و هي عبارة عن نتيجة للجهود المكثفة لفريق العمل من خلال جمع المعلومات اللازمة ، التحليل النقدي الهادف، التخطيط المدروس والمشاركة الواسعة لأصحاب المصلحة. ولقد تم اختيار حوض وادي "رمل" نتيجة للحاجة الملحة إلى زيادة الوعي بالتحديات التي تواجه المجتمع المدني نتيجة للتغيرات المناخية. تم التركيز في هذه الخطة على خيارات التصرف في المياه التي من شأنها تحسين الإدارة المستدامة لحوض وادي "رمل" على المدى القريب والطويل. إذ تمثل هذه المنهجية حافزا لتطوير خطط تكيف الأحواض المائية مع التغيرات المناخية في منطقة البحر الأبيض المتوسط و في جميع أنحاء أوروبا.

Glossary of key terms

- **Acceptability (as criteria for water management options)** - an option is considered as acceptable if there is not significant reason a priori for actors in the basin to reject the option, e.g. because of its design [i]
- **Adaptation pathway** - portrays a sequence of actions and their implementation prioritisation over the short, medium and long-term, with regards to achieving a set of pre-specified objectives under uncertain changing conditions [ii]
- **Adaptive management** - an approach to reduce ecological uncertainty and increase resilience by emphasising that management regimes should be regularly adjusted to changes in the ecological system being managed and to managers' evolving understanding of this system
- **Bottom-up approach** - entails the participation of local actors in decision-making about the selection of the priorities and actions to be pursued in their local area; the approach can interact and be combined with top-down approaches from national and/or regional authorities in order to achieve better overall results [iii]
- **Bulk water** - water obtained from the source and provided to a water service entity for distribution to end-users
- **Carrying capacity** - the maximum capacity of the natural environment in a certain area to provide ecosystem services (e.g. water, fertile soil for the production of crops, growth of natural vegetation or a healthy interplay between species that controls pests and diseases) to sustain the development of human activities; overriding the carrying capacity of a territory means disrupting its functionality
- **Citizen participation** - a process in which ordinary people take part – whether on a voluntary or obligatory basis and whether acting alone or as part of a group – with the goal of influencing a decision that will affect their community; this can take place within an institutional framework, and may be organized either by members of civil society or by decision makers [iv]
- **Challenge** - something that by its nature or character serves as a call to a special effort; the RBAP focuses on the challenges related to the impacts of global change in the river basin - now and in the years to come
- **Climate change** - any long-term change in climate over time, whether due to natural processes or as a result of human activity [v]
- **Climate change adaptation** - appropriate action to prevent or minimise the damage that climate change impacts can cause, or taking advantage of opportunities that may arise due to climate change [vi]
- **Climate change scenario** - the difference between a climate scenario (i.e. a plausible and often simplified representation of the future climate) and the current climate [vii]
- **Co-benefits (as criteria for water management options)** – options are considered to have co-benefits when their combined implementation amplifies the total impact-related

benefits, as compared to the benefits which would arise from implementing each option individually

- **Environmental flow regime** - describes the amount of water that is needed by the river ecosystem to sustain its natural functioning
- **Extreme climate event** – an event that is rare within its statistical reference distribution at a particular place (i.e. normally as rare as or rarer than the 10th or 90th percentile); specific characteristics may vary from place to place[viii]
- **Extreme weather event** - an average of a number of weather events over a certain period of time, an average which is itself extreme (e.g. rainfall over a season) [ix]
- **Feasibility (as criteria for water management options)** - an option is considered as feasible if physical, technical, regulatory or organizational obstacles are not existing or can be easily overcome during option's implementation [x]
- **Flexibility (as criteria for water management options)** - an option is considered flexible when it can be adjusted/ complemented or reversed when it turns out to be inadequate or inappropriate in practice [xi]
- **Fuzzy cognitive map** - a tool to graphically represent the knowledge about or the perception of a given system; can be converted into simple mathematical models to run simulations and calculate outcomes of possible scenarios to facilitate the discussion and exploration of complex issues [xii]
- **Global change** - changes in the global environment that may alter the capacity of the Earth to sustain life, encompassing climate change as well as other critical drivers of environmental change that may interact with climate change, such as land use change, population trends, the alteration of the water cycle and changes in ecosystem functionality [xiii]
- **Good status (of a water body)** – a term to describe a condition under which water bodies have the biological and chemical characteristics expected under sustainable conditions [xiv]
- **Governance** - the way rules, norms and actions are produced, sustained, regulated and held accountable; it refers to the processes of interaction and decision-making among the actors involved in a collective problem that lead to the creation, reinforcement, or reproduction of social norms and institutions [xv]
- **(Invasive) alien species** – plants, animals, pathogens and other organisms that are non-native to an ecosystem, and which may cause economic or environmental harm or adversely affect human health [xvi]
- **Impact assessment** – a method to identify the environmental, social and economic impacts of an action or project prior to decision-making
- **Implementation barrier or opportunity** - elements deriving from the implementation context influencing the foreseen or ideal development of an action
- **Karst** - a special type of landscape formed by the dissolution of soluble rocks, including limestone, dolomite and gypsum; it is characterised by underground drainage systems with sinkholes and caves; Karst regions contain aquifers that are capable of providing

large supplies of water [xxvii]; subterranean drainage may limit surface water with few to no rivers or lakes

- **Knowledge transfer** – the process of engaging with researchers, decision-makers or the community and decision-makers to generate, acquire, apply and make accessible the knowledge necessary to successfully develop and enhance evidence-based initiatives which enhance human, material, social and/or environmental wellbeing [xviii]
- **Meander** - a bend in a watercourse or river formed by erosion on the outer banks due to the flow of moving water and resulting in a winding water course; when a meander gets cut off from the main stream, an oxbow lake forms
- **Multi-criteria analysis** - a tool for supporting complex decision-making situations with multiple and often conflicting objectives (e.g. economic, ecological and social) that stakeholder groups and/or decision-makers value differently [xix]
- **Mutual learning** - a learning process experienced and shared by different actors developed through direct interactions; the process is conducive to adaptive water management and includes the exchange of information on technical features of river basin management, scientific findings, as well as political aspects, so as to arrive at a shared understanding of issues and possible solutions
- **Non-conventional water resources** - in the context of this plan, unconventional water resources are the desalination of brackish and seawater and cloud seeding, which present potential options for balancing future demands on water and available supplies [xx]
- **Oxbow lake** - a crescent shaped body of water lying alongside a winding river; formed when a wide meander from the main stem of a river is cut off [xxi]
- **Participatory co-creation** - an approach which integrates all stakeholders in the entire design process of an action, i.e. problem definition, solution generation, evaluation of proposed solutions during development, and implementation of solutions, to help ensure the result meets user needs and increase acceptability
- **Policy framework** - a broad set of laws, regulations, or processes that structure political, social, cultural or economic activities in a society; these policies form an interacting web and therewith impact the functioning of existing policies as well as new policy developments and policy amendments [xxii]
- **Pressure** - anthropogenic factors inducing environmental change (impacts), including for example the release of substances (emissions), physical and biological agents, the use of resources and the use of land by human activities [xxiii]
- **Resilience** - the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change [xxiv]
- **River basin** - the area of land from which all surface water runs off through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta [xxv]. It is a natural geographical and hydrological unit that is used e.g. by the European legislation to manage a single drainage area [xxvi]

- **River Basin Adaptation Plan** - management plans containing a series of basin-specific options for enhancing the resilience of the basin's water resources as well as societal resilience in the face of global change. They include an analysis of the options' implementation over time and present a range of further aspects relating to these options, such as implementation opportunities and co-benefits between the options.
- **River Basin District** - the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters [xxvii]
- **Robustness (as criteria for water management options)** - an option is considered robust to uncertainties if it can maintain its effectiveness under different climatic and socio-economic development scenarios [xxviii]
- **Sediment management** - organized and coordinated actions to reduce the impact of human activities or natural changes on the quantity and quality conditions of solid material that is or can be transported by or deposited from the river's water [xxix]
- **Shelterbelts** - a row of trees planted across the direction of wind to deflect and reduce wind speed without causing turbulence; generally, provide protection from desiccating winds to the extent of 5 to 10 times their height on windward side and up to 30 times on leeward side, thus reducing evaporation losses and wind erosion [xxx]
- **Socio-ecological system** – consists of 'a bio-geophysical' unit and its associated social actors and institutions; delimited by spatial or functional boundaries surrounding particular ecosystems and their problem context [xxxi]
- **Stakeholder** - any person, group or organisation with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome; the term is usually reserved for well-organised and active groups and organisations, thus making a distinction from the general public
- **Terrace** - a permanent berm and channel arrangement either constructed along the face of a slope at regular intervals or constructed as a continuous series of horizontal steps on the face of a slope in order to reduce erosion damage by capturing or slowing down surface runoff and directing it to a stable outlet at a velocity that minimizes erosion [xxxii]
- **Water management option** – activity developed within the scope of the BeWater project which aims to impact the interactions between water uses and the water body; can be characterised as nature-based approaches (enhancing natural regulation of ecosystem functionality), soft approaches (acting on management or policy norms and regulations) or technical approaches (developed through engineering)
- **Water scarcity** – a lack of sufficient available or safe water resources to meet water needs within a region; this can involve water stress, water shortage or deficits, and water crisis as a result of climate change, increased pollution, or increased human demand and overuse of water [xxxiii]
- **Watershed** - the area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater; this area is typically smaller than a river basin, meaning that several watersheds may comprise a single river basin [xxxiv]

List of acronyms

AEPR	Drinking Water in the Rural Area (Alimentation en Eau Potable Rural)
EU	European Union
IRDP	Integrated Rural Development Programs
Ha	Hectares
GDA	Agricultural Development Groups
Km	Kilometers
Mm	Millimeter
Mm ³	Million m ³
PMU	Management Unit Programs
RBAP	River Basin Adaptation Plan
ROAD	Regional Office of Agricultural Development
SONEDE	National Company of Water Exploitation and Distribution
WMO	Water Management Option
° C	Degree Celsius
WSC	Water soil conservation

PART 1

1 Introduction

1.1 Context of the plan

Global changes (e.g., climate, population, land use, economic development) are considered major challenges in the Rmel river basin. In fact, water resources in this watershed, as in most parts of Tunisia, are limited, unevenly distributed and annually variable. In light of future climate conditions, the growing demand for water by various sectors (agriculture, drinking water, industry, tourism, etc.) will exert acute pressure on these resources in the next years and will therefore bring a confrontation between resource supplies and needs. Consequently, the management of water resources remains a prominent issue whose resolution requires the roll-out of management plans not only on a large-scale (national level) but also on a small scale (watershed level).

The development of an adaptive management plan for a watershed requires a good knowledge of the general context (e.g., existing resources, the main problems and issues) and a strong mobilization of stakeholders at both national and local levels. The involvement of the local population (e.g., public actors, farmers, civil society and associations) is fundamental as it allows a better understanding of the current needs and constraints as well as an acceptance of commonly agreed solutions. In addition, a participatory approach leads to rising awareness among local actors on the challenges related to integrated water management and displays the need to adapt to global changes. It promotes a deeper sense of ownership of the water management.

At the same time, in view of the complexity and technicality of the matter, the development of an adaptive management plan for a watershed requires also the use of a scientific approach. In the BeWater project, a science driven approach is combined with a bottom-up participatory approach: the technicality and neutrality science offers is combined with the benefits of stakeholder participation.

Text box 1: Definition of RBAP

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

1.2 Objectives and vision

The Rmel river basin adaptation plan is a pilot case developed within a science and society project (BeWater). One of the underpinning objectives was to develop a novel approach to engage with society on matters related to sustainable water management and adaptation to global change. This document presents the synthesis of the initiative and key recommendations. It deals with climate change and the adapted water management options to the Rmel watershed while considering the six main key challenges: 1- Water quantity, 2-

Water quality, 3- Agriculture, 4-Forest and biodiversity management, 5- Awareness of civil society and 6- Human resources and employment.

The objectives of the river basin adaptation plan, and the processes that led to it, are:

- To raise public awareness on sustainable water management, with particular focus on the expected climate change impacts at river basin scale;
- To actively engage with local communities, discuss current water uses related problems and consider potential solutions;
- To present in a synthetic way a range of options and key recommendations that would increase the capacity of the Rmel river basin to adapt to the impact of global changes while considering water resources.

As such, the plan is voluntary and should be seen as a source of inspiration and ideas for the future management of the Rmel river basin and beyond. [14]

1.3 Overview of content

This document is divided into two main parts.

The first part comprises 5 major chapters.

- The first chapter introduces the BeWater project, the global context and main objectives of the plan for adapting the Rmel watershed to climate change.
- The second chapter presents the current and future status and the policy context of the watershed. In addition, the key challenges for the Rmel river basin are introduced.
- The methodology developed and adopted in the BeWater process and an overview of the detailed steps are presented in the third chapter.
- In the fourth chapter, the adaptation actions are introduced and synthesised in six bundles corresponding to the six key challenges identified for the Rmel river basin. Approaches to monitoring are also presented.
- The last chapter is devoted to the next steps and recommendations for the Rmel river basin.

The second part of this document includes detailed information on the individual water management options for the Rmel river basin as identified together with the stakeholders. In addition, an overview of the main achievements is presented.

2 Rmel River Basin

2.1 Current status and dynamics

2.1.1 Land

The watershed of Wadi Rmel is located on the eastern coast of Tunisia, about 80 km south of Tunis. It provides a transition between different regions: the north of the Tunisian Dorsal, the Sahel and the Cap Bon. This basin extends essentially on the Zriba delegation of the governorate of Zaghouna and a substantial part of the same governorate with a total area of approximately 87000 ha. (Figure 1)

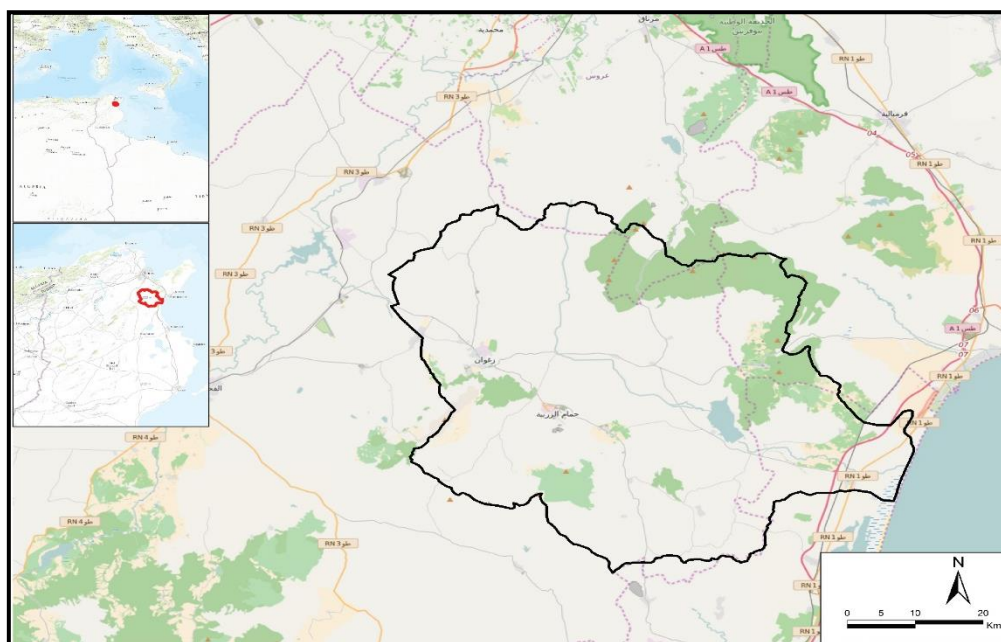


Figure 1: Geo-localization of the Rmel River Basin

The Rmel river basin is spread over 17 local territorial units and covers administratively four governorates (70% in Zaghouna, 19% in Sousse, 8% in Nabeul and 3% in BenArous). Several administrative departments are included in the Rmel river basin: four in Zaghouna (Zriba, Zaghouna, Saouaf and BirMchergua), one in Sousse (Bouficha), another at Nabeul (Hammamet) and the last one belongs to Ben Arous (Mornag) [2].

The Rmel watershed is characterized by a relatively rugged land, especially in the mountains of south-west and the north-east, and by medium to steep slopes. Slopes are between 0 and 10% over most of the basin. The steepest slopes are encountered mainly in south western and north-eastern sides [2].

The basin is covered by forest formations ranging from degraded scrubland to dense forest. Bushes or scrubland areas as well as forest relics of Aleppo pine occupy deposit slopes, forming the catchment. In the hills connecting the mountain, low lands lopes and agro cereal. Plains and piedmonts are under a heavy human pressure. They are systematically cultivated, mainly with cereals, which speeds up the process of soil erosion and consequently land degradation [2].

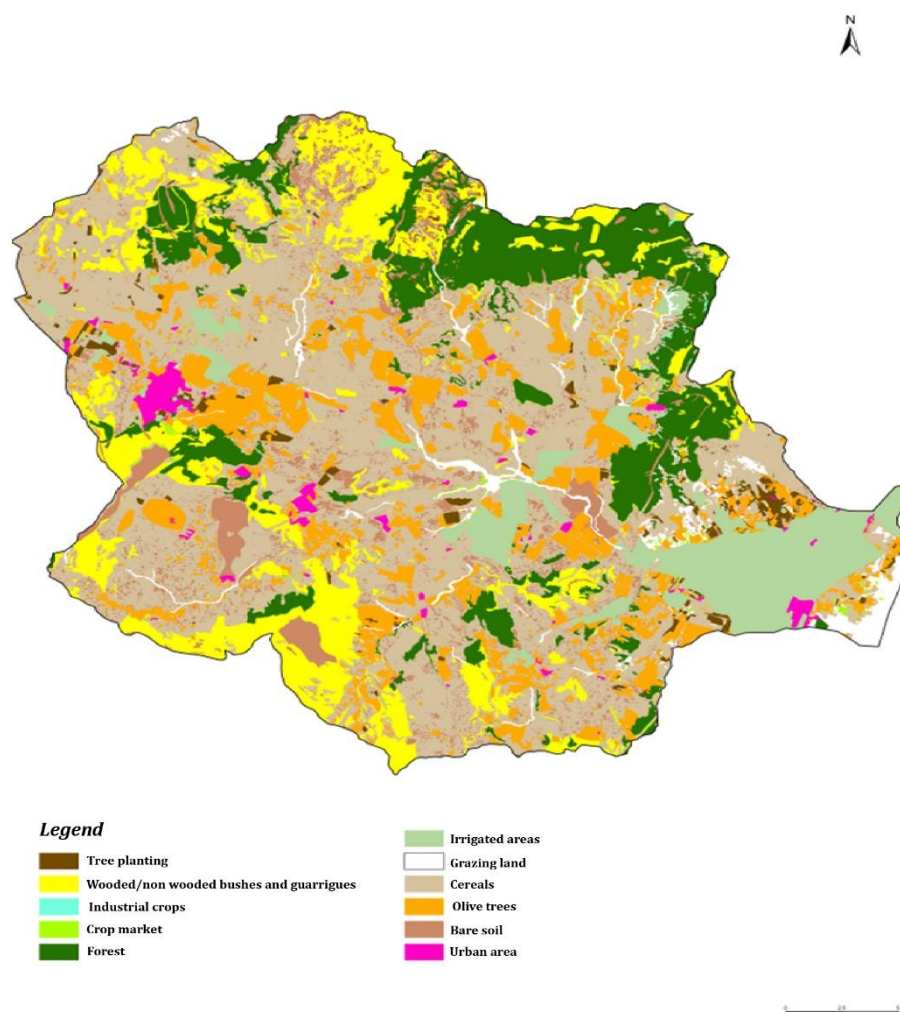


Figure 2: Soil cover at Rmel river basin

Agriculture in the Rmel river basin will be impacted in multiple ways by climate change. In the occurrence of a succession of dry years, lower production of olive and cereal areas in the central and southern part of the country is likely to be observed. Cattle raising is also affected during the droughts.

During the wet years, the olive oil production and the crop yields increase by 20% [4]. In case of flooding, irrigated areas and crop yields are affected. In the Southern part, climate change impacts the situation of oasis (microclimate) more critically [2].

In the next years, the climate projections display that more risk of large fires in the Northern part of Tunisia will be observed. Rising temperatures and sea levels (50 cm by 2100) are likely to increase coastal erosion and will cause the advance of the sea to the mainland coastal areas, posing threats to the integrity of coastal wetlands. All sebkhas with an area of 730 ha will turn into lagoons. The same is true for the Gulf of Hammamet, where about 1400 ha will be affected [4].

2.1.2 Climate change and water

The Rmel watershed is subject to a double climate influence, Mediterranean and continental, with an average temperature of 18.5°C and an average rainfall between 350-600 mm that is

characterized by high annual and seasonal irregularity. In addition, the basin has two deep groundwater bodies with a capacity of 8.38 million m³ [5].

The basin is part of the average semi-arid bioclimatic stage [5]. The limits in the south west are located in a sub humid region. The overall annual amount of precipitation is rather low and characterized by high irregularity [5]. The summer rain is generally of the convective type and breaks out as storms. During these short, sudden and violent storms heavy runoff is typical. The floods that originate in the mountains spread onto the coastal plains in the eastern part, where they represent either a source of life for the farmers or a catastrophe that destroys their assets. The wadis are quite wide and shallow and are known to be unpredictable. Almost everywhere during rainstorms they carry large quantities of water and sediments, blocking traffic for hours, and threatening the lives and property of the people along their usually dry banks.

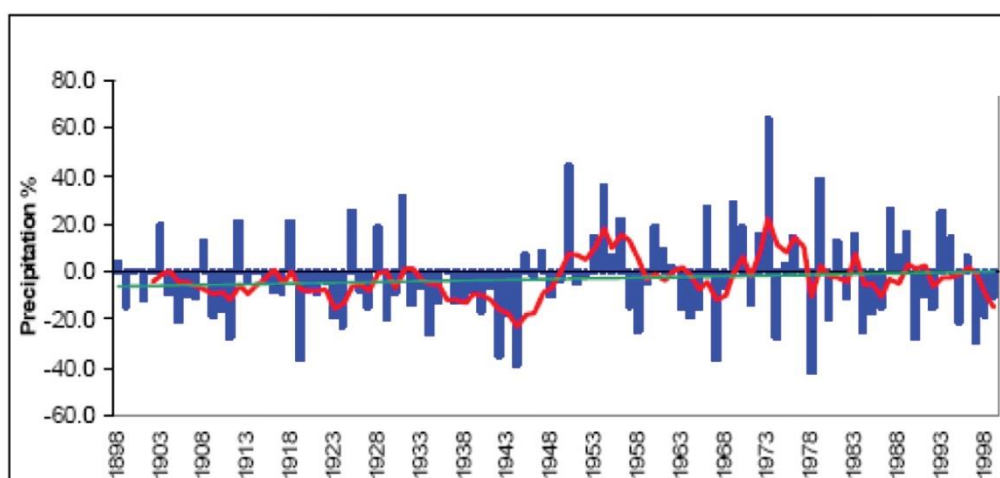


Figure 3: *Irregularity of annual precipitation (1898-1998)*

Water resources in semiarid areas are a limiting factor. In fact, the problem of storing a near-annual volume of rainwater that falls in only 5 months is a known issue to sustain agricultural activities within the different geomorphological units. Consequently, rainfall variability represents one of the biggest challenges regarding water resource development in the Rmel river basin. A dam with an initial capacity of 22 million m³ was built in 1998 about 9 km from the city of Bouficha. Water is intended mainly for the irrigation of 5900 ha of cropland in Bouficha and about 500 ha in Zaghuan [2] [5].

Water demand in Tunisia is estimated at 2 689 Mm³ in 2010 and projected to reach 2 770 Mm³ by the year 2030. Main water uses are irrigation, tourism, industry and drinking water (Figure 4). The demand for irrigation presents 77% of the total potential in 2030, making agriculture by far the largest water consumer. Drinking water demand was estimated at 381 Mm³ in 2010 and is projected to reach 491 by the year 2030 due to population growth (inhabitants will reach 12 million by 2030). As far as industry is concerned, the projected needs will almost double between 2010 and 2030 going from 136 Mm³ to 203 Mm³. Water demand in the tourism sector was estimated at 19 Mm³ in 2010, the projected needs will reach 41 Mm³ by the year 2030. Overall, the trend of water resources (groundwater & surface water) mobilization will reach 95% by 2025. Moreover, starting from 2020, Tunisia

will have recourse to unconventional water resources to respond the demand of different sectors.

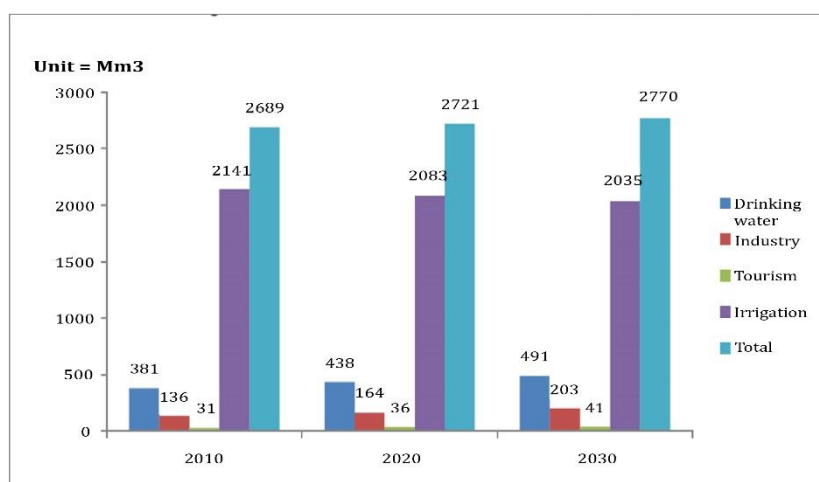


Figure 4: Future demand for water resources in Tunisia (2010-2030)

Additional infrastructure has been developed to exploit water resources. These are: 13 used natural springs, 104 boreholes, 370 shallow wells and 22 hill lakes. Groundwater use and drilling is primarily intended for irrigation and drinking water supply, and to provide a “security” supply during dry years. Hill lakes are intended either for supplementary irrigation, for groundwater recharge, or for the protection of the Rmel dam against siltation [5].

For climate projections over Tunisia, the HadCM3 model (general circulation model coupled atmosphere-ocean) was used to quantify and evaluate the increase in temperature and the likely decrease of rainfall in addition to the study of the variability of precipitation and the extremes horizons of 2020-2050 as compared to the reference period 1961-1990 [4]. The average annual increase over the entire country while considering scenarios A2 and B2 will be + 1.1 ° C in 2020 and + 2.1 ° C by 2050. (Figure 5)

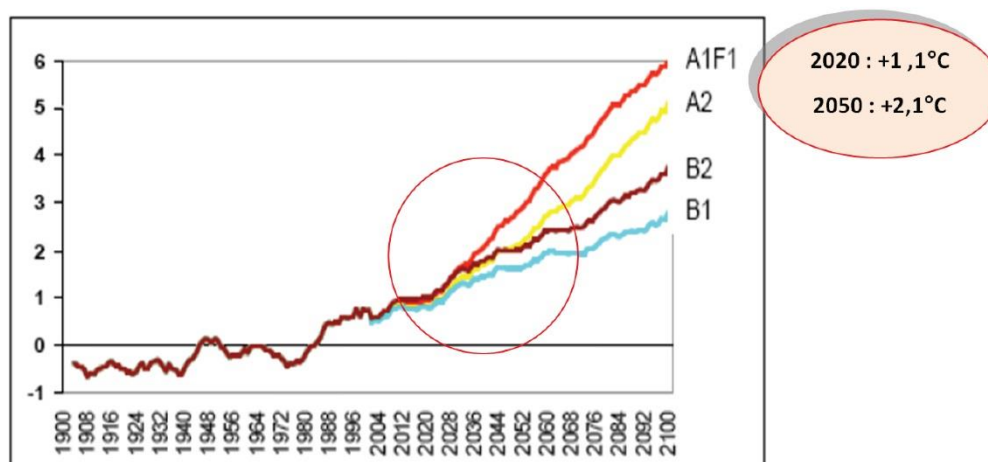


Figure 5: Elevated Temperature (° C) related to the four scenarios A1-F1 (high scenario), A2, B2 (average scenarios) and B1 (low scenario) from 1900 to 2100[4]

The Rmel watershed is a region rich in wildlife, as reflected in the variety of species such as boar, jackal, fox, wild cat and partridge. It is important to stress some species of birds such as hawks that are sedentary, while others are migratory as the booted eagle or dove. The wealth of wildlife has declined but remains important and deserves to be developed as it may be the basis of a great contribution to launch the green tourism in the areas near Tunis, Hammamet, Sousse, in an attractive environment where the forest and hill dams are highly valued landscapes [4].

2.1.4 People

The total population was estimated in 2014 at about 135 438 inhabitants, with about 46% living in urban areas and 54% in rural areas [7]. The distribution of the population in the basin is closely related to water resources. Indeed, valleys, wadis, small lakes and groundwater (aquifers and springs) are among the factors encouraging sedentary populations in the basin. In addition, the Rmel river basin has a strong cultural heritage around water resources (see Text box 2).

Text box 2. Cultural heritage in the Rmel river basin: the Water Temple [8]

A historic feature of Zaghouan Governorate, which is the most important part of the basin under study, is the roman monument "the Water Temple", located behind the Zaghouan city and right under the mountain of Jebel Zaghouan. It was built near the water spring known since antiquity. In addition to the water temple, there is an aqueduct connecting Zaghouan to Carthage, allowing the water supply to reach the Terms of Antonius and a source for the temple.

In mountainous regions, drinking water provision is manual or through cisterns that are transported along 3kms of the water source. However, households are increasingly seeking connection to a drinking water network. Since 2007, new rehabilitation projects aim to provide households access to the drinking water network [9].

In the Rmel river basin, agriculture is still the largest economic sector for employment with 31.9% (as opposed to 20% for Tunisia as a whole), closely followed by the manufacturing sector with 28%. Agricultural employment has gained momentum with an increase of 9.2% employment between 1999 and 2010. In rural areas, agriculture accounts for 34% the main source of employment and it provides jobs to almost all rural women [9].

The Rmel river basin holds an industrial zone with an area of 44 ha. It is located in the delegation of Zriba and contains 38 companies with a total workforce of 4 500 employees. This area is causing a water pollution problem due to direct dumping of waste in waterways [9].

In addition to agriculture and industrial activities, the Rmel river basin consists of 20% of forests that are used mainly for firewood, the extraction of oil, and the production of Alep seeds. Given the mountainous landscape, several areas of the watershed have been considered for agro-tourism projects.

The financing of agricultural private investments in the governorate of Zaghouan is largely provided by self-financing and bank loans, which represent 92% of the total. These investments were in the order of 23 million dinars in the year 2012. Agricultural activity is supervised by technicians assigned to agricultural extension, animal production, irrigation and crop production. Agricultural extension is provided by local cells of the extension. Future economic development is likely to result in growing water demand. With limited available resources and increased aridity due to climate change, the rising pressure on water resources is a challenge for the near future [9].

2.2 Policy context

The Rmel river basin and its citizens nevertheless face great challenges in relation to sustainable water management. Important gaps with regards to drinking water supply and

wastewater treatment remain, while demand for further economic opportunities and development is high.

Tunisia has undertaken a prospective thinking initiative on the impacts of climate change on the agriculture and natural resources. For this reason, a national strategy for the adaptation of Tunisian agriculture and ecosystems to the climate change [6] and a study on protecting ecosystems and climate change adaptation [4] have been developed.

The Tunisian Government has established an extensive national legal framework, reflecting, on the one hand, an awareness of the problems related to the management of natural resources, and, on the other hand, its commitment to improve the rational and sustainable use of water for future generations. This legal framework is composed of provisions contained in codes such as the water code [10], the forestry code [11], the investment incentives code [12] as well as a wealth of laws, regulations, and ministerial orders. However, challenges remain, in particular regarding levels of enforcement, which are closely linked to the lack of financial resources to support implementation and effective governance to support collaboration across the large range of actors relevant for sustainable river basin management (see Text box 3).

The “Water Code”, now being revised, is the major legislative instrument for water management in Tunisia since 1975. This code is the legal baseline organizing the ownership and exploitation of water in Tunisia. In addition, every five years, the Tunisian Government sets its “Development Strategy” which includes a core component on water. Management is based primarily on a system of financial incentives for the promotion of facilities and water-saving technologies. The government offers subsidies for farmers to promote the rationalization of water in agriculture. In addition, the “Development Strategy” promotes the decentralization of the state and the participation of users in water management. The authorities display an interest in the water saving policy domain; authorizations or concessions affecting water, drinking and agricultural water, as well as the efforts put to reduce water pollution.

In Tunisia, rural development is considered in the context of five-year socio-economic development plans. The Ministry of Agriculture and Water Resources is the body responsible for water resources mobilization and development, to ensure access to drinking water for the urban and rural population and supply water to the agriculture, industry and tourism sectors. Technical bureaus within the Regional Offices for Agricultural Development (ROAD) enforce all programs and projects at the regional level. These are the government’s main agricultural development institutions in each governorate. The districts are represented in the delegations by representatives. Often under Integrated Rural Development Programs (IRDP), the representatives are supported by a management unit (PMU). It is divided into the departments for water resources, forests, land resources and agricultural engineering. In addition, the ROAD works closely with Agricultural Development Groups (GDA) which brings together owners and users to jointly manage natural resources.

In Tunisia, the Ministry of Agriculture and Water Resources (MAWR) is the supervisory authority that organizes the varying frameworks responsible for water management and the development of public irrigated perimeters. The ministry carries out studies and water mobilization work and manages large reservoirs. Furthermore, it promotes user groups in the field of irrigation, and develops and implements management tools for water demand in the agricultural sector. The present Regional Offices of Agricultural Development (ROAD) represent the ministry in each Tunisian governorate. These offices have the human

resources, engineering equipment, financial and legal means to ensure preservation of the water resources, watershed management, hydro-agricultural development, agricultural extension, financial incentives and approvals (Berndtsson and al., 2016).

The creation of ROAD in 1987 intended to encourage the revitalization of the associative movement to support the management of water projects by the beneficiaries. Following this trend of decentralization, regulatory texts relating to collective interest associations (AIC) were revised in 1991. In 1999, these associations evolved to collective interest groups (GIC) under contract with the CRDA. In 2007, new regulations required the GIC to evolve into Groups for Agricultural Development (GDA). The GDA undertake other management activities related to the protection and exploitation of natural resources. However, the water management activities are predominant. Eventually, the state retained the maintenance, rehabilitation, and upgrading of large structures. People who use water from hydraulic infrastructure financed by the state have to join these associations (Selmi and Sai 1998).

Textbox 3: Water management in Tunisia: historical development and current challenges

Early on, the risk of water scarcity has prompted the political class to take decisions and to set specific strategies in this sector. The first strategy of water resources management that Tunisia undertook after independence was considered as a technical investment phase (1960-1980). It was marked by the construction of large hydraulic structures that mobilized more than 50 per cent of total agricultural investment. These projects stored, allocated, transferred, treated and distributed water resources. These choices were based on the logic of better resource allocation between different regions in order to accelerate the country's development. This infrastructure was intended to increase agricultural production in the northern region, ensure the supply of drinking water, promote the tourism industry in the Sahel, and supply large cultivated areas with irrigation. However, the legal and structural component that accompanied these programs resulted in a policy which encouraged intensification of agriculture and natural resource use.

Since 2000, a period of adjustment has been occurred, characterized by the launch of several studies (e.g., Water 2000 [13] - water sector strategy) for the rational and sustainable exploitation of water resources. This policy aims to promote a number of "modern" water management approaches such as water demand management, better water pricing, encouraging water saving, reinforcement of collective management, and promotion of small and medium hydraulic infrastructure.

Nevertheless, several challenges regarding water management in Tunisia remain, in particular in rural river basins such as the Rmel. Investments in large hydraulic projects did not always result in widespread benefits and the emergence of a resilient rural economy. Rural society is suffering from unemployment and underemployment, rural exodus with the loss of know-how in traditional irrigation practices, the accentuation of regional imbalances favoring urban development and the industrial and touristic sectors, and the emergence and a deepening, chronic food deficit. Small hydraulic structures, which have the potential to benefit small farm holders, are mobilizing less than 10 per cent of total agricultural investment. In parallel, decentralization and local water governance remain to be fully established and appropriated by the government and society. Water associations have had a relative success, affected by challenges regarding enforcement, empowerment, commitment and inclusion of marginalized farmers.

2.3 Main challenges

As part of the participatory process, stakeholders were actively involved in identifying the main challenges characterizing the Rmel river basin. In fact, during the first workshop that took place in Zaghouan on 24 June 2014, all the participants had to answer the following questions [14]:

- From your perspective, what are the biggest challenges in the medium-long term for this river basin?
- If you are allowed to dream and looking from your perspective, what should water management have achieved by 2030, in this river basin?
- What options do you see to help achieve that desired state by 2030?

Building on the information collected during this workshop and additional interviews that were conducted in the Rmel river basin, six main challenges were identified.

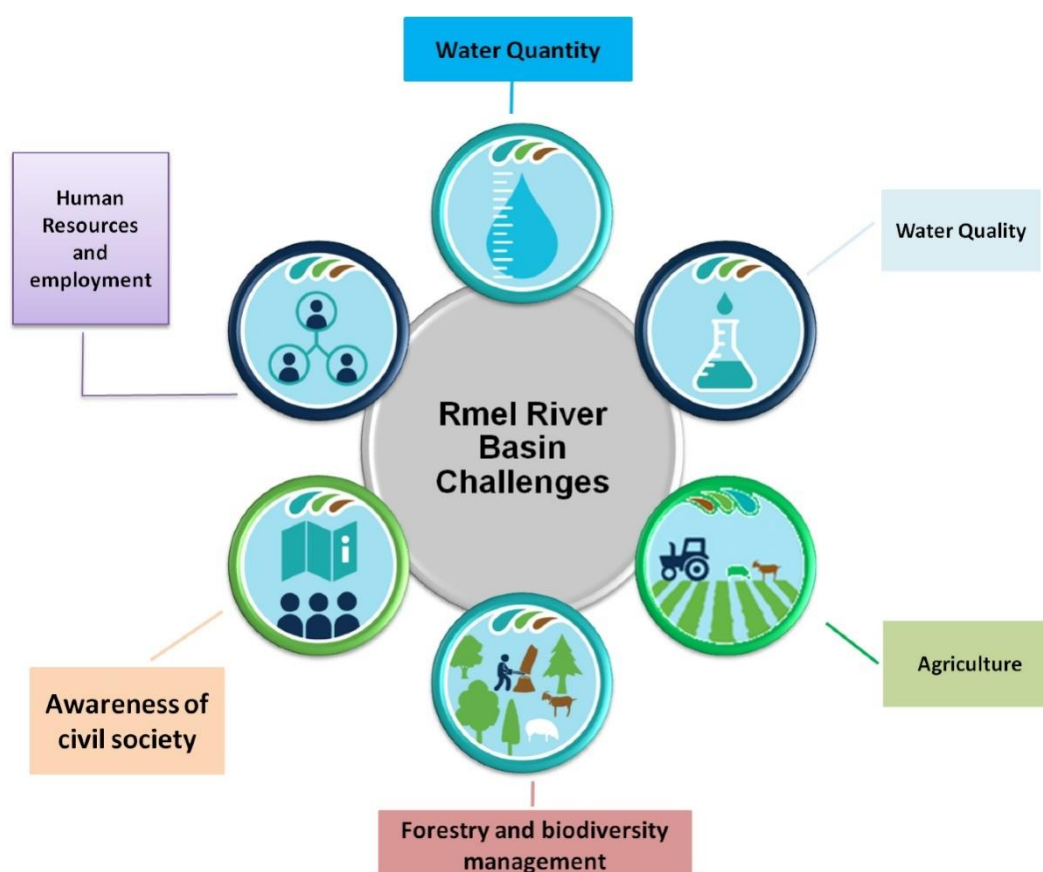


Figure 7: The main challenges of Rmel River basin

➤ Challenge A: Water quantity

In the study area, the rainfall regime is characterized by irregularity and high intensity that cause soil degradation. Also, inappropriate human activities (overgrazing, unsustainable agricultural practices, etc.), accelerate water erosion processes. The limited use of water

and soil conservation techniques all over the catchment is causing a reduction of the dam storage capacity. Certain areas remain disserved of drinking water. Losses in the drinking water supply network and low flows affect the quantity of water especially during peak hours. Responding to the needs of the local population by considering sound water management is a priority in our basin.

This challenge is related to: water and soil conservation techniques, soil degradation, flooding, surface water, ground water, irrigated cropland, soil water reserve, water demand and water availability in reservoirs.

➤ **Challenge B: Water quality**

This region consists of 33 enterprises that release their waste liquids (waste of olive presses, lime) in the Rmel river. These waste liquids have a high influence on the water quality in the basin. Waste water treatment and control of contamination of the river is necessary to preserve the water quality in the basin.

This challenge is related to: water quality, industry and tourism, surface water and ground water, water demand.

➤ **Challenge C: Agriculture**

The current situation of the irrigated sector is characterized by several levels of overuse and an overall modest increase resulting from various constraints, mainly related social and land pressures. The agriculture sector can face water shortage during summer time. In fact, the mobilized water at the Rmel dam is limited and can't supply all downstream irrigated perimeters. The majorities of farmers are very aged and are practicing ancient techniques and old agricultural customs; moreover, they are struggling with land conflicts. Good management of irrigated perimeters, support of farmers and improving operational and management requirements constitute a challenge to improve agriculture that represents the main occupation of the basin.

This challenge is related to: population livelihood and settlements, irrigated cropland, rainfed cropland, job creation, water quality.

➤ **Challenge D: Forestry and biodiversity management**

The forest is both a valuable protective mantle for soil and an incomparable set of sites and landscapes but it is particularly threatened. The over-exploitation of the forest and the intensive agro-pastoral practices have led to severe degradation of forest resources. Consequently, it becomes crucial to highlight the economic, social, and ecological importance of forests. Future strategies need to develop and ensure the protection of this precious and fragile heritage.

This challenge is related to: forest fire, forest resources, soil degradation, pasture and cattle rising, population and settlements.

➤ **Challenge E: Awareness of civil society**

The lack of awareness of civil society about the importance of natural resources is due to the lack of coordination between the authorities and civil society, as well as the fact that local people are kept out of decision making processes (not only in the basin, but in the whole region). Therefore, awareness, training and integration of civil society in studies and the coordination between society and science are necessary for the success of adaptive water management.

This challenge is related to: population and settlement, forest resources, surface water and ground water, soil degradation, pasture and cattle rising, irrigated cropland, industry and tourism.

➤ **Challenge F: Human resources and employment**

The analysis of socio-economic issues has identified constraints that concern the future beneficiaries: the main constraints mentioned by young people are, namely, guidance difficulty towards vocational training, lack of generating income projects, unemployment, migration, and lack of specialized manpower. A better exploitation of existing human resources in the basin and the creation of jobs are a relevant challenge for the development of the area.

This challenge is related to: job creation, industry and tourism, population and settlements, irrigated cropland, rainfed cropland.

3 Participatory development of River Basin Adaptation Plan

3.1 Development process of Rmel River Basin Adaptation Plan

The Adaptation plan of Rmel River Basin was developed through an interactive process of mutual learning, participatory techniques and a bottom-up approach to ensure that stakeholders played an active role in developing appropriate strategies for the management of river basins. Several groups of stakeholders were invited to express their interest and views on managing water resources in the Rmel river basin. Relevant discussions were conducted every time to describe the current situation and the main issues regarding water resources. Therefore, specific local knowledge, several suggestions and different water management options that would be considered at the Rmel watershed scale emerged.

Development of river basin

2014

January–March

1st general project meeting in Barcelona
Identification and mapping of river basin stakeholders and key actors

April–June

1st stakeholder workshop on identifying the current and desired status of the river basin
Review and analysis of river basin adaptation plans and strategies from around the world

2015

January–March

Stakeholder consultation on draft narratives and the basin's graphical representation (fuzzy cognitive map)

April–June

Finalisation of river basin narrative, fuzzy cognitive map, and main challenges
Formulation of water management options to tackle challenges
2nd stakeholder workshop on evaluating water management options

2016

January–March

Characterisation of policy and stakeholder basis of water management options
Assessment of water management option synergies and co-benefits
Design of draft bundles of water management options

April–June

3rd stakeholder workshop on desired content and implementation of the River Basin Adaptation Plan
Finalisation of adaptation pathways and bundles of water management options

adaptation plan



July–September

Stakeholder interviews on the river basin context and challenges

October–December

2nd general project meeting in Nicosia

July–September

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

October–December

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

3rd general project meeting in Barcelona

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

July–September

Completion of River Basin Adaptation Plan

Next steps

Development of policy recommendations to support river basin adaptation

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

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

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

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

3.1.1 Identification of stakeholders

The identification process of stakeholders focused on ensuring a sufficient diversity of identified stakeholders taking into consideration the activity's area (agriculture, infrastructure, water, environment, energy and forest management), gender and organizational affiliation such as business and economy, government and public authorities, civil society, practitioners, media, youth and education. Therefore, a stakeholder database was developed in order to facilitate the selection of participants for major stakeholder engagement activities, according to a selection process based on Prospex' CQI method. The latter established some selection criteria, together with target quota, in order to achieve a balanced group of stakeholders. Scientists from the National Research Institute for Rural Engineering Water and Forestry (INRGREF) are involved in the BeWater project and have organized several workshops to discuss water management in the context of global change for the Rmel river basin [15].

3.1.2 Integration of stakeholders

The first BeWater workshop aimed to gather a representative and knowledgeable stakeholders's group for discussing the current water use problems. They identified issues and challenges for the medium-long term and created their preliminary vision for Rmel river basin. The **second BeWater stakeholders' workshop** held in Yasmine Hammamet (Tunisia) on the 4th of June 2015 was attended by 24 stakeholders and the research team. The main objectives of this workshop were to gather the Rmel basin stakeholders together in order to discuss the registered progress since the first stakeholder workshop (2014) and screening for their evaluations concerning the water management options (WMOs) [16].

On the 7th of October 2015, the BeWater stakeholder event took place in Tunis (Tunisia). About 50 participants attended this event, including engineers, educators, administrators, sociologists, policy makers and planners who covered various sectors such as agriculture, education, associations, technical directions, irrigation, and development. Participants in the third stakeholder workshop reviewed the 19 options defined in previous workshops and gave their options according to their knowledge, experience and expertise. Furthermore, participants discussed their experience with each option, as well as any barriers (political, social, and economical) in order to implement options and costs [17].

The following BeWater stakeholder workshop took place in Tunis on Thursday, 7th of April 2016, as a close cooperation with experts from Ecologic Institute. This workshop was attended by about 50 participants and it involved interactive sessions for identified options from the previous workshops and their possible combinations, as well as potential synergies and conflicts between them. Furthermore, the workshop explored how options can be eventually implemented.

Furthermore, in order to present the project and its objectives, several events and awareness campaigns were conducted by the project team in the Rmel river basin (primary school, public areas....). All these events are detailed in Annex 1.

3.2 Methodological overview

SELECTING STAKEHOLDERS

To develop successful adaptation strategies, stakeholders need to be involved. Their participation is important to ensure robust and enriched decision-making, and the creation of awareness, trust and acceptance within river basin communities. Experts identify relevant stakeholder categories throughout the project. The identification of individual stakeholders follows a process, using a set of selection criteria to achieve a balanced and sufficiently diverse group of participating stakeholders.



Identify stakeholders for the river basin

UNDERSTANDING BASIN PRESSURES

Scientific information on the river basin is available from various sources. It contains historic information on climate change, land use change, population development etc., as well as potential future changes of these pressures. This information is collected and structured by scientific experts and is made available to stakeholders.



Compile available information on climate change impacts and future trends

AGREEING ON CHALLENGES

The local stakeholders discuss the impacts of climate change and other pressures on their river basin, based on the available scientific information. Furthermore, they discuss the main challenges to be tackled by water management by 2030. The main findings and shared insights are summarized in a narrative of the river basin by the scientific experts.



Develop narratives on the current status and identify challenges of the river basin

MAPPING BASIC DYNAMICS

Stakeholders and scientific experts contribute to the creation of a qualitative model (Fuzzy Cognitive Map) that describes how different factors affect the basin. It considers important factors that contribute to the status of the river basin, as well as the relations between these factors. The qualitative model allows organizing all the information available to provide a clear understanding of the current status in the basin: main challenges at stake, drivers that influence them and their relations in the river basin system.



Develop a qualitative model for the river basin

IDENTIFYING OPTIONS

When the local stakeholders have developed a shared understanding of the dynamics within the river basin, they identify potential solutions, i.e. water management options, to help achieve the objectives they had stated for the river basin. These include soft options, such as educational and awareness initiatives, grey options - infrastructural works - and green options (ecosystem based initiatives). The options are described by scientific experts in sufficient detail to enable estimating their impact as well as conducting an indicative cost-effectiveness analysis.



Formulate water management options

ASSESSING EFFECTIVENESS

When the options have been identified and clearly described, they are integrated into the qualitative model to assess their impact on the status of the river basin. This impact assessment is conducted by the scientific experts and discussed with stakeholders.



The BeWater process at the Rmel River Basin



3.3 Methodological description

In order to formulate and evaluate water management options (WMOs) for adapting the functioning of the Rmel river basin to global change, we conducted the following series of steps: (i) Elicit the main challenges in each river basin based on the current state and future expectations, (ii) Formulate water management options for each of the challenges, and (iii) Evaluate the water management options [18].

The BeWater project has set up clear mechanisms of sustained stakeholder engagement, integrated in a well-defined science-based methodology. The integration of science-driven and stakeholder-driven approaches clearly contributes to the societal relevance of the scientific activities. Indeed, stakeholders feed the scientific process with knowledge, arguments, suggestions, ideas, and challenge the outcome of the scientific approach.

The first step of the BeWater process in the Rmel river basin consisted in collecting scientific information related to climate change, land use, development of population, economic activities and potential future pressures. This information was collected and structured by scientific experts and discussed with stakeholders during the first workshop. The latter was organized in 2014 as part of the participatory process that aimed to discuss current water use problems, to identify issues and challenges for the Rmel basin and to create a preliminary vision for the river. In order to be able to evaluate the water management options against the different challenges expressed by the stakeholders, a method called Fuzzy Cognitive Mapping was applied.

During a series of workshops and consultations, a group of carefully selected stakeholders expressed their views on challenges faced in the Rmel river basin. Stakeholders also suggested a range of solutions to tackle these challenges. Each of the options was described in detail and was characterised using a set of descriptors concerning the approach to tackle the challenges, the time needed to implement options, the implementation estimated costs, etc. To ensure that the options suggested by the stakeholders were correctly understood, the refinement and characterisation of all of the options was carried out in close cooperation with experts and stakeholders through interviews, consultations and workshops.

The cost effectiveness analysis was based on an estimation of the costs of each of the options. This was performed using information on the cost of implementing and running similar options in other basins or on an implementation scenario defined with local stakeholders. Given available information, these costs are ranges rather than actual costs. The cost effectiveness was calculated using the results of the multi-criteria analysis, based on the impact criteria only, and the estimated cost as a ratio. These analyses give information to help select appropriate water management options based on their expected impacts and characteristics, and their cost-effectiveness.

Using the outcomes of previous workshops and the results of FCM, MCA and co-benefits, the options were grouped into bundles. The choice of bundles was based on the main identified challenges. In fact, we associated a bundle to each challenge in order to maximize the best options on six challenges identified. The options most directly associated to every challenge were called "priority options". The next step was to identify, for each challenge, synergies and conflicts between the priority options and other options.

However, the options, the analyses and the plans within which these elements are contained lay the foundation for successful future water management efforts within the river basin.

Furthermore, these elements represent an important contribution to river basin adaptation planning within the Mediterranean and beyond.

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

Text box 4: Fuzzy Cognitive Mapping

To be able to evaluate the water management options against the different challenges expressed by the stakeholders, a method called Fuzzy Cognitive Mapping was applied. A Fuzzy Cognitive Map is a graphical representation of a system - in this case a river basin - where the components (factors) are represented as boxes and relationships as arrows. The arrows reflect the sign and strength of the relationships between the factors. The map is cognitive because it represents the dynamics in the system based on the understanding of individuals. Fuzzy cognitive maps allow all the information available on the basin to be organized in a clear way to illustrate the current status in the basin: main challenges at stake, drivers that influence them and their relationships in the system. The maps were constructed with inputs was used to assess the impacts of the water management options on the river basin. In this way, the BeWater team was able to produce a semi-quantitative estimate of the impacts of water management options and their ability to effectively face the challenges of the basin, as input to a multi-criteria analysis that was conducted in a series of Stakeholder Workshops.

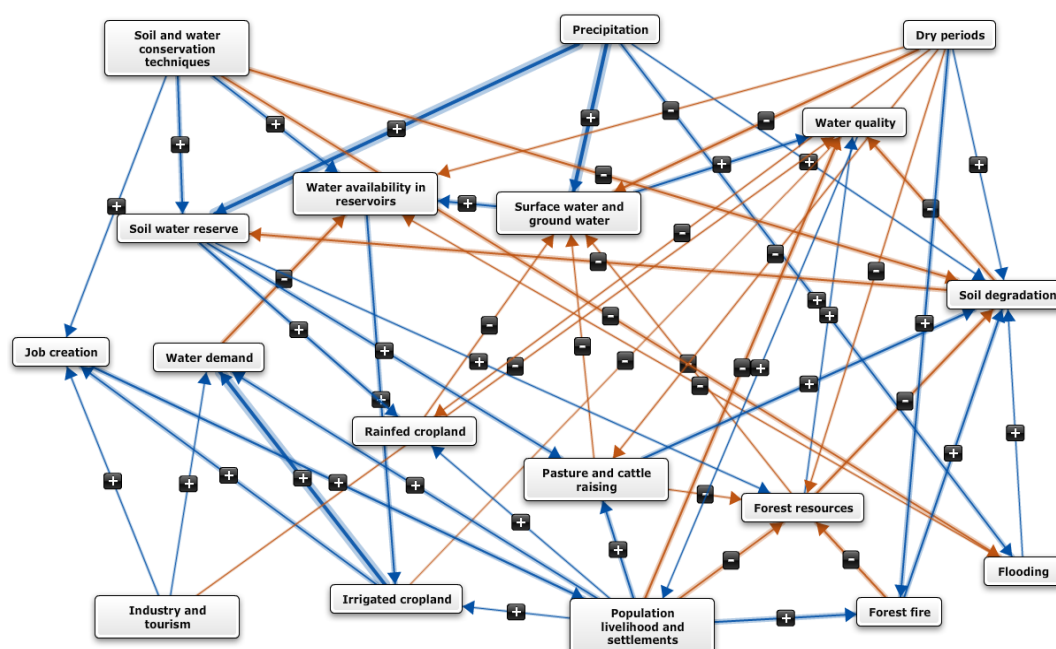


Figure 8: Cognitive map of the Rmel river basin (blue: +, red: -; strength: thin line:

1, medium width: 2, wide line: 3)

Text box 5: Multi-Criteria Analysis

Water management options have quite different characteristics and impacts on the water basin and the local communities. Selecting the specific options that should be included in the river basin adaptation plan is a complex endeavour. To support this process, a participatory multi-criteria analysis was conducted. During a workshop, stakeholders were asked to select the evaluation criteria to decide how well options perform, as well as the importance of each of these criteria in relation to each other. Criteria referred to both the design of the water management options and their expected impacts on the river basin, as estimated with the fuzzy cognitive map. The scores and weights of the criteria given by the stakeholders were combined with the characterization of the water management option and the outcomes of the impact assessment to evaluate the water management options prepared by experts and the research team. The evaluation results are presented on a scale of 0-100 with a 0 indicating the least preferred evaluation outcome and a value of 100 as the most preferred evaluation outcome. More detailed information on the individual criteria can be found in Chapter 4.1.

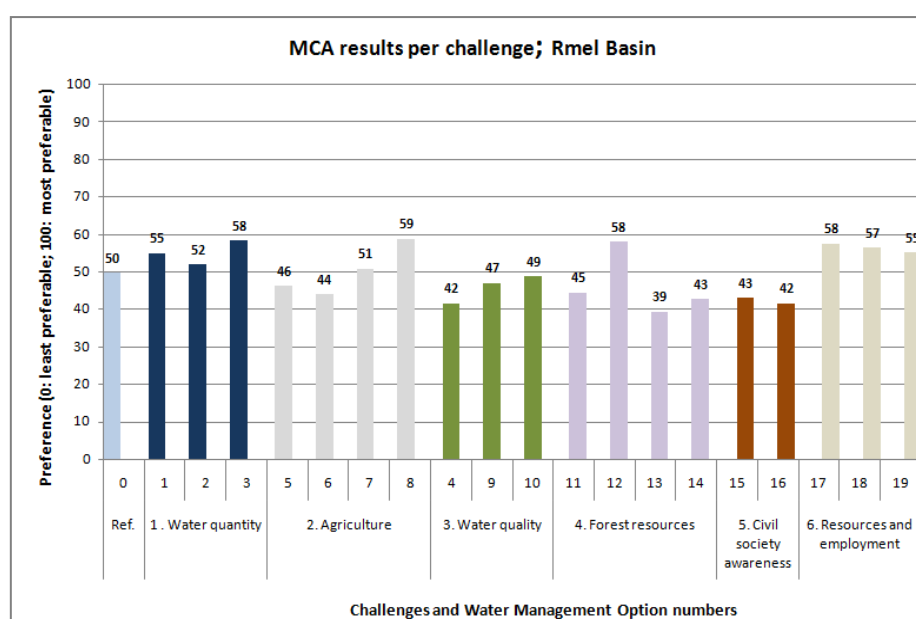


Figure 9: Outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment.

4 Adaptation actions

4.1 Overview of Water Management Options

Table 1 below lists the water management options (WMOs) developed for the Rmel river basin and presents a selection of additional information associated with each option. While the options are grouped together in bundles in Chapter 4 according to their synergistic interactions with one another and a common objective they contribute to, this table provides an overview of information that is specific to individual options. This information can be used by decision-makers when determining which single option(s) would be most appropriate to achieve their targeted objectives.











More specifically, the table associates each option with one of the challenges identified for the Rmel basin (see Chapter 2.3) and a score from the multi-criteria analysis. This score is based on the characterization of the option, the result of an assessment of the option's impact when applied in the river basin and stakeholder evaluations ('weights') of the importance of different possibilities for option features and impacts. A higher score from the multi-criteria analysis (ranging from 0 to 100) represents a stronger overall performance than that of possible alternatives in view of the criteria important to local stakeholders (see Box 5 for more information about the multi-criteria analysis).











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











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

- *All water management options identified are feasible and acceptable.*
- *14 options performed particularly well in the multi-criteria analysis and are therefore presented mostly with high priorities. Nevertheless, 5 options are involved with medium priority.*
- *8 options have strong synergies with national policies and 7 options have medium synergies.*
- *Three options (WMO 1, 2 & 3) were identified to cope with the challenge to increase water quantity (challenge A). This bundle presents the highest costs.*
- *The majority of options designed to cope with challenge D have high priority. The implementation of water management options enhancing sustainable forest management seems therefore most crucial when making adaptation planning for the Rmel river basin.*

- *16 water management options are characterized by a high co benefits while 3 options have a medium co benefits.*

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium, 2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-<1,000,000 euro), €€€: high (>1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
1		Promote new water and soil conservation techniques.		51	2	2	2	€€€	1,21	High
2		Consolidation of existing water and soil conservation techniques.		40	2	2	2	€€€	1,21	High
3		Creation and rehabilitation of hydraulic infrastructure		41	0	1,5	2	€€€	1,36	Medium
4		Application of taxes.		47	1	0,5	1	€	1,50	High
5		Developing agricultural cooperatives.		42	1	0,5	2	€€	1,60	High

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium, 2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
6		Good use of agriculture land.		37	1	1	2	€€	1,42	High
7		Developing financial awareness tools.		39	0	1,5	1	€€€	1,11	Medium
8		Use of water irrigation technologies		40	1	2	2	€€€	1,30	Medium
9		Improvement of the treatment of waste water.		46	0	0,5	2	€€€	1,33	Medium
10		Water discharge control.		42	1	0,5	1	€€€	1,29	Medium

WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium, 2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high (>1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
11		Reduction of society pressure on forests		39	1	0,5	1	€€	1,38	High
12		Protection against forest fire		48	1	2	1	€€€	1,50	High
13		Introduction of new agro forestry species and enrichment of existing forest.		37	1	0,5	1	€€€	1,45	High
14		Better governance of forest resources		42	1	1,5	0	€€	1,38	High
15		Awareness campaign and learning		40	1	1,5	2	€	1,12	High









WMO Rmel		Name of WMO	Challenge addressed	MCA results (0: least preferable; 100: most preferable)	Feasibility(0: serious obstacles, 1: no major obstacles, 2: minor obstacles)	Acceptability(0: low, 1: medium, 2: high)	Policy synergies (0: none, 1: medium, 2: high)	Costs (€: low (<200,000 euro), €€: medium (200,000-1,000,000 euro), €€€: high >1,000,000 euro))*	Co-benefit (>1: high, 1: medium, <1: none or conflicts)	Priority
16		Improved decision making		38	1	1,5	2	€	1,13	High
17		Promote projects that generate more income.		45	2	1,5	2	€€€	1,00	High
18		Encourage investments		41	1	1,5	2	€€€	1,00	High
19		Developing skills for young people		44	2	1,5	1	€€	1,00	High

Table 1: Overview of the identified water management options for Rmel River Basin

4.2 Bundle factsheets

4.2.1 Bundle on water quantity (Challenge A)

The main objective of this group of options is the quantitative management of water resources with emphasis on the conservation of water and soil while improving and developing water supply infrastructure.

Situational analysis	Context	Priority options
<p>The availability of water is a major issue. Indeed, the Rmel watershed is characterized by a semiarid climate and a very irregular rainfall. However, there is strong demand to improve the supply and meet the needs of the local population. It is crucial to have sufficient drinking water and resources to support the development of economic activities. Currently, users in various sectors present in the basin already exert significant pressure on water resources.. Human activities such as agriculture have also contributed to land degradation with consequent reduction of the capacity of soil to retain water and inducing siltation of reservoirs as well as the hydraulic infrastructure located downstream. Climate change contributes to intensifying the pressure on water resources and increases the risk of water erosion.</p>	<p>The phenomenon of water erosion is a major issue in the basin, with impacts on soil quality, their ability to retain water, siltation of downstream reservoirs and reducing their storage capacity.</p>	<p>WMO-01. Promote new water and soil conservation techniques</p> <p>The objective of this option is to reduce the impact of the phenomenon of water erosion, promote infiltration and collecting runoff water via WSC conservation techniques as well as soft techniques placed on agricultural land upstream.</p> <p>Examples: mechanical benches, dry stone cords, hill lakes, recharge works, dry stone thresholds and bowls. Cost (15 years): 3 508 769 TND.</p>
	<p>The water and soil conservation techniques are in poor condition and thus currently have limited effectiveness.</p>	<p>WMO-02. Consolidation of existing water and soil conservation techniques</p> <p>This option aims to improve the function of existing water and soil conservation techniques</p> <p>Examples: Consolidation of mechanical benches, rehabilitation of irrigation schemes, re-profiling and clearing of wadis. Cost (15 years): 1 526 920 TND.</p>
	<p>The distribution of water from source to recipients (drinking and irrigation water) is done primarily by hydraulic infrastructures that become increasingly dilapidated, causing losses of water.</p>	<p>WMO-03. Creation and rehabilitation of hydraulic infrastructure</p> <p>The objective of this option is to meet the needs of the population while controlling the demand for water resources. It consists, among other things, of encouraging rehabilitation and upgrading of existing drinking water and irrigation networks.</p> <p>Example: Rehabilitation and modernization of existing drinking water and irrigation networks, Creation of discharge stations, cisterns construction. Cost (15 years): 1 110 253 TND.</p>

Co-benefits with other options

Several water management options will have strong co-benefits along with the priority options WMO-01, WMO-02 and WMO-03 on the issue of “water quantity”. WMO-06 fosters the proper use of agricultural land, WMO-13 aimed at protecting forests and WMO-17 incites investment in diversification projects and consolidation of the rural economy (e.g. organic farming; eco-tourism, crafts). They all contribute to strengthening the impact of WMO-01 and WMO-02 on the control of water erosion and runoff. WMO-05 is designed to organize farmers in cooperatives while WMO-08 promotes the adoption of efficient irrigation techniques contributing to strengthen the impact of WMO-03 on saving water. Finally, WMO-15 has a specific section on water savings to strengthen WMO-03.

Associated options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-01	WMO-02	WMO-03
WMO-04: Application of taxes			
WMO-05: Developing agricultural cooperatives			
WMO-06: Good use of agriculture land			
WMO-07: Developing financial awareness tools			
WMO-08: Use of water irrigation technologies			
WMO-09: Improvement of the treatment of waste water			
WMO-10: Water discharge control			
WMO-12: Protection against forest fire			
WMO-13: New agro forestry species and enrichment of existing forest			
WMO-15: Awareness campaign and learning			
WMO-16: Improved decision making			
WMO-17: Promote projects that generate more income			
WMO-18: Encourage investments			
WMO-19: Developing skills for young people			

Political and participatory implementation of priority options

WMO-01. Promote new water and soil conservation techniques

At the present time, this option is mainly supported by the Conservation Code of water and soil. It is also reinforced by the 11th Plan for Agricultural Development Policy.

It will be necessary to raise awareness among farmers and local people while also involving associations.

WMO-02. Consolidation of existing water and soil conservation techniques

This option is also supported by the Conservation Code of water and soil, and reinforced by the 11th Plan for Agricultural Development Policy. These actions can help overcome the problems due to the lack of transparency on land and the lack of an updated register of properties.

It will be necessary to strengthen the involvement and awareness of farmers and local people (through associations) of the benefits and importance of the protection of the realized developments.

WMO-03. Creation and rehabilitation of hydraulic infrastructure

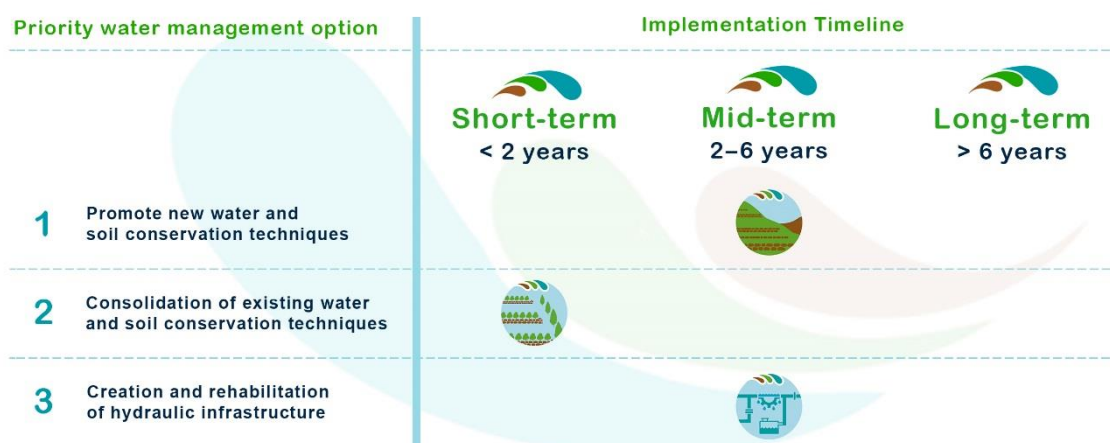
This option is reinforced by the Water Code. Corresponding work aims at the development, the economy, and the improvement of water quantity. The protection of national water resources is now declared a public utility.

The management of rural drinking water supply systems is provided either by the National Company of Water Exploitation and Distribution (SONEDE) through its own network or by user associations called Agricultural Development Group (GDAP) for AEPR systems carried out by the Office of Rural Engineering.

Temporal implementation of priority options

The WMO-02 is to be implemented in the short term as it has been assessed as priority during the participatory process. Through multiple previous experiences in the basin, its implementation is facing some technical difficulties and can rely on a favorable regulatory framework. Local actors have a good knowledge of these techniques. The WMO-01 seeks to complement in the medium term the WMO-02 by extending the implementation of technical conservation of water and soil on new surfaces. The WMO-03 must be done in the medium term.

Bundle 1: Water Quantity



4.2.2 Bundle on Water Quality (Challenge B)

The main objective of this group of options is the protection and improvement of water quality in the Rmel watershed via strengthening economic incentives, a stricter implementation of laws and regulations, and recycling of unconventional resources.

Situational analysis	Context	Priority options
<p>Water resources are heavily polluted by discharges from industries, small factories, domestic population and other human activities. Pollution is not only harmful to the ecological balance of rivers but also may reduce the opportunities for using the downstream resource for agriculture and drinking water. The pollution of watercourses may also increase water treatment costs. The wastewater treatment is still limited in the basin, with little infrastructure and effective management systems in place. The valuation of wastewater is poorly developed although the opportunities for recycling exist for irrigation uses.</p>	<p>Even though there is a tax system on industrial wastewater discharges; its implementation is currently limited.</p>	<p>WMO-04. Application of taxes</p> <p>The option proposes to support a stricter implementation of penalties, which will encourage the adoption of more efficient water treatment systems.</p> <p>Cost (15 years): 8 367 TND.</p>
	<p>The waste water can be treated and reused for irrigation of certain crops. This will contribute to the reduction of the risk of pollution in the environment and reduce the pressure on conventional resources.</p>	<p>WMO-09. Improvement of the treatment of waste water</p> <p>This option consists of investing in the domestic and industrial wastewater treatment facilities (eg. Upgrading, expansion of networks, creation of waste water treatment plants) and to value the treated water for specific irrigated crops.</p> <p>Example: Create mini-stations for wastewater treatment, maintenance of existing stations. Cost (15 years): 546 934 TND.</p>
	<p>Random disposal of solid waste and the non-compliance of emissions by operators pose a risk to water quality in the wadis. The lack of solid waste management systems, especially in rural towns, contributes to this deterioration.</p>	<p>WMO-10. Water discharge control</p> <p>The action aims to strengthen controls in connection with the regulation and support the development of effective solid waste management systems. It also aims to encourage the recovery of waste from food processing, particularly olive presses, as fertilizers (spreading).</p> <p>Example: Creation of controlled new landfill sites, setting up of solid waste management systems in rural towns. Cost (15 years): 4500 000TND.</p>

Co-benefits with other options

The WMO-05 will have strong co-benefits along with WMO-09 priority options on the issue of "water quality", particularly by encouraging established cooperatives to use treated wastewater for irrigation of certain crops. The WMO-15 will help strengthen the WMO-10 by sensitizing local actors on the importance of controlling discharges.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-04	WMO-09	WMO-10
WMO-01: Promote new water and soil conservation techniques			
WMO-02: Consolidation of existing water and soil conservation techniques			
WMO-05: Developing agricultural cooperatives			
WMO-08: Use of water irrigation technologies			
WMO-15: Awareness campaign and learning			
WMO-16: Improved decision making			
WMO-19: Developing skills for young people			

Political and participatory implementation of priority options

WMO-04: Application of taxes

This option is backed by environmental policy on sanitation and waste management. Such a policy recognizes industrial pollution as one of the most important sources of quality degradation of natural resources as well as the health and environmental situation.

This option is based on communication, awareness and environmental education programme considered as basic element of any strategy to promote behaviour change. Such an option can be accompanied by awareness campaigns for the public and the private sectors (in particular industry).

WMO-09: Improvement of the treatment of waste water

This option is mainly supported by the Water Code which aims to fight against any actions that may cause or increase water degradation by modifying its physical, chemical, biological or bacteriological characteristics, whether it be surface water or groundwater.

Awareness campaigns should be organized for public and private industries in order to enlighten them on the importance of their roles in the protection of natural resources in general and in particular water resources. This option also requires significant involvement of associations to raise awareness among farmers.

WMO-10: Water discharge control

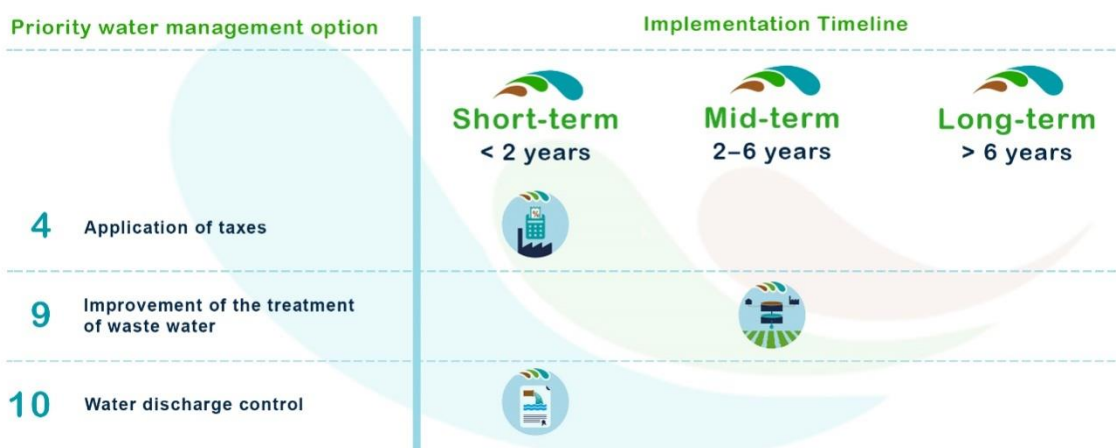
Waste management is a central component of the National Strategy of Sustainable Development in Tunisia. Similarly, it is reinforced by the Water Code and the Investment Incentives Code.

The option can be supported by awareness campaigns for the public and the private sector to foster responsible behaviour towards the environment. Similarly, a greater involvement of associations can be encouraged (e.g. Through training, technical and financial assistance, etc.). Also, collaboration between associations and local authorities should be supported.

Temporal implementation of priority options

The WMO-04 is to be applied in the short term because strengthening the implementation of taxes on waste water at industrial level can provide significant income and implicitly strengthen the implementation of laws and regulations on wastewater treatment. The WMO-09 demands greater technical capacity and investment, which will require the means and continued preparations in the medium term.

Bundle 2: Water Quality



4.2.3 Bundle on Agriculture (Challenge C)

This group of options aims to protect water resources through better organization of the agricultural sector, particularly through the implementation of collective solutions, improving the land situation, and promoting conservation farming and an efficient irrigation.

Situational analysis Agriculture is the main industry in the Rmel watershed and strongly impacts water resources. Water demand by the agricultural sector continues to grow from one year to the next and induces increasing pressure on natural resources. The dominant agricultural techniques that tend towards the intensification of agriculture promote uncontrolled water consumption and accelerate the phenomenon of water erosion and impoverished land. The local population which is mostly rural is mainly based on agriculture as a primary source of income. However, the lack of means, knowledge and the complexity of the land situation constitute obstacles to the implementation of sustainable solutions.	Context	Priority options
	The agricultural sector in Rmel watershed remains fragmented and the lack of communication (between farmers and the public authority) adds complexity to the promotion of comprehensive and integrated solutions.	WMO-05. Developing agricultural cooperatives The option is designed to encourage farmers to organize themselves into cooperatives to strengthen collaboration between private and public actors. This option facilitates the implementation of more comprehensive solutions, especially the sector of sustainable agriculture. Example: Creation of agricultural cooperatives, employers Training, Organization of awareness campaigns. Cost (15 years): 170 380 TND.
	The intense agricultural land use and farming practices based on highly water-consuming crops are destroying the quality of soil (Salinization) and promote the water erosion phenomenon.	WMO-06. Good use of agriculture land This option is intended to encourage conservation agriculture and use of suitable crops. This will improve productivity while also reducing irrigation. Example: Promotion of appropriate cultures, awareness campaigns. Cost (15 years): 292 834 TND.
	The farmers commonly face a deficit of financial and technical resources to sustainably improve their farms.	WMO-07. Developing financial awareness tools This option aims to improve land and tax situation of farmers through programmes of counselling and greater involvement of farmers in the grant procedure. Example: Improvement of land, counselling on subsidies. Cost (15 years): 917 555 TND.
	Water efficient and Saving irrigation techniques remain infrequently used in the watershed.	WMO-08. Use of water irrigation technologies This option aims to encourage farmers to reduce their water consumption through the adoption of efficient water irrigation techniques. Example: Adoption of efficient water irrigation techniques. Cost (15 years): 2 210 433 TND.

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-05, WMO-06, WMO-07 and WMO-08 on the issue "Agriculture". Options WMO-01 and WMO-02 will strengthen the impact of the WMO-06 on the protection of soil fertility and natural water storage. The WMO-03 and WMO-09 will strengthen the options WMO-05 and WMO-08 by promoting individual and collective technical solutions. The WMO-11 and WMO-13 options will increase the impact of the WMO-06 on soil protection. The WMO-15 and WMO-16 options will support the impact of the WMO-05 by sensitizing local stakeholders and facilitating their integration into the process of decision making. The WMO-17 and WMO-18 will strengthen the impact of the WMO-07 by encouraging farmers to organize themselves collectively (eg. Channels) and sustainably invest in their farms.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-05	WMO-06	WMO-07	WMO-08
WMO-01. Promote new water and soil conservation techniques				
WMO-02. Consolidation of existing water and soil conservation techniques				
WMO-03. Creation and rehabilitation of hydraulic infrastructure				
WMO-09. Improvement of the treatment of waste water				
WMO-11. Reduction of society pressure on forests				
WMO-13. Introduction of new agro forestry species and enrichment of existing forest				
WMO-14. Better governance of forest resources				
WMO-15. Awareness campaign and learning				
WMO-16. Improved decision making				
WMO-17. Promote projects that generate more income				
WMO-18. Encourage investments				
WMO-19. Developing skills for young people				

Political and participatory implementation of priority options

WMO-05. Developing agricultural cooperatives

This option is synergistic with the goals of most state programmes advocating a stronger structuring of the agricultural sector and collaboration between farmers. This can be based on the Law relating to companies of Agricultural Services.

The awareness raising of farmers about the importance of taking part and fit in a cooperative in order to improve profitability and minimize the production cost.

WMO-06. Good use of agriculture land

This option is backed up by the Water Code. Similarly, the National Development Strategy of the Ministry of Environment focuses on the implementation of innovations and developments in the field of climate change, among others by

Sensitizing beneficiaries to the impact of climate change on agricultural production and the involvement of associations in organizing awareness campaigns, training and extension services.

considering the agricultural practices.

WMO-07. Developing financial awareness tools

This is mainly supported by the incentive code of Investments.

The awareness rising of farmers and their organizations within cooperatives.

WMO-08. Use of water irrigation technologies

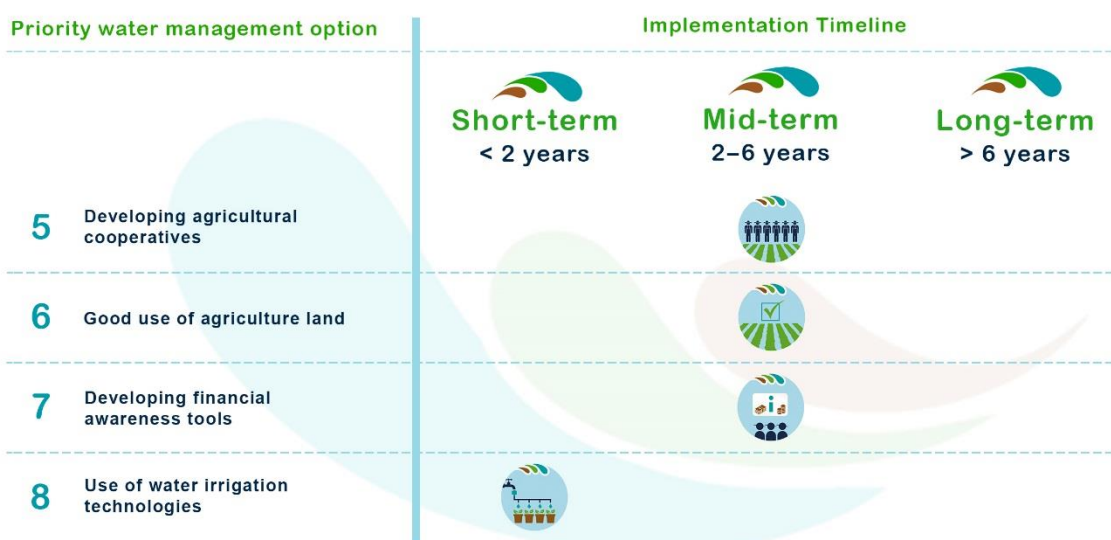
This option is synergistic along with several articles of the Water Code. Similarly, the option is in accordance with the investment code.

Raising awareness among farmers and professional organizations to the principle of "saving water" and less water-consuming crops. Similarly, associations must actively contribute to the public awareness of the scarcity of water resources, the necessity for proper management, and preservation and protection of water.

Temporal implementation of priority options

Although it may face financing difficulties, WMO-08 is to be implemented in the short term because it allows a quick water savings. WMO-06 can complete WMO-08 in the medium term by ensuring a smooth transition of farms to more sustainable production methods. Due to their administrative and organizational complexity, WMO-05 and WMO-07 are also options for the medium term.

Bundle 3: Agriculture



4.2.4 Bundle on Forest and biodiversity management (Challenge D)

The aim of this group of options is to protect the forest resources by improving technical and environmental solutions, as well as those of legislative nature that already exist.

Situational analysis	Context	Priority options
<p>Forests are natural resources that strongly influence the water and soil resources. Forest cover can for example contribute to reducing soil exposure to wind and heavy rain. It reduces runoff and water erosion. The forest is also a strategic resource with economic opportunities in timber exploitation and development of eco-tourism. However, they are increasingly threatened by multiple pressures: forest fires, unsustainable logging or the development of agriculture and pastoralism. Climate change by increasing the temperature during the summer season and increased dry periods contribute to intensifying the risks of their damage.</p>	<p>Forest resources are subjects of multiple societal pressures such as economic development and pastoralism. Hence the importance of strengthening the implementation of management plans and participation of the local population.</p>	<p>WMO-11. Reduction of society pressure on forests</p> <p>This option aspires to reach greater involvement from local population in forest protection and better management of the adjacent pastoral areas.</p> <p>Example: Review of forest management plans, eco-tourism projects, pasture improvements. Cost (15 years): 350 192 TND.</p>
	<p>The increase in temperature in recent decades equally increases the risk of forest fires. Similarly, the human factor in the region plays an important role in the reporting of fires.</p>	<p>WMO-12. Protection against forest fire</p> <p>This option aims to strengthen options to protect and respond to fires as well as putting together awareness campaigns for the local population.</p> <p>Example: Creation and maintenance of forest roads and firewall trenches, equipment maintenance of forests massifs, organization of awareness campaigns. Cost (15 years): 2 600 413 TND.</p>
	<p>The lack of reforestation actions or resumption of operations in areas affected by the fires limit the renewal of forest cover and increases the vulnerability of the forest sector.</p>	<p>WMO-13. Introduction of new agro forestry species and enrichment of existing forest</p> <p>This option aims to increase forest cover and strengthen the forestry sector through the development of agro forestry, enriching existing forests and a forestation of areas devastated by fire.</p> <p>Example: Forest plantations. Cost (15 years): 502 001 TND.</p>
	<p>The implementation of the Forest Code is limited. Local and national actors could benefit from better collaborative framework.</p>	<p>WMO-14. Better governance of forest resources</p> <p>The option consists of a better implementation of existing forest laws, and the settlement of the lease situation of forest communities as well as setting a framework for cooperation between governmental, forestry, agricultural and more generally social actors.</p> <p>Example: Strengthening governance. Cost (15 years): 100 000 TND.</p>

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-11, WMO-12, WMO-13 and WMO-14 on the "forest resources" issue. The WMO-01 and WMO-02 on water conservation techniques and soil contribute to strengthening the impact of the WMO-13 on the protection of plant and forest cover. By encouraging the preservation and better use of agricultural land, the WMO-06 significantly promote (in an indirect way) to reduce the pressure on forests (WMO-11) and recovery (WMO-13). The WMO-15 will be mobilized to strengthen the action of the WMO-12, WMO-13 and WMO-14 on the participation from the local population in the protection, promotion and collective management of forest resources.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-11	WMO-12	WMO-13	WMO-14
WMO-01. Promote new water and soil conservation techniques				
WMO-02. Consolidation of existing water and soil conservation techniques				
WMO-05. Developing agricultural cooperatives				
WMO-06. Good use of agriculture land				
WMO-07. Developing financial awareness tools				
WMO-15. Awareness campaign and learning				
WMO-16. Improved decision making				
WMO-17. Promote projects that generate more income				
WMO-18. Encourage investments				
WMO-19. Developing skills for young people				

Political and participatory implementation of priority Options

WMO-11. Reduction of society pressure on forests

This option can rely on the Forest Code which sets a number of regulations on users that aims to control the impact of society on forest resources.

User awareness and participation in collective associations should be strengthened.

WMO-12. Protection against forest fire

This option is an integral part of both the Forestry Code objectives and articles regulating the activities in the forests and their vicinity to limit the risk of fire.

Raising awareness is an important line of action in order to increase the interest of local people to protect the forest (e.g. Forest as a source of income). Collaborative co-management projects between local residents, landowners and public authorities will also be involved.

WMO-13. Introduction of new agro forestry species and enrichment of existing forest

This option is consistent with the objectives of the Forestry Code, which aims at ensuring the protection, conservation and rational exploitation of forest resources and also to guarantee users the lawful exercise of their rights.

Strengthening awareness actions and training among the local population. These actions can help overcome the overexploitation problems of forest resources.

WMO-14. Better governance of forest resources

The creation of an institutional and regulatory environment and strengthening favourable capacity for sustainable engagement of stakeholders (users, institutional partners) is a central component of the National Strategy for Development and Sustainable Management of Forests and Ranges.

To give more importance to the existing legislation in the forestry sector through the strengthening of institutional and individual capacities in the sector and achieve coordination between regional and central departments within and between the Ministry, research and civil society.

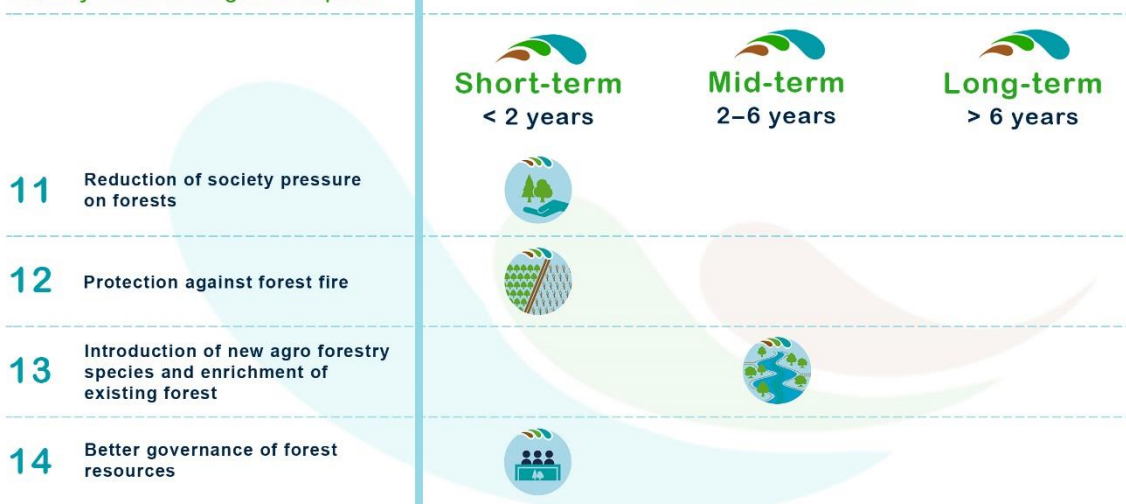
Temporal implementation of priority options

The WMO-14 as well as the WMO-11 and WMO-12 are a priority in the short term because they do not require new technical skills. The WMO-13 will become far more acceptable along with the awareness raising of the local population on forest issues and water resources.

Bundle 4: Forest and biodiversity management

Priority water management option

Implementation Timeline



4.2.5 Bundle on Sensitization of civil society (Challenge E)

The objective of this group of options is primarily to ensure the awareness of the population on the challenges of integrated water management in Rmel watershed. It facilitates greater participation of civil society in the management of natural resources as well as their protection.

Situational analysis	Context	Priority options
Although civil society is aware of water management issues in the Rmel watershed, resource protection remains rather secondary in relation to economic development needs. In addition, the management of natural resources is traditionally controlled by government authorities with little involvement of civil society. Collaboration between stakeholders and research remain exceptional.	Sustainable natural resource management is not a priority for local actors, in particular when it comes to increased protection. The economic opportunities offered by the sustainable management of natural resources are not known.	WMO-15. Awareness campaign and learning This option aims to raise awareness among Rmel population on the importance of protecting natural resources and promoting sustainable development of the basin, including encouraging water savings, diversification of activities, sanitation or again the protection of forests. Example: Organisation of awareness campaigns. Cost (15 years): 70 856 TND.
	The participation of civil society in decision making can ensure better ownership of sustainable development policies and sustainable management practices of natural resources.	WMO-16. Improved decision making This option aims to improve decision making through a stronger collaboration among politics, civil society and research, particularly in agricultural cooperatives and forestry associations. Example: Consultation meetings. Cost (15 years): 41 833 TND.

Co-benefits with other options

Several options will have strong co-benefits along with the priority options WMO-15 and WMO-16 on the «sensitization of civil society» issue. The options WMO-03, WMO-05, WMO-08, WMO-10, WMO-11 and WMO-12 all have strong commitments in terms of awareness of local actors. Their application along with the WMO-15, will seek to reinforce better and conducive behaviours to the sustainable development of the basin. WMO-05 and WMO-14 options seek to strengthen collective management for the sustainable management of agricultural and forest areas. Their combination along with the WMO-16 will facilitate the organization of work within cooperatives and strengthening the implementation of public policies.

Related options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-15	WMO-16
WMO-01. Promote new water and soil conservation techniques		
WMO-02. Consolidation of existing water and soil conservation techniques		
WMO-03. Creation and rehabilitation of hydraulic infrastructure		
WMO-05. Developing agricultural cooperatives		
WMO-06. Good use of agriculture land		

WMO-07. Developing financial awareness tools		
WMO-08. Use of water irrigation technologies		
WMO-09. Improvement of the treatment of waste water		
WMO-10. Water discharge control		
WMO-11. Reduction of society pressure on forests		
WMO-12. Protection against forest fire		
WMO-13. Introduction of new agro forestry species and enrichment of existing forest		
WMO-14. Better governance of forest resources		
WMO-17. Promote projects that generate more income		
WMO-18. Encourage investments		
WMO-19. Developing skills for young people		

Political and participatory implementation of priority Options

WMO-15. Awareness campaign and learning

The different national strategies (e.g. Water resources, forest resources, conservation of water and soil, etc.) emphasize the importance of awareness of civil society for their implementation.

It will be necessary to progressively and gradually introduce new forms of partnerships to promote civil participation and ensure the sustainability of project actions. Leadership training and operators are becoming a necessity.

WMO-16. Improved decision making

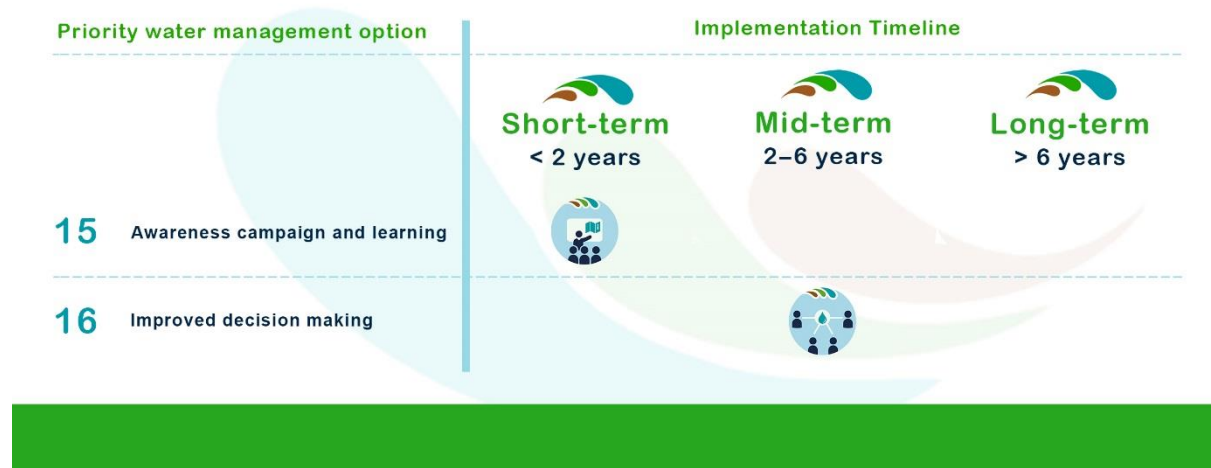
The different national strategies (e.g. Water resources, forest resources, conservation of water and soil, etc.) emphasize the importance of moving from a hierarchical approach to a participatory approach for more relevant results.

This option requires collaboration between development agents, researchers and civil society. Similarly, awareness campaigns must bring together the different actors (e.g. Public authorities, civil society) to discuss the main points related to the area.

Temporal implementation of priority options

The importance of the human factor on the achievement and success of improvement actions in the basin makes awareness and integration of local actors in the process of decision making a priority. The organization of education campaigns should be considered in the short term but the involvement of stakeholders will be more effective after being sensitized and trained, so this option should succeed option 15 and be applied in the medium term.

Bundle 5: Sensitization of civil society



4.2.6 Bundle on Human Resources and Employment (Challenge F)

This group of options aims to improve the standard of living of the population of the Rmel basin by means of project promotion, investment and youth training programmes showcasing sustainable development and protection of natural resources.

Situational analysis	Context	Priority Options
The Rmel basin's natural resources suffer from pressures exerted by economic activities. However, their protection will increase by improving economic and social conditions of the local population. The Rmel faces significant challenges due to the lack of economic opportunities and particularly with a high unemployment rate among the youth. The development and improvement of living standards of the local people of the area requires a better use of existing human resources and encouragement of the state as well.	The Rmel basin is facing a lack of opportunity for the implementation of projects that enhance living standards while also reducing the impact on water resources and preserving soil quality.	WMO-17. Promote projects that generate more income
		This option aims to encourage investment in projects that diversify the rural economy: eco-tourism, organic agriculture and handicrafts for women.
		Example: Agricultural Micro projects, micro craft projects for rural women. Cost (15 years): 1 338 670 TND.
	The Rmel basin is facing a lack of access to liquidity for the implementation of projects that enhance living standards while complying with the natural environment.	WMO-18. Encourage investments
		This option is designed to facilitate investment in agriculture, industry and tourism through the provision of loans and grants for small farmers and the youth.
		Example: Facilitation of obtaining short-term loans, facilitating obtaining grants (advice and assistance). Cost (15 years): 1 004 002 TND.
	The youth of Rmel basin face a lack of information on the various steps of projects creation as well as modern techniques that could be used in a context of development of sustainable agriculture.	WMO-19. Developing skills for young people
		This option aims to improve the professional skills of young people of the basin, to facilitate their integration into working life and to create a generation of skilled technicians in the use of sustainable and innovative techniques.
		Example: Organization and training in sustainable agriculture and handicraft courses programmes, staff training for the regional commission of Zaghuan. Cost (15 years): 131 357 TND.

Co-benefits with other options

Several options will have strong co-benefits with the priority options WMO-17, WMO-18 and WMO-19 on the issue of "Human resources and employment". Just like WMO-17, WMO-01 and WMO-02 options are designed to promote agricultural projects that protect water resources and soil fertility. The WMO-07 is designed to encourage farmers to adopt the projects receiving state aid. This latter will increase family income as sought by the WMO-17 and boost a more general agricultural investments drawn by the WMO-18. The WMO-15 will strengthen WMO-17 options by encouraging farmers to invest in sustainable development

projects and the WMO-19 by supporting the motivation of young people to participate in training sessions to improve their skills.

Related Options [Synergy: strong (dark); medium (light); low to zero (white)]	WMO-17	WMO-18	WMO-19
WMO-01. Promote new water and soil conservation techniques			
WMO-02. Consolidation of existing water and soil conservation techniques			
WMO-03. Creation and rehabilitation of hydraulic infrastructure			
WMO-05. Developing agricultural cooperatives			
WMO-06. Good use of agriculture land			
WMO-07. Developing financial awareness tools			
WMO-08. Use of water irrigation technologies			
WMO-09. Improvement of the treatment of waste water			
WMO-10. Water discharge control			
WMO-11. Reduction of society pressure on forests			
WMO-13. Introduction of new agro forestry species and enrichment of existing forest			
WMO-14. Better governance of forest resources			
WMO-15. Awareness campaign and learning			
WMO-16. Improved decision making			

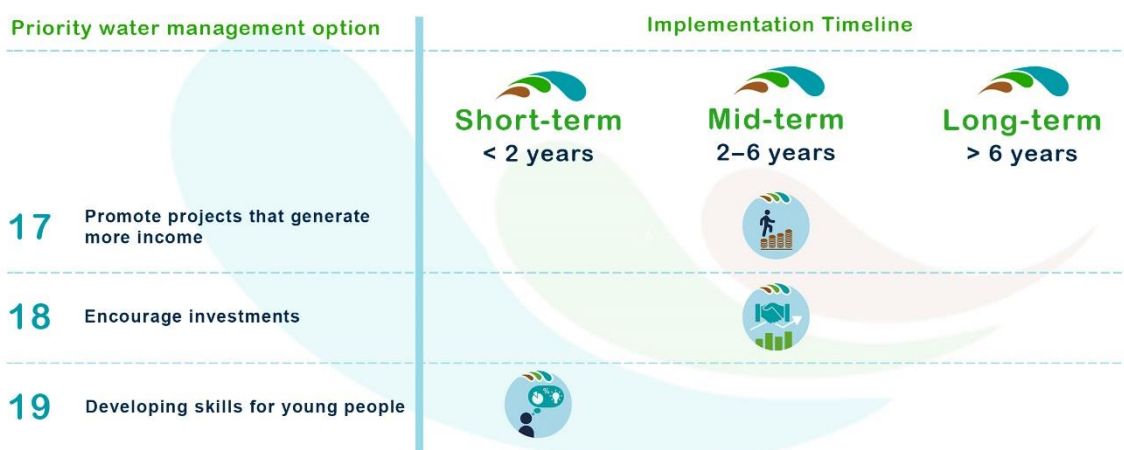
Political and participatory implementation of priority Options

WMO-17. Promote projects that generate more income	
The option is consistent with the Investment Incentive Code, which encourages local operators to use natural resources as a source to increase their income and improve their economic and social life.	The common awareness of civil society by identifying the options and specific development actions on their roles in the use of natural resources and their responsibility in the protection and conservation of these resources. It also requires the integration of civil associations in sensitization.
WMO-18. Encourage investments	
The Code of Investment Incentive promotes investments in the sectors of agriculture, industry, tourism, crafts and the area of services. The National Development Strategy is also favourable to the option.	Awareness raising and involvement of beneficiaries in all actions carried out. Some non-governmental organizations can act as an intermediary to facilitate obtaining loans and grants.
WMO-19. Developing skills for young people	
The National Development Strategy is promoting training of the youth and job seekers in light of a local economic development.	This option will require the involvement of civil society and NGOs. It will be important to ensure the awareness and involvements of beneficiaries in all actions carried out, and address appropriate trainers and training centers.

Temporal implementation of priority options

The WMO-19 is to be implemented in the short term to rapidly ensure better participation and better prospective employment among young people. The WMO-17 and WMO-18 options will take longer because of public funds and private investment should be mobilized.

Bundle 6: Human and Resources Employment



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 learning¹. Therefore, this section aims to outline the main elements that should be taken into account when monitoring the outcomes and impact of the proposed adaptation options.

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

Indicators for monitoring implementation

Indicators for monitoring can assume various forms, each of which contributes to building a comprehensive overview of the measure's or bundles' implementation. Types of indicators include those of a financial nature which typically measuring input (e.g. the costs that were invested in the implementation of the measure), or those which assess project outputs as relates to the activities associated with the given water management option, i.e. what the options achieved.

Technical and financial monitoring: This monitoring primarily consists of the collection and compilation of information about the physical achievements and financial execution. This collection of information will be carried out by a management unit and through a Territorial Sector Unit (TSU) and in collaboration with stakeholders. The tool used for this step is a dashboard with indicators of the progress of the project and which are connected to the implementation of water management options. The indicators are factors that reflect changes that have occurred in the watershed Rmel and which can be either qualitative or quantitative. All indicators should be of type SMART (Specific, Measurable, Achievable, Relevant, Time bound)

¹European Environmental Agency, 2013. Adaptation in Europe: Addressing risks and opportunities from climate change in the context of socio-economic developments. EEA Report No 3/2013

Text Box 6 : SMART indicators [19]

Select indicators can be complex and time-consuming.

SMART is a popular acronym for selecting indicators:

- **Specific:** Is the indicator specific enough to measure progress to-wards the results?
- **Measurable:** Is the indicator a reliable and clear measure of results?
- **Achievable:** The target value of the indicator is achievable within the defined timeframe.
- **Relevant:** Is the indicator relevant to the intended outputs and out-comes?
- **Time bound:** An expected date of accomplishment needs to be set.

Such technical and financial monitoring will help obtain the following information with a well-defined frequency for each already executed option or an option that is being executed:

- Physical objective
- Level of realization
- Expected costs (budget monitoring)
- Actual costs
- Discrepancies and explanations for any discrepancies.

Table 2: Sample dashboard for monitoring the implementation of WMOs

UST/bundle/ challenge	Example : WMO	Unit	Reference situation	Forecasts	Execution	Execution rate (%)	Anticipated costs	Actual costs
Water Quantity	Promote new water and soil conservation techniques	Ha						
Human Resources & employment	Awareness campaign and learning	Day / training campaign						

This information will be used for the drafting of progress reports of the adaptation project of Rmel watershed to climate change.

- **Impact evaluation:** the evaluation of impacts of the adaptation plan will be done through periodic surveys. This evaluation can be done through Territorial Sector Unit (TSU) of the Project that will represent the sample on which the impacts will be measured. The evaluation will therefore focus on a specific number of indicators mainly of type:

- **Economic:** Income, investment promotion
- **Social:** Job creation, improving access to infrastructure, the workforce qualification, etc.
- **Environmental:** Improving the quality of water, reduction of land degradation

The criteria and indicators must emanate out of the cognitive FCM map initially developed.

The assessment methodology consists of measuring the indicators defined in the reference situation (situation without the project), on the midterm situation as well as the completion of the project on the same TSU specified (same sample) which will allow to monitor and assess the implementation rate and to undertake corrective measures for steering and learning.

The evaluation of impacts will be carried out at all stages in a participatory manner with the stakeholders, who will be involved in the whole evaluation process. The results of the evaluation shall be restituted to the stakeholders themselves and discussed with them. The implementation of this evaluation will be conducted by the project team, in addition to workshops of two to three days with all partners in order to validate the assessment and to reprogram activities.

When developing the water management options for this plan, a review of and comparison with existing management plans focussing on the river basin was undertaken (see Part 2). These existing plans, established during the two specific strategies called CES I & CES 2 and conducted by the *Farmland Conservation and Management Department* have a kind of monitoring and evaluation network in which the monitoring and evaluation of the presented water management options can be integrated. Such potential monitoring synergies exist, for example, with regards to Option 1 (Promote a new water and soil conservation techniques) and Option 2 (consolidation of existing water and soil conservation techniques).

However, some water management options are unique to this river basin adaptation plan and therefore do not have specific links to existing monitoring strategies. For some of these options, opportunities exist to implement them within the frame of an ongoing project, such as PDRIGRN: “Projets de développement Régional Intégré pour la Gestion des Ressources Naturelles Tunisie” Within this river basin adaptation plan, monitoring for the following options could be funded via the state’s own resources or an external budget (EU contribution, ABD, AFD, etc.) [19] [20]

5 BeWater recommendations for Rmel River Basin

5.1 From planning to action: Recommendations for implementation

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

Based on the results of group discussions during the various workshops, the main recommendations are:

- To conduct scientific studies on the estimated impacts of climate change on the availability of water resources and hydrological extremes (drought, floods);
- The legal framework needs to be updated. Therefore there is a need for a major review of existing codes (e.g., forestry code, water code, water and soil conservation code and the investment incentives code);
- Research needs to adopt transdisciplinary methods to work together with society in the development of solutions and innovations for sustainable agriculture and sustainable water use. Society including farmers, local economy, and communities need to strengthen the market of sustainable agriculture.
- To reinforce the capacity of local and national actors to better manage collectively water and forestry resources (Bundles 1 and 2)
- To increase and improve investment by solving the problems of the Land rights and property rights.(Bundle 5)
- To involve farmers in decision making: farmers' preferences on the management of resources, overall planning and development of a legal framework are crucial from now. (Bundle 6)
- Policy needs to provide the adequate legal framework to enable education institutions, research, farmers, and community to make use of their capabilities in becoming agents for change toward sustainable water management. Efforts should be made to raise environmental awareness and behavior among all citizens, including the sustainable use of water. (Bundle 6)
- Financial support as well as awareness development can be used to enlighten and educate landowners and land users, and hence let them become more directly involved. Such a commitment can lead to the conception and spreading of interventions that could be understood and streamlined by the local population. (Bundles 5 and 6)

Implementation of all options within a given bundle

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

In the bundle factsheets in Chapter 4, a wealth of information is provided on the interaction of the water management options to support decision-making processes. This includes, for example, indications of the objectives which may be reached by choosing to implement a given bundle, the costs involved, the ideal phasing of the options in time, etc. If an entire bundle is to be implemented, the 'adaptation pathway' provides further information about which options are critical to implement before other water management options in the bundle. For example, implementing Bundle 1 would focus on achieving quantitative management of water resources. Should conservation of water and soil while improving and developing water supply infrastructure be prioritized as a key objective and limited financing be a main consideration, water quantity would be a more appropriate bundle.

Implementation of individual water management options

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

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

- WMO5: Application of taxes will provide the protection and improvement of water quality (Challenge B) in the Rmel watershed via a stricter implementation of laws, penalties and regulations.
- WMO13: Introduction of new agro forestry species and enrichment of existing forest related to challenge D (bundle 4) is consistent with the objectives of the Forestry

Code, which aims at ensuring the protection, conservation and rational exploitation of forest resources and also to guarantee users the lawful exercise of their rights.

- WMO 15 (Awareness campaign and learning) and WMO 16 (Improved decision making) related to Sensitization of civil society: Challenge E (Bundle 5) have a high priority and may facilitate the implementation of all other water management options identified.
- WMO19: Developing skills for young people related to Human and Resources Employment (Challenge F) has a high priority according to stakeholders. This option will facilitate the integration of young people into working life and to create a generation of skilled technicians in the use of sustainable and innovative techniques. So this option will allow the better implementation of other options such as encouraging investments (WMO18), reducing pressure on forest (WMO 11), etc.

In order to assure the successful implementation of individual water management options or bundles of options, the development and execution of a monitoring plan including sound indicators is crucial. Therefore, the suggestions made in Chapter 4.3 regarding the alignment of existing monitoring plans with the needs of the water management options specified in this plan should be considered. This includes finding synergies with existing monitoring schemes regarding the identification of suitable indicators for measuring the output.

5.2 Next steps

The synthesis of experiences on development projects in Tunisia and the conducted interviews with experts on their visions for the implementation of the Rmel river basin adaptation plan has led to the proposal of the following approach. (Figure 10)

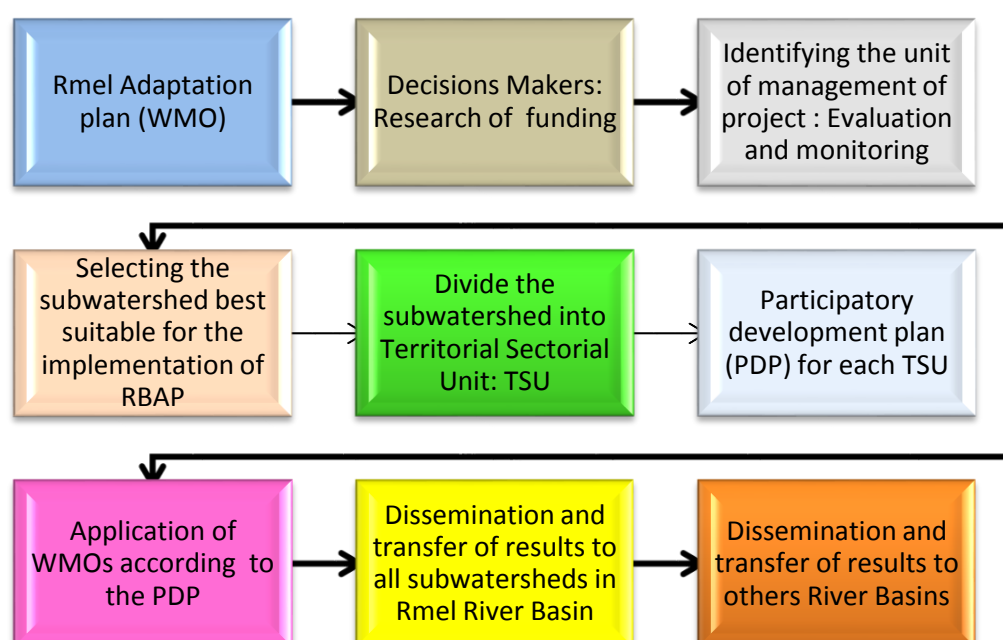


Figure 10: Suggestion of next steps of implementation of Rmel River Basin Adaptation plan

The flowchart in Figure 10 presents a proposed sequence of steps to follow the development of the river basin adaptation plan. These detailed steps are as follows:

1. Presentation of the adaptation plan to the authorities as a project file to grant the necessary funding and budgeting of the project.
2. Identification of a project management unit: represented by experts in the field of agriculture, water and soil conservation techniques, forests, soil...
3. Specify a pilot area whose characteristics meet the main challenges identified for Rmel river basin and encompasses (in which we can apply) the majority of water management options defined by the BeWater project.
4. Divide the pilot sub-basin into units by territorial sector by prioritization for example: Bundle 4: Forest Resources in the area of Jebel Zaghaouan, Bundle 2: Water Quality in the delegation of Zriba since there is a wastewater treatment station, and Bundle 3: Agriculture in the delegation of Bouachir where most irrigated areas are located.
5. Develop a participatory development plan that shows the actions for each territorial sector indicating the objectives, monitoring indicators (budget, time, goal) taking into account the opinion of the population.
6. Application of water management options in the selected pilot sub basin to ensure the evaluation of results achieved compared to targets.
7. Dissemination of the used model for the pilot area to other areas of the Rmel river basin.
8. Apply the approach of the BeWater project to other river basins in Tunisia

PART 2

6 Water management options

WMO 1: Promote new water and soil conservation techniques

Description	The first option aims to promote new water and soil conservation techniques to harvest runoff water. These techniques are placed on agricultural landscape (upstream) and are based on traditional, technological and engineering solutions (waterway development techniques and watershed development techniques). Moreover, from now on, this option should consider the participatory approaches.
Addressed challenges	This measure will directly participate in the quantitative water management of the basin and in the reduction of the risk related to droughts and flooding. Indirectly, the measure will contribute in improving the water quality and promote a sustainable agriculture.
Target locations and water uses	In order to choose priority sub-basins for the development of water and soil conservation, a prioritization study is carried out based on multi-criteria analysis and taking into account the sensitivity criteria for soil erosion, water resources saving measures, existing development, and agricultural and socio-economic enhancement. The selected sub-basins are those that obtained the highest weight. Within the framework of the project funded by the African Development Bank, the selected sub basins are as follows; Wadisbayhia, WadiJouf and Wadi Ain batteria.
Benefits	This measure offers several benefits including: maximizing the use of runoff water on agricultural parcels; Maintaining the fertility and productivity of agricultural land; the reduction of solid transportation at the level of Rmel dam; approximation of water points to operators; Job creation as well as associated investments.
Potential negative impacts	This measure involves several risks, including: reduction of agricultural land; constraint on direct grazing of animals during the execution of works (ref).
Timeline of implementation	This option will be applied in the medium term.
Feasibility	For several years, the water and soil conservation measures have been a political object. There is therefore a good technical understanding to facilitate their implementation, which calls for a reinforcement of awareness-raising and training for operators. These actions can help overcome the problems due to lack of transparency on land tenure and the absence of up-to-date registry of properties.
Robustness	The conservation techniques of water and soil will contribute to reducing the risk of desertification regardless of the impacts of future global change (e.g. climate.). However, it is possible that an increase in the availability of water in the short term (in particular via the hill lakes) increases the dependence of economic activities to water and their vulnerability to drought.
Flexibility	Most preservation techniques of water and soil require little initial investment, and are easy to edit (e.g. plowing, grass strips). Some measures, however, like the tracks of technical development, may request a larger investment and result in an infrastructure that is difficult to change in the future (e.g. Threshold, lakes).

Costs	<p>Taking account of the costs over a period of 15 years, the cost required for this measure is which 3 billion TD.</p>
Synergies and conflicts with policy objectives	<p>Currently, this option is mainly supported by Conservation Code of Water and Soil which prohibits the use of any tool or technique that can lead to the destruction of soil structure in areas threatened by water or wind erosion. The Code also prohibits any action that may damage the conservation of water and soil works declared for public utilities or executed in accordance with the provisions of the Water Code and existing on their lands. The code finances and compensates owners who carry out conservation work in order to ensure the sustainability of productivity the agricultural land. The option is also synergistic with the goals of the Water and Soil Conservation Strategy, of which one of the objectives is the conservation and rational use of natural resources. The investment code gives rise to specific bonuses for achieving conservation work of water and soil. The option is also reinforced by the 11th Plan for Agricultural Development Policy (2007-2011) as a minimum condition that requires the application of Water and Soil Conservation Code. However, the option is confronted with a national policy of production-oriented agriculture, which can lead to intensive agricultural practices. It also lacks appropriate funding mechanisms to a broader natural resources management.</p>
Acceptance	<p>The key stakeholders of this option are farmers, civil society (non-institutional actors) and the Ministry of Agriculture (public authorities). This option is generally little intrusive and will have direct beneficial impacts on the operator (e.g. Farmer). It promotes an environmental protection which will be perceived positively by environmental groups. In addition, it is actively supported by the Ministry of Agriculture through legislation and regulations in place. However, there exists certain barriers; Some benefits of this option are poorly quantifiable and difficult to be perceived (e.g. Fertility improvement) while there will be a loss of productive land. At the same time, this measure is voluntarily applied upon the operators' request (who will receive financial compensation). Currently, there is a lack of interest and participation from the farmers' part. The establishment of associations to counter the fragmentation of the problem is also confronted with long administrative procedures.</p>
Suggested stakeholder involvement	<p>It will be necessary to increase the awareness and involvement of farmers and local communities in the design and implementation of all proposed actions. The option can depend in part on the National Strategy for Conservation of Water and Soil that focuses on the popularization and awareness of erosion problems and appropriate responses.</p>
Preconditions for success	<p>Raising the awareness of operators</p> <ul style="list-style-type: none"> - Financial compensation for loss of agricultural land - Involvement of operators in all the programs and projects carried out in their lands - A collaborative approach among owners to counter land fragmentation problems)
Examples	<p>Current water and soil conservation projects undertaken within the Rmel river basin/each year the CRDA programs 300 ha of manual work of CES in the regions of Oued Rmel, Zriba, Oued Jouf, Oued zit</p>

WMO 2: Consolidation of existing water and soil conservation techniques

Description	The second option aims to improve the function of existing soil and water conservation techniques based on ecological solutions. It is based on the strengthening of these techniques by plantations. The implication of Rural Development firms (e.g., SMVDA) and the setting for incentive context become crucial.
Addressed challenges	This measure will directly participate in the quantitative water management of the basin and in the reduction of the risk related to droughts and flooding. Indirectly, the measure will contribute in improving the water quality and promote a sustainable agriculture.
Target locations and water uses	In order to choose priority sub-basins for the development of water and soil conservation, a prioritization study is carried out based on multi-criteria analysis and taking into account the sensitivity criteria for soil erosion, water resources saving measures, existing development, agricultural promotion and socio-economic enhancement. The selected sub-basins are those that obtained the highest weight. Within the framework of the project funded by the African Development Bank, the selected sub basins are as follows; Wadisbayhia, WadiJouf and Wadi Ain batteria.
Benefits	This measure offers several benefits including: maximizing the use of runoff water on agricultural parcels; Maintaining the fertility and productivity of agricultural land; the reduction of solid transportation at the level of Rmel dam; approximation of water points to operators; Job creation as well as associated investments.
Potential negative impacts	This measure involves several risks, including: reduction of agricultural land; constraint on direct grazing of animals during the execution of works (ref).
Timeline of implementation	The consolidation of technical conservation of existing water and soil are to be applied in the short term.
Feasibility	For several years, the water and soil conservation measures have been a political object. There is therefore a good technical understanding to facilitate their implementation, which calls for a reinforcement of awareness-raising and training for operators. These actions can help overcome the problems due to lack of transparency on land tenure and the absence of up-to-date registry of properties.
Robustness	The conservation techniques of water and soil will contribute to reducing the risk of desertification regardless of the impacts of future global change (e.g. climate.). However, it is possible that an increase in the availability of water in the short term (in particular via the hill lakes) increases the dependence of economic activities to water and their vulnerability to drought.
Flexibility	Most preservation techniques of water and soil require little initial investment, and are easy to edit (e.g. plowing, grass strips). Some measures, however, like the tracks of technical development, may request a larger investment and result in an infrastructure that is difficult to change in the future (e.g. Threshold, lakes).
Costs	Taking account of the costs over a period of 15 years, the fees required to consolidate the existing water and soil conservation devices are about 2 billion TD.
Synergies and conflicts with policy objectives	Currently, this option is mainly supported by Conservation Code of Water and Soil which prohibits the use of any tool or technique that can lead to the destruction of soil structure in areas threatened by water or wind erosion. The Code also prohibits any action that may damage the conservation of water and soil works

	<p>declared for public utilities or executed in accordance with the provisions of the Water Code and existing on their lands. The code, finances and compensates owners who carry out conservation work in order to ensure the sustainability of productivity of agricultural land. The option is also synergistic with the goals of the Water and Soil Conservation Strategy, of which one of the objectives is the conservation and rational use of natural resources. The investment code gives rise to specific bonuses for achieving conservation work of water and soil. The option is also reinforced by the 11th Plan for Agricultural Development Policy (2007-2011) as a minimum condition that requires the application of Water and Soil Conservation Code. However, the option is confronted with a national policy of production-oriented agriculture, which can lead to intensive agricultural practices. It also lacks appropriate funding mechanisms to a broader natural resources management.</p> <p>The key stakeholders of this option are farmers, civil society (non-institutional actors) and the Ministry of Agriculture (public authorities). This option is generally little intrusive and will have direct beneficial impacts on the operator (e.g. Farmer). It promotes an environmental protection which will be perceived positively by environmental groups. In addition, it is actively supported by the Ministry of Agriculture through legislation and regulations in place. However, there exists certain barriers; Some benefits of this option are poorly quantifiable and difficult to be perceived (e.g. Fertility improvement) while there will be a loss of productive land. At the same time, this measure is voluntarily applied upon the operators' request (who will receive financial compensation). Currently, there is a lack of interest and participation from the farmers' part. The establishment of associations to counter the fragmentation of the problem is also confronted with long administrative procedures.</p> <p>It will be necessary to increase the awareness and involvement of farmers and local communities in the design and implementation of all proposed actions. The option can depend in part on the National Strategy for Conservation of Water and Soil that focuses on the popularization and awareness of erosion problems and appropriate responses.</p> <p>Raising the awareness of operators</p> <ul style="list-style-type: none"> - Financial compensation for loss of agricultural land - Involvement of operators in all the programs and projects carried out in their lands - A collaborative approach among owners to counter land fragmentation problems) <p>As an example, the mechanical benches at Ain El Battriya which are consolidated with Acacia by the ROAD in 1990</p>
Acceptance	
Suggested stakeholder involvement	
Preconditions for success	
Examples	

WMO 3: Creation and rehabilitation of hydraulic infrastructure

Description	Hydraulic structures will be improved to meet the demands of the population (rehabilitation and upgrading of existing networks, construction cisterns and lifting stations, etc.) while maintaining the balance between demand and distribution.
Addressed challenges	This will allow the quantitative management of water by reducing losses and water leaks in distribution pipes and adduction whether for agriculture and drinking water.
Target locations and water uses	All areas of the basin are affected by this option. The management of AEP systems (drinking water supply) in rural areas is found satisfactory for 20% of GDAP (agricultural development group for drinking water), average for 55% of GDAP and low for the rest of GDAP, which is still suffering some management shortcomings. Despite the specific technical assistance and training programs that have been implemented by the Administration in favor of GDAP to improve their knowledge in the field of management, several problems still persist and hinder the development of certain GDAP. As an illustration, we refer to the low level of education among Board members who are volunteers, project complexity with successive extensions and development of Individual connections; the proliferation of illicit individual connections; free interventions support of the Authority; the virtual absence of preventive maintenance of infrastructure and equipment; the low cover rates of operating and maintenance costs; response times during breaks and breakdowns is slow; and the limited involvement of women in the management of water supply systems (AEP).
Benefits	Rehabilitation and modernization of existing drinking water and irrigation systems, construction of cisterns to increase the number of hours of access to water, creation of artificial recharge wells of groundwater, creating shallow wells in areas with surplus water balance and improved pumping conditions, creating discharge stations to cover water demand of rural populations, electrification of existing water points established in areas covered by the groundwater of wadi Rmel.
Potential negative impacts	The creation and rehabilitation of existing water infrastructure require significant funding. This option requires human and technical capacities.
Timeline of implementation	The application of this option should be in the short term.
Feasibility	The high dispersion of population and access constraints to mountain sites limit the execution of projects at reasonable costs. The supply of household water is made through cans or tanks towed over distances that don't exceed 3 km. But given the evolution of living standards in rural areas, people are starting to look for more comfort and the service mode by individual connection that characterizes the SONEDE (The Tunisian drinkable Water supply Authority) began to gain ground especially in rural areas previously served collectively and its implementation is done in the framework of a coherent approach integrating all technical, institutional, economic and financial aspects. Starting from 2007, all new and rehabilitation projects are designed on the basis of individual service.
Robustness	The savings in water, the reduction in demand and rationalization of the drinking water distribution will help to address the impacts of future change whatever their future development.
Flexibility	This option requires significant funding and significant human and technical capacities, as well as large investments. Thus, this option is considered very flexible.

Costs	Based on cost over 15 years in the WP3, the cost required for this option is 1 110 253 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	<p>Water is a national asset that must be developed, protected and used in a manner that ensures the sustainability of satisfying all the needs of citizens as well as the economic sectors. The water economy is considered one of the most important means for development, reservation and rational use of water resources. The work aiming at the development, the economy, improving the quality and the protection of national water resources are of public utility. The management of rural drinking water supply systems is ensured either by the National Company of Exploitation and Distribution of Water (SONEDE) through its own network or by user associations called Agricultural Development Group (GDAP) through AEPR systems made by the Office of Rural Engineering. Nationally, the number of GDAP groups approximates 1400 at the end of 2009. These groupings, amongst other things, take charge of the management of AEPR systems (water sales, servicing and maintenance of systems, etc.). They benefit from the continued support of the State which has set up a national strategy to promote associations since 1992 in order to develop their capacities in the technical, financial and organizational domains.</p>
Acceptance	<p>The Ministry of Agriculture is working notably with its decentralized services in rural engineering Districts in the ROAD (24 Districts, one for each regional department). In particular the DGGREE deals with defining strategic directions in the field of AEPR, project planning and technical assistance to the Rural Engineering Districts to improve the quality of studies and work as well as training, mentoring and support for GDAPs. The studies, direct monitoring of works, supervision, training and development of GDAPs are provided by the Agricultural Engineering District services in each ROAD as follows: 1- The service of AEPR studies whose role is the realization and supervision of out sourced studies to private consulting firms, and which incorporate the participation of beneficiaries in all phases of the study. 2- The AEPR (Rural drinking water supply) works department is responsible for supervising the work done by private companies. 3- The control of works is assured by previously trained technicians in the field. But, given the very limited human and material resources at the level of the ROAD, some of them have begun to outsource this task to private consulting firms. 4- The supervision services, training and improvement of GDAP takes charge of monitoring and technical assistance of GDAP in technical, financial and social fields, and that, as part of a promotion strategy of GDAP implemented nationwide since 1992.</p> <p>The SONED intervenes in urban and rural areas regrouped and bordering its distribution network using the same approach applied in cities. Through its regional districts and its own means, the SONED means assures the realization of studies, monitoring of work entrusted to private companies as well as supervision, training and improvement. The Agricultural Development Groups (GDA) is created at the request of the majority of owners, farmers and fishermen concerned. Their creation is done by order of the governor of the region. Each GDAP has a Board of Directors consisting of 3 or 6 members, including a president elected by the beneficiaries for a period of 3 years. Under Decree 2004-24, their responsibilities have expanded to include other activities related to the protection of natural resources and rationalizing their use, development of rural areas, coaching and training.</p>
Suggested stakeholder involvement	Organizing training sessions and coaching for farmers
Preconditions for success	<ul style="list-style-type: none"> - Organize training sessions and coaching for local people and farmers. - Organization Of meetings bringing together leaders in the field to discuss the importance of the implementation of this option.

Examples**-**

WMO 4: Application of taxes

Description	The option proposes to strengthen the application of taxes on discharges of wastewater caused by factories. This taxation preserves the quality of water for agriculture and drinking water.
Addressed challenges	This option will contribute to the protection of the quality of ground and surface water.
Target locations and water uses	The industrial Zone of HammamZriba, the industrial zone of Zaghouan.
Benefits	The benefits of this measure are: strengthening existing laws and regulations, protection of water resources.
Potential negative impacts	Taxes can impose additional costs on people and the concerned activities.
Timeline of implementation	This option should be applied in the short term.
Feasibility	The strengthening of tax implementation primarily requires reinforced administrative capacity, and therefore greater financial resources.
Robustness	The option is primarily administrative and of organizational nature, which means that it can be maintained regardless of future conditions (in different forms if necessary).
Flexibility	The option is primarily of administrative and organizational nature, which means that it can be adapted to societal, economic or environmental changes.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 8 367 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The environmental policy acknowledges the industrial pollution as one of the most important sources of quality degradation of natural resources as well as health and environmental situation. Therefore, It aims to develop the means and prevention methods of industrial pollution. In this regard, the legal aspect was supported and developed through the preparation of the Environmental Code and the publication of numerous legislative and regulatory texts.
Acceptance	The Ministry of Environment is responsible for the coordination and animation of the state's policy in terms of sustainable development, taking all options that could improve the quality and efficiency of the action of the state in environmental domains, as well as options that may be required by the need to inform relevant sectors.
Suggested stakeholder involvement	This management is based on support to communication efforts, awareness and environmental education considered as a basic element of any strategy aiming the change of behavior. The option may be accompanied by awareness campaigns for the public and the private sector. Similarly, the strengthening of controls and incentives to be paid (e.g. the introduction of heavy fines if the tax is not paid) are necessary.
Preconditions for success	Update Study of environmental standards to be compatible with the technological and economic development.

Examples

A tax that varies between 50 TND and 50 000 TND is applied.

WMO 5: Developing agricultural cooperatives

Description	Agricultural cooperatives are companies freely organized by farmers to ensure supply of their operations, improve production conditions and facilitate the flow of products. These companies organized under the principle cooperative do not pursue profit. Their exclusive mission is to promote the development of their members' holdings (cost reduction, improved irrigation systems and facilitating the agricultural flow products).The option aims to favor in particular cooperatives which have a clear objective to develop sustainable agricultural products that are coherent with available water resources.
Addressed challenges	The grouping of farmers in cooperatives will facilitate several actions (having inputs, flow of products after harvest) and thus the development of agriculture.
Target locations and water uses	The option mainly focuses on the farmers of WadiSbayhia.
Benefits	The option will secure agricultural activities in a context of low yields and financial vulnerability, and thereby increase the ability of farmers to deal with future global changes.
Potential negative impacts	If they're uncontrolled, intensification of farming practices can result in negative environmental impacts (e.g. water Pollution, water use), increasing the risk of conflicts between uses.
Timeline of implementation	This option should be applied in the medium term.
Feasibility	No major technical obstacles identified.
Robustness	The measure favours strengthening the agricultural sector and thus participate in immediate benefits for the local population (low regret Measures).
Flexibility	The option is hardly intrusive and promotes voluntary cooperation of farmers. It can thus be adjusted to better take into account future challenges.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 170 380 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is synergistic with the goals of most of the relevant state programs advocating a stronger structuring of the agricultural sector and collaboration between farmers. This option is based on the Law on Agricultural Services Corporation. The objective would be to strengthen the application of the law in Rmel watershed.
Acceptance	The option should be well received by farmers via the associated benefits (e.g. Purchase of inputs, increased access to distribution channels). However, experience shows a lack of farmer participation due in part to difficulties encountered during the implementation of the association, the lack of trust between members and the lack of collective financing. Moreover cooperatives do not necessarily imply integration of all concerned farmers.
Suggested stakeholder involvement	Raising awareness amongst farmers of the importance to be part of a cooperative.
Preconditions	Information and coaching for farmers for a good management of cooperatives.

for success	To facilitate Legislative actions regarding the creation of cooperatives (possible revision of the law and financing)
Examples	URAP Zaghuan: Regional Union of Agriculture and fisheries of Zaghuan (www.facebook.com/URAP-zaghuan-1575727276046309/info/?tab=page_info)

WMO 6: Good use of agricultural land

Description	The option aims at the proper use of agricultural land in order to improve productivity and reduce water consumption by introducing adapted crops. It consists of promoting conservation farming techniques, introducing adopted crops (crops that adapt to droughts) and disseminate good practices.
Addressed challenges	This option will contribute to improving and organizing the exploitation at the level of agricultural land.
Target locations and water uses	This option affects all areas of the watershed.
Benefits	This option offers many benefits including: reducing the use of water, reducing pressure on the resource, erosion reduction, reducing vulnerability to droughts.
Potential negative impacts	The option may result in the short term by a reduction in agricultural production and therefore a loss of income. It can also result in installation costs, for example, the need to purchase the right equipment for new crops or the need for training.
Timeline of implementation	The implementation of this option is in the medium term: this option requires: awareness, extension, taxation, resolution of land issues (land clearance), the development of conservation agriculture ...
Feasibility	The option is facing a problem of fragmentation of land and requires certain technical knowledge (e.g. agronomy).
Robustness	The option aims to adopt new farming practices and more adopted crops to drought and therefore respond to the possibility of more frequent extreme weather events in the future.
Flexibility	This option rather flexible because it is based on changes in agricultural practices and not heavy investment. However, some significant changes to the agricultural holding, such as the adoption new cultures can represent a significant investment for the operator and therefore limit the possibility of future changes.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 292 834 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is supported by the Water Code (protection of agricultural land) aiming at the protection of agricultural land against the threats of water erosion of land. The Code specifically prohibits the use of any tools or techniques for the cultivation of the land and may result in the destruction of soil structure in areas threatened by water erosion, which make it difficult to protect these lands. Similarly, the National development strategy of the Ministry of Environment focuses on the implementation of innovations and developments in the field of climate change in order to confront the impact of change that will accentuate the phenomena of degradation of agricultural land.
Acceptance	The option should be well received by farmers. The Ministry of Agriculture in collaboration with the associations must focus on raising awareness of civil society on the importance of the protection of agricultural land and the need to develop crops adapted to climate change.
Suggested stakeholder involvement	To raise awareness among beneficiaries on the impact of climate change regarding agricultural production.

Preconditions for success	Involve associations in the organization of awareness campaigns.
	Revision of the water and soil conservation Code. Introduction of new techniques and plants resilient to climate change.
Examples	The agricultural enhancement and development companies of Ben Cherifa in Zaghouan (year of implementation, 2011)

WMO 7: Developing financial awareness tools

Description	This option aims to improve access to sources of agricultural financing. It consists of setting up counseling programs to help farmers access to agricultural subsidies and reduce taxes. This requires improving the land tenure situation and fragmentation, a better involvement of farmers in the grant process and a reform of financial instruments. It also requires the diversification of funding mechanisms (e.g. Bank, development associations). The option aims to favor in particular farmers who aim to develop sustainable agricultural products that are coherent with available water resources.
Addressed challenges	This option will contribute to the development and expansion of the agricultural sector.
Target locations and water uses	This option affects all areas of the watershed and all its inhabitants.
Benefits	This option offers many benefits including: consolidation of the agricultural sector, improving of production, strengthening of funding sources and income for farmers.
Potential negative impacts	This option may result in the intensification of agricultural production and greater environmental damage.
Timeline of implementation	The implementation of this option is in the medium term.
Feasibility	The option does not require heavy investments. However, it requires administrative and legal changes which can be complicated.
Robustness	The consolidation of the agricultural sector, improving incomes and better access to financial instruments set up by the government will help the agricultural sector cope with different possible futures.
Flexibility	The option requires administrative and legal changes which can be complex and lengthy, and difficult to modify in the future.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 917 555 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is mainly supported by the Encouragement of Investment Code. This code provides land loans which can be granted for the purchase of agricultural land by specialized technicians and young farmers or for the acquisition of the shares of agricultural project promoters an agricultural holding constituting an economic unit. This option is limited by the lack of land titles (Fragmentation of land tenure systems) that prevent the obtaining loans.
Acceptance	Local operators are not mobilized given the failures of the articles concerning the financing mechanism in the investment code.
Suggested stakeholder involvement	Raising awareness and involvement of farmers in cooperatives.
Preconditions for success	<ul style="list-style-type: none"> -Revision of the investment code. -Creating an agricultural radiation cell.

Examples

-Setting up a training program and specific extension to the project zone.

The Women's Group for Agricultural Development of Oued Sbayhia (WGAD) is an organization gathering small farming women in the area of Wadi Sbayhia in the delegation of Zaghouan. created in the year 2002, it has today approximately 150 members of women divided into 9 territorial units. In recent years the WGAD has been able to grow remarkably thanks to the will, abnegation and courage of its female members. It now has a workshop production in line with international standards, a meeting room to plan trainings and administrative offices. The GFDA today produces a wide range of essential oils and floral waters, extracted from aromatic and medicinal plants collected by member of the Group in the forests of Mount Sidi Salem, which is located in the region of WadiSbayhia.

WMO 8: Use of water irrigation technologies

Description	This option targets a proper use of farmland to improve production and reduce the amount of consumed water.
Addressed challenges	The implementation of this measure will be very useful and effective for saving water, thus reducing the amount of water consumed.
Target locations and water uses	Agricultural land in the watershed.
Benefits	The main objective is to rationalize the use of agricultural water in order to make the best economic profit and maintain the demand for irrigation at a compatible level with the available water resources.
Potential negative impacts	The option requires financial means to use modern techniques in agriculture. Training users for better management of irrigated water is crucial.
Timeline of implementation	This option must begin in the short term with great support and good technical assistance. In the medium run, this option should continue adapt while considering new technologies in terms of new irrigation techniques.
Feasibility	It lacks technical expertise on servicing and network maintenance.
Robustness	Better control of demand for irrigation water and a more efficient use are beneficial regardless of future global change.
Flexibility	Investments in irrigation techniques are a significant financial effort, which may limit the ability of farmers to invest and adapt their short and medium-term practice.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 2 210 433 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	<p>There is a national strategy for water management. The main objective of water saving programs is to rationalize the use of agricultural water in order to make the best economic profit and maintain the demand for irrigation at a compatible level with the available water resources.</p> <p>The option is synergistic with several articles within the water Code. Chapter 1: Article 19: presenting any proposals concerning the development of a national water saving policy through programs to rationalize water consumption. Chapter VI: Article 86: The water saving is considered one of the most important ways to development, the preservation and rational use of water resources. Work on developing the water saving techniques, improving the quality and the protection of national water resources is of public interest. Likewise, the option is synergistic with the investment code. Article 29: the investments made in the context of the irrigated water saving by groups of common interest are mentioned by the Water Code. It was promulgated by Act No. 75-16 of March 31, 1975 and state the benefit from the advantages granted to category "A". Article 33: the components of agricultural investment given below give rise to the benefit of specific overall premiums excluding all other premiums: the installation of an irrigation system allowing irrigated water saving or replacement of equipment with improved irrigation system; (Decree 2001-2185 du 17 September 2001). Article 42a 6: Investments to achieve water savings in various sectors, with the exception of the agricultural sector, and investments for the development of research of non-traditional water resources,</p>

	<p>their production and exploitation accordance with the legislation in force, and audit activities of the waters give entitlement to an overall specific premium whose rate, terms and conditions for issue are provided by decree.</p>
Acceptance	<p>This option is acceptable to citizens. However, lack of knowledge of farmers in respect of the use of water-saving techniques is a problem.</p> <p>The state and the administration are still the main actors in the mobilization, transfer and transport to the user. As for irrigation, the Ministry of Agriculture is organized in the mobilization and management of surface water and groundwater. Similarly, within the ROAD, a development unit shall monitor and provide assistance to farmers and private actors. Low irrigation performance can only reflect a problem of training of users directly in the field. Private actors and Collective Interest Groups supplement the administrative system in the management of agricultural water, and if they are not individuals, they are then grouped into GIC (Groups of collective interest) or agricultural development companies, which directly exploit water resources and hydraulic networks. Training to improve technical efficiency is not sufficient. Technical performance can sometimes be hampered by organizational problems (product marketing, purchase of inputs) and the hydro-agricultural system still fails, despite the technical prowess. The Tunisian Union of Agriculture and Fisheries (UTAP) also supervise farmers. In most irrigated areas, water is poorly managed by farmers and insufficiently valued. This inefficient use of irrigation water can sometimes have a negative impact on certain irrigated areas. The UTAP could encourage the maintenance and rehabilitation of failed irrigation projects to minimize water loss. Companies of studies and infrastructure works involved in the water sector (equipment maintenance, new work and network equipment, outsourcing of maintenance work etc.).</p> <p>The behavior of the farmer regarding the irrigation components, its implementation, the advices, all other information and training services, depends on its economic vision of water. Pricing is therefore one of the tools, which must be wedged in time and space, to improve the sensitivity of the operator to the water economy. Professional agricultural organizations and NGOs play an important role in catalyzing agricultural development in general (groups).</p>
Suggested stakeholder involvement	<p>The series of actions and incentives implemented by the Tunisian State, led on one hand to an awareness of farmers and professional organizations to the principle "Water Economy", by limiting squandering and the rational use of irrigation water. On the other hand, it led to the massive use of water-saving equipment by farmers at the level of the plot. Associations should actively contribute to the public awareness related to the scarcity of water resources, proper management, and its preservation and protection. It should also encourage less water consuming crops.</p>
Preconditions for success	<p>To have significant funding and to carry out an impact study on the environment.</p>
Examples	<p>The drip irrigation system in the nursery of SidiZid in Zaghouan</p>

WMO 9: Improvement of the treatment of waste water

Description	This option aims to improve wastewater treatment to reduce the impact on the water quality in the natural environment and the reuse of water for other purposes. It consists in increasing the exploitation and development of unconventional water (ex. treating water and then use it for irrigation of specific crops), setting the standard wastewater stations, the extension of sewage networks, and the creation of waste water treatment plants.
Addressed challenges	This option will participate in the improvement of water quality in particular and the water management in general. It has an economical side for farmers who use treated wastewater for their irrigated agriculture.
Target locations and water uses	The administrative departments considering this option are those of Zriba and Zaghuan.
Benefits	This option offers several benefits including: maximizing the use of water resources, improving the water quality and the reduction of the increased pressure on natural resources.
Potential negative impacts	This option requires significant material and investments that could eventually raise the price of water.
Timeline of implementation	This option is to be applied in the medium term because technically it is not feasible in the short term.
Feasibility	The implementation of this option requires significant technical capacity and a legislative framework and in particular to secure effective control of wastewater use in agriculture.
Robustness	This option will participate in reducing the risk of degradation of conventional water resources through the use of unconventional water to fight against the global changes in the coming years.
Flexibility	This type of option requires a significant investment.
Costs	Based on costs over a period of 15 years in the WP3, the cost required for this option is 546 934 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is mainly supported by the Water Code which aims to fight against all actions that could provoke or increase water degradation by modifying their physical, chemical, biological or bacteriological characteristics, whether it is surface water or groundwater. It prohibits making any surface deposition likely to pollute by infiltration groundwater, or by runoff, surface waters. The Code provides that the use of waste water for agricultural purposes is permitted only after appropriate treatment of the waste water in treatment plants and on the decision of the Minister for Agriculture, taken with the agreement of the Minister of public health. In all cases, the reuse of wastewater, even treated, for irrigation or watering vegetables is prohibited.
Acceptance	This option requires primarily information and sensitization of all industries (public and private), the main actors of the importance of respecting the rules of wastewater discharges. The use of wastewater in agriculture may face opposition from farmers.
Suggested	Awareness campaigns should be organized for public and private industry on the

stakeholder involvement	importance of their roles in the protection of natural resources in general and water resources in particular. This option also requires significant involvement of associations to sensitize farmers.
Preconditions for success	<ul style="list-style-type: none">-Have Significant funding-Improving And developing treatment plants according to standards.-Improve awareness raising of industrials
Examples	As an example, the irrigated area of 'SidiMerayeh' using the treated wastewater from the treatment plant of Zaghouan: the total area is 50 (ha), The number of plots is 24 and the number of farmers 18

WMO 10: Water discharge control

Description	The action aims to promote the control of discharges of pollutants by strengthening the regulatory application and utilization of waste (especially olive presses). This involves creating the implementation of solid waste management systems (collection + transportation + treatment) in rural towns and industrial sites, and the creation of new landfill sites controlled and the use of food waste as fertilizer (spreading).
Addressed challenges	This will direct the water resources protection and indirectly to environmental protection.
Target locations and water uses	The industrial zone of HammamZriba, the industrial zone of Zaghouan,
Benefits	The option aims to improve the water quality which will secure its possible use by other applications (e.g. Agriculture, drinking water) and for environmental uses (protection of the aquatic environment).
Potential negative impacts	The option requests a major reorganization of industrial waste treatment and wastewater treatment plants. The creation of landfill site can cause problems for local residents (e.g. Odor).
Timeline of implementation	The option can be performed immediately. Funding is planned via the ADB for 5 years starting from 2016.
Feasibility	The option does not require specific technical capabilities, only a strengthening of existing actions.
Robustness	The option aims to strengthen the capabilities for collecting, storing, processing and use of polluting waste for water resources. The option seems beneficial in the short term (low regret option) And long term (possible performance regardless of impacts of future global changes).
Flexibility	The option consists of institutional arrangements (e.g. Strengthening existing activities) and the establishment of heavier infrastructure (e.g. discharges). Hence its capacity to be adapted over time is average and requires special attention to the sequencing of activities to maximize the immediate and future benefits.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 4 500 000 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	Waste management is a central element of the environmental policy in Tunisia with a National Agency for Waste Management (ANGED). It is a question of National Strategy for Integrated and Sustainable Waste Management, which aims to establish a network of landfills and development of collection and recycling channel. The Water Code requires a systematic treatment of domestic or industrial sewage if it poses a risk to downstream water supply for household and food. However, the implementation is slightly followed by lack of means. In addition the Investment Incentives Code has set up a program that exempts from tax some investment in the collection, processing and treatment of garbage and waste.
Acceptance	The waste treatment should at first glance be a well-accepted activity by the entire society given its central role in the quality of life of citizens. However, the implementation faces many barriers, including a lack of information and awareness of citizens, lack of dialogue and communication between actors and the tendency to prioritize other economic development goals. Local authorities and

Suggested stakeholder involvement	<p>municipalities are particularly affected by the lack of human and financial resources. Also the private sector has a little participation.</p> <p>The option may be accompanied by awareness campaigns to the public and the private sector for positive behavior towards the environment. In addition, greater participation of associations can be encouraged (through training, technical and financial assistance) and collaboration between associations and local authorities.</p>
Preconditions for success	<p>Increase funding for waste management</p> <p>Improve awareness of citizens and strengthen pro-environmental attitudes</p>
Examples	<p>This water management measure applies in the industrial area of Zaghuan, discharge area of Jimla.</p> <p>An agreement between the ROAD, the Ministry of Health and the GDA is signed to ensure the control of discharge</p>

WMO 11: Reduction of society pressure on forests

Description	<p>The forest will be protected by implementing prevention and control measures in order to reduce overgrazing. Users will be involved and integrated in the management and protection of forests. The private forest owners will be compensated for the resulting costs or the losses in production.</p> <p>The integration of the local population may go through the establishment of agricultural development groups. Compensation may be required to allow public authorities to take options in order to avoid the overexploitation of forests.</p>
Addressed challenges	The reduction of pressure from civil society on forests contribute to the challenge on the protection and enhancement of forest resources
Target locations and water uses	Selected forests are: the forests of Sidi Zid, the forests of Jimla and the forests of Jebel Zaghouan.
Benefits	This measure offers several benefits, including conservation of forest cover, soil protection to a natural hydrological regime, improved grazing conditions, and job creation through the development of income-generating activities for forest users.
Potential negative impacts	This option aims in part to reduce grazing pressure on forests which can cause production losses for farmers and local people.
Timeline of implementation	The measure is a long-term one. It can rely on the programs of the regional department of forests which are valid for 10 years.
Feasibility	The option is based on institutional measures (e.g. control, public participation, compensation) and their strengthening on the risk areas. User involvement implies the establishment of new collective management methods (need of return of existing experience and training).
Robustness	The reduction of pressures on forests contributes to forest resilience to extreme events (e.g. drought, storms, and floods).
Flexibility	The option is based on institutional activities that appear adjustable in time.
Costs	The cost required for this measurement over a period of 15 years is estimated at 350 192 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option is based on the Forest Code which sets a number of regulations on users aiming at controlling their impact. In addition, the Forest Code allows users to band together for protection and exploitation actions. However, it is common that users do not respect the rules and the rights of exploitation of forest resources. The lack of financial support and lengthy administrative procedures prevent the creation of an association of forest users.
Acceptance	There is a lack of interest on the part of forest populations to implement (enforce) the Code, in particular the creation of associations.
Suggested stakeholder involvement	User awareness and participation in collective associations should be strengthened.

Preconditions for success	User awareness More incentive regulatory framework
Examples	Protection of access to the forest of Zaghouan National Park by fencing in order to reduce pressure on the forest.

WMO 12: Protection against forest fire

Description	The protection of forests against fires will be achieved by implementing appropriate techniques and providing the required equipment, as well as by involving users in forest management to make them aware of the importance of managing in a sustainable way these resources while improving their incomes
Addressed challenges	Protection against forest fires contributes to the challenge on the protection and enhancement of forest resources. Moreover, this WMO is having an indirect impact on soil protection and on keeping the natural hydrological regime within the studied river basin.
Target locations and water uses	The forests of Jimla were chosen due to the number of fires
Benefits	This measure offers several benefits, including limiting the number of fires, protecting the forest area, controlling the desertification, protecting the soil fertility and controlling the runoff phenomenon (bare ground).
Potential negative impacts	This can lead to forest loss and forest fragmentation (trenches firewalls, road infrastructure, etc.).
Timeline of implementation	This option can be set up in the short term. It can be based on a 10-year program of the Regional Directorate of Forestry.
Feasibility	The fight against fires via maintenance of undergrowth and the firewall aisles installation is a common practice in Tunisia. Also the equipment of intervention and the establishment of lookout during critical periods are present on the entire territory. Finally, the forest code imposes strict prohibitions on risky behavior. What is essential, therefore, is to strengthen the existing modes of action and develop a public awareness program.
Robustness	The protection of forests against fire reduces the phenomenon of desertification and maintains soil fertility which will have beneficial effects on the ability of forests to adapt to different possible future climate change.
Flexibility	Apart from the installation / expansion of firewall trenches, the proposed activities are institutional and easily adjustable.
Costs	The cost required for this measure over a 15-year period is estimated at 2 600 413 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	This option can be based on the objectives of the Forest Code and several sections regulating the activities in or near forests to minimize the risk of fire. A major barrier comes from the complexity of legal texts relating to the exploitation of forest resources.
Acceptance	Local people are poorly mobilized on the issue of sustainable forest management.
Suggested stakeholder involvement	An important issue is to increase the interest of local people in forest protection (eg. Forest as a source of revenue) notably through collaborative co-management projects between local residents and land owners and the public authorities. Awareness is also an important line of action.
Preconditions	Revision of various articles of the Forestry Code

for success	Awareness of local people about the importance of protecting forest resources
Examples	<p>The establishment of a firewall across the forests of the watershed of Wadi Rmel</p> <p>The creation of a center to protect forests against fires, that is equipped with modernized equipment for fire detection</p>

WMO 13: Introduction of new agro forestry species and enrichment of existing forest

Description	Good management of forest resources by introducing new species for agro forestry purposes as well as enriching and preserving existing species in order to preserve and develop the forest
Addressed challenges	The introduction of new species will participate in the development and management of forest resources and thus to improve the standard of living.
Target locations and water uses	Selected forests are: forests of Jimla, and forests of SidiZid
Benefits	This measure offers several benefits, including the valuation of forest products and the improvement of the operation of standard of living by sales of forest fruits.
Potential negative impacts	This option aims to improve the management of forest resources, but it is a long term action.
Timeline of implementation	This option is to be applied in the medium term but must be specified and followed by research on the species and varieties to be introduced before starting the plantations. This option considers the short term.
Feasibility	This action is technically feasible. Indeed, the state gives the users the species to be planted.
Robustness	The enrichment of forests contributes to forest resilience to extreme events (e.g. drought, storms, and floods).
Flexibility	The implementation of this measure requires a strengthening of awareness-raising and training for local people. These actions can help overcome the overexploitation of forest resources problems.
Costs	Based on cost over 15 years in the WP3, the cost required for this option is 502 001 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The measure is consistent with the objectives of the Forest Code, which aims to ensure the protection, conservation and rational exploitation of forest resources and also to ensure users the lawful exercise of their rights. The protection of national territory against desertification and the development of forestry-pastoral resources are actions of national interest. These actions benefit from the encouragement of the State in the form of grants, loans, aid in kind or any form of encouragement. The incentive measures taken by the State under this Act are designed to encourage the participation of individuals, communities or any other legal person, to carry out actions aimed at increasing timber and fodder production. These incentive measures also aim at improving the economic and social life of forest populations. A major challenge, however, is to increase the application of the Forest Code. Moreover, the low contribution of the owners to carry out the work is a problem. The measure is consistent with the objective of the 11th Plan of Agricultural Policy (2007-2011) which aims at the "Sustainable development of natural resources" among other things, and in particular the protection and development of forest resources.
Acceptance	The Ministry of Agriculture (Forestry Department) encourages the promotion of forestry-pastoral activities. However, the contribution of the local population to carry out the work is low. There is a lack of interest on the part of forest populations to implement this type of action, because of the long time required for the operation of the introduced products. Moreover, the forest population

Suggested stakeholder involvement	mainly aims to improve production as well as their income.
Preconditions for success	It will be necessary to raise awareness and enhance the involvement of forest populations in the design and realization of this long-term action.
Examples	Organization of the local population / valuation of non-timber forest products. The introduction of new species (carob, capers, Eglantine) in the demonstration plot of Ain El Bateria and forest of WadiSbaihiya of the Rmel watershed.

WMO 14: Better governance of forest resources

Description	The option aims to improve the governance of forest resources. It consists of better enforcement of existing forest laws and the regulations of the lease situation of forest communities.
Addressed challenges	Good governance of forest resources contributes to the protection and proper management of these resources.
Target locations and water uses	This action concerns all forest resources in the basin: forests of SidiZid, forests of Jimla and the forests of Jebel Zaghouan.
Benefits	This option provides several positive aspects, including the conservation of forest cover, soil protection and improvement of pastoral conditions.
Potential negative impacts	-
Timeline of implementation	This WMO must be applied in the medium term because it must proceed by an identification of failures and accurate action to take. Then comes to the application of remedies and improvements.
Feasibility	The option is based on legislative options aimed at improving and strengthening existing laws and regulations. Strengthening agricultural development groups will also be necessary in order to ensure the development of the forestry sector.
Robustness	This option reduces the degradation of this richness and preserves soil fertility which will have beneficial effects on the ability of forests to adapt to different possible future climate change.
Flexibility	The option is based on legislative activities that appear hardly adjustable over time.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 100 000 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The creation of an institutional and regulatory environment as well as favorable capacity for sustainable engagement of stakeholders (users, institutional partners) is a central component of the National Strategy Development and Sustainable Management of Forests and Range. However, this action is limited by the absence of texts governing the relationships between regional and central departments in the Ministry, the lack of formal processes between the forestry administration and its institutional partners and potential partners in other sectors as well as the absence of synergy between development structures, research and higher education structures.
Acceptance	The key players of this option are the Ministry of Agriculture and more specifically the Regional Directorate of Forestry (public bodies) and forest population (non-institutional actors). This option will have direct positive impacts on the forest administration. It promotes the strengthening of its capabilities. In addition, it allows the forest to have judicious population access to resources and appropriate sharing of efforts and benefits. Some barriers do exist. The fact that the Forest Code remains too focused on heritage conservation without suitable opening to development problems and the participation of other stakeholders. Organizations (GDA, associations, etc.) have not achieved the desired objectives. Indeed, it was not possible to involve communities benefit in the management of programs where

Suggested stakeholder involvement	<p>the role of these organizations remained passive with no real power.</p> <p>An important issue is to give greater prominence to the existing legislation in the forestry sector through building institutional and individual capacities of the sector and get coordination between regional and central departments within the ministry and between ministries, research and civil society.</p>
Preconditions for success	<ul style="list-style-type: none"> -Revision of the various articles of the forestry code - Creating A national mechanism of sector financing through the development and implementation of a payment scheme for ecosystem services and the revision / adaptation of the investment code. - Focus on the role of associations for the management of forest resources
Examples	<ul style="list-style-type: none"> -

WMO 15: Awareness campaign and learning

Description	This option aims to improve the exploitation and management of natural resources by sensitizing civil society about the importance of natural resources and their protection. It consists in particular to facilitate the work of associations and organize awareness campaigns.
Addressed challenges	Raising awareness and progressive involvement of the relevant civil society. This society will participate in achieving the objectives of protection of natural resources to ensure sustainable management of these resources.
Target locations and water uses	This option is very advantageous for all areas of the basin.
Benefits	This option offers many benefits including: collaboration among development agents, researchers and civil society. Moreover, it will facilitate the implementation of the various actions in relation to civil society.
Potential negative impacts	-
Timeline of implementation	This option must begin immediately in the short term
Feasibility	This action mainly depends on the flexibility of the civil society.
Robustness	This option will contribute to reducing the risk of degradation of natural resources regardless of the impacts of future global changes (climate, increased demand, etc.).
Flexibility	This option is of an institutional nature and therefore is easy to change based on future global changes.
Costs	Based on the costs over a period of 15 years as stated in the WP3, the cost required for this option is 70 856 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The different future strategies (water resources, forest resources, conservation of water and soil) emphasize the importance of civil society for the conduct of such a project. Indeed the awareness and training of the operators will therefore become a necessity.
Acceptance	This option essentially requires the integration of associations. However the lack of coordination between different actors makes the acceptability of civil society in such action quite difficult.
Suggested stakeholder involvement	It will be necessary to progressively and gradually introduce new forms of partnership (NGOs) to promote self-development of the population and ensure the sustainability of the actions of a project in the area. Furthermore the organization of awareness campaigns that include all possible decision levels and all implementation phases to improve the understanding of the environment to properly identify constraints and optimal solutions to major problems of the area.
Preconditions for success	Give more importance to awareness campaigns by increasing the number of sessions.

Examples

An annual budget is devoted to plan and organize conferences and training sessions in different specialties and aimed at different categories (organic farming, agricultural extension, personal training)

WMO 16: Improved decision making

Description	This option aims to improve decision making by involving stakeholders in all stages of the study and the decision process. The government can encourage a reorientation of existing institutions. The financial support and development of awareness can be used to enhance coordination between public authorities and civil society. Moreover, this context can create integrated businesses between graduates and farmers in order to manage the public lands (science + experience). The option may consider co-creation of a link between education, research, society and politics. The research need to adopt interdisciplinary approaches to work with the society to develop solutions and innovations for agriculture and sustainable water use.
Addressed challenges	The involvement of stakeholders in decision making is essential for the development and success of the projects.
Target locations and water uses	The entire Rmel watershed is affected by this option.
Benefits	The main benefits are: the coordination between public authorities and civil society, creating integrated businesses between graduates and farmers, research should adopt transdisciplinary methods to integrate society in development and solution innovations for a better agriculture and sustainable water use. Work towards developing a background incentive for the proper management of natural resources.
Potential negative impacts	The dialogue between the authorities and civil society is not always productive. Similarly, civil society is not always ready to apply new techniques based on science.
Timeline of implementation	This option is to be applied in the medium term after the sensitization of civil society.
Feasibility	The feasibility depends on funding of scientific research (adopt programs that facilitate the integration of graduates in agricultural areas) also the integration of civil society in all stages of decision making.
Robustness	This option will contribute facilitating the acceptance of the operators to the technical measures proposed by the state and thus reducing losses and degradation of natural resources regardless of the impacts of future global changes.
Flexibility	Flexibility can be accelerated by improving academic degree programs and adopt a method to integrate graduates in the development of solution for the management of natural resources as a new start of the civil society in a second stage.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 41 833 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The different future strategies (water resources, forest resources, conservation of water and soil) consider the human factor as the main partner in any operation of development and conservation of natural resources. A participatory approach therefore becomes a necessity. The methods of intervention that were based on the vertical approach did not allow involving operators at all stages of planning and implementation. Indeed, they do not feel concerned by this problem.

Acceptance	This option requires collaboration between development agents, researchers and civil society. In fact, due to lack of coordination, the participatory approach would be a further complication for both the administration and operators, and it maintains an environment of uncertainty that will negatively influence the behavior of operators.
Suggested stakeholder involvement	The organization of awareness campaigns bringing together the various stakeholders (public authorities, private sector, civil society) to discuss the main issues related to the area.
Preconditions for success	<p>Organization committee meetings that bring together those responsible for decision making.</p> <p>Preparation and implementation of participatory management plans</p>
Examples	Development projects in the governorate of Zaghuan: ADB project (African Development Bank) and FMFW project (financing management framework of the watershed)

WMO 17: Promote projects that generate more income

Description	This option aims to improve means of subsistence by encouraging investment in income generating projects and employment. This mainly passes through economic incentives for eco-tourism projects, introducing craft activities for women in rural areas, promotion of new production activities and development of organic agriculture. This option should support projects that take into account impacts on water resources and that aim to develop the river basin in a sustainable way.
Addressed challenges	This option will contribute to encouraging natural-resource-based-projects and characteristics in the area in order to improve the living standards of local people.
Target locations and water uses	The entire Rmel watershed is affected by this option.
Benefits	The benefits of this option are: improving living standards, increasing the access to basic necessities and increasing production, and environmental protection.
Potential negative impacts	-
Timeline of implementation	This option is to be applied in the medium term.
Feasibility	This option requires no special technical capacity.
Robustness	The implementation of this option will participate in the management of the different natural resources that will help reduce the risk of future global change impacts.
Flexibility	Flexibility depends on the motivation of the local population (women and youth) to participate in this type of action.
Costs	Based on the costs over a period of 15 years in the WP3, the cost required for this option is 1 338 670 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The option is consistent with the incentives code of investment, which encourages the use of natural resources. Incentive options taken by the state are intended to encourage the participation of the local population, mainly women. It tries to promote the execution of actions to increase revenues and improve the conditions of economic and social life.
Acceptance	Public authorities (Ministry of Agriculture, the Ministry of Industry and Trade and Ministry of Environment) encourage the promotion of social and economic activities by identifying specific development options and actions such as training and support for the creation of income generating activities. There is a lack of interest on the part of operators to implement this type of action, due to lack of funding mechanism.
Suggested stakeholder involvement	<ul style="list-style-type: none"> - Joint awareness of civil society through identifying options and specific development actions on their roles in the use of natural resources and their responsibility for the protection and conservation of these resources. - Integration of associations in raising awareness.

Preconditions for success	Encourage the launching of projects that are tolerant to the environment / Work towards creating an incentive background.
Examples	The exploitation of small plots in the Jebel Zaghuan National Park as a botanical garden The production of essential oils by rural women in WadiSbaihla,

WMO 18: Encourage investments

Description	This option aims to improve livelihoods through job creation and encouragement of the launch of income generating projects. This option should support investments that take into account impacts on water resources and that aim to develop the river basin in a sustainable way.
Addressed challenges	This option aims at the development of different sectors to create new jobs likely to improve the living standards of the local population.
Target locations and water uses	Sub-basin of wadiSbaihia / the Rmel watershed
Benefits	To facilitate the obtaining of short-term loans and grants for small farmers and youth, and to facilitate access to information on the opportunities, financing and investment procedures.
Potential negative impacts	Obtaining loans may depend on certain criteria that are usually limiting the beneficiaries / young people are not always motivated by the idea of creating their own projects
Timeline of implementation	- This option must be applied in the medium term
Feasibility	The feasibility depends on the strategy of the country which must provide a budget for beneficiaries and adjust the criteria to the measure.
Robustness	The willingness to invest and create projects.
Flexibility	-Improved knowledge and youth technical capabilities can help boost the capacity of local communities to plan and adapt to future global changes.
Costs	-Based on cost over 15 years in the WP3, the cost required for this option is 1 004 002 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	The Investment Incentives Code promotes investments in the sectors of agriculture, industry, tourism, crafts and some service activities. This is achieved in the areas of encouragement of regional development established by the decree referred to in the abovementioned Article 23. These areas benefit from the state's support and the employer's contribution to statutory social security for wages paid to Tunisian officials. However, the procedures are long and the contribution of the state is low. The National Development Strategy is favourable to the measure. In order to boost investment and promote jobs in the field of environment, which represents a growth industry in this regard, Tunisia has organized in 2009, the second International Forum of Investment and Employment in the environmental sector. This approach is considered essential to establish a social climate favorable to the policy of encouraging domestic and foreign investment in various economic sectors, and the strategic choice knowledge-based economy: a dynamic, efficient, innovative, creative of new wealth and self-financing and regulatory mechanisms.
Acceptance	In order to consolidate the achievements in ecological tourism and to better define the role and tasks of different stakeholders in the ecotourism sector, the Ministry of Environment and Sustainable Development has set up a study on "the strategy the revaluation of ecotourism in Tunisia, "and this in collaboration with the German technical cooperation agency. However, it is not automatic

<p>Suggested stakeholder involvement</p> <p>Preconditions for success</p> <p>Examples</p>	<p>that the projects are not harmful to the environment.</p> <p>The Ministry of Agriculture encourages investment in general and investment in agriculture and fisheries. This has been particularly established by Law 93-120 of 27 of December 1993 on the promulgation of the Code of Investment Incentives. The provisions of the Code apply to investment operations concerning the creation, Extension, Renewal, the redevelopment or activities transformation.</p> <p>In Industry, the New Promoters (NP) and Small and Medium Enterprises (PME) that undertake projects in the activities of manufacturing, craft activities and industry-related service activities, enjoy a premium of study and technical assistance set at 70% of the cost with a ceiling of 20 000 DTN.</p> <p>Awareness and involvement of beneficiaries in all performed actions.</p> <p>Some non-governmental associations can act as an intermediary to facilitate obtaining loans and grants.</p> <p>The promotion of projects in the sectors of agriculture, industry, economy and crafts and consider youth awareness to invest in the private sector. The latter, is almost deserted compared to the state sector</p> <p>The promotion of ecotourism in the town of Zriba and Zaghouan (http://www.darzaghoulane.com/)</p>
--	---

WMO 19: Developing skills for young people

Description	This options aims to organize training sessions to facilitate the integration of young people into working life and thus a generation of skilled technicians for proper use of different techniques. This option should support the development of skills for water-friendly techniques and thereby support the sustainable development of the river basin.
Addressed challenges	This will give an importance to young people to prepare them to manage projects that will participate in following the development of the area.
Target locations and water uses	Sub-basin of wadisbaihia
Benefits	Training young people in modern specialty programs, organizing training sessions and internships, improve employability.
Potential negative impacts	These training sessions may not lead to jobs. Young people are sometimes less interested in training if the conditions are not favorable.
Timeline of implementation	This option must be applied in the short term.
Feasibility	The feasibility depends on the financing of these trainings / the availability of training centers.
Robustness	The creation of training centers / training for trainers
Flexibility	-Improved knowledge and youth technical capabilities can help boost the capacity of local communities to plan and adapt to future global changes
Costs	-Based on cost over 15 years in the WP3, the cost required for this option is 131 357 TND (TND 2016, discount rate: 10%).
Synergies and conflicts with policy objectives	Totally exporting service companies established before the promulgation of the Code of Investment Incentives can recruit foreign supervisory and control agents for a transitional period of two years from the date of enactment of this Act. This is considered after informing the Ministry of Vocational Training and Employment. However, trainers or supervisory staff are not always available, hence the ability to schedule training for young people. These training sessions are currently proving to be limited. The National Development Strategy seeks an overall upgrading of the training sector. This sector must be for the benefit of key stakeholders, namely, first and foremost; job seekers, businesses, economic sectors and regions while considering their development needs and investment. The program should thus enable to address the challenges of the next stage in the light of the imperatives of continues economic and technological change, and to open up wider prospects for investment in promising and innovative sectors. However, the support programs are always relative to market demand, of companies in economic and agricultural sector. If no request is made, the trainings are then absent.
Acceptance	This option is acceptable because it is done on the request of the beneficiaries and the market, but it faces some obstacles: there are problems of funding and lack of awareness on the importance of these trainings for the integration of young people in the professional life; training may not always be frequent. The civil society sometimes provides the opportunity for young people to train in the areas required

Suggested stakeholder involvement	by the market. NGOs can allocate necessary funds of budget to support and fund development projects and that, on the basis of competence, the nature of the projects and scheduled activities.
Preconditions for success	Civil society and NGOs. Awareness and involvement of beneficiaries in all performed actions. Awareness of the beneficiaries of the importance of the capacity and potential of youth. Address adequate trainers as well as training centres / Offer free training. Similarly to motivate the youth by allowances.
Examples	The Jouggar training center for the training of young people: http://www.avfa.agrinet.tn/fr/detail_centre.php?code=29

References

- [i] Verkerk H, Robert N, Varela E, Martinez de Arano I, Libbrecht S, Dude R, Boiten V, Broekman A, Sánchez A, Giannakis E, Bruggeman A, Zoumides C, Jebari S, Oussaifi D, Daly H, Magjar M, Krivograd Klemenčič A, Smolar-Žvanut N (2015). Four reports with the water management options and the evaluation, one per case study river basin. Deliverable D3.3, BeWater, FP7 project no. 612385-SIS.2013.1.2-1 European Commission, 308 pp.
- [ii] Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change* 23, 485-498.
- [iii] European LEADER Association for Rural Development (2016). The Bottom Up approach. Retrieved from http://www.elard.eu/en_GB/the-bottom-up-approach
- [iv] André, P. with the collaboration of P. Martin and G. Lanmafankpotin (2012). Citizen Participation, in L. Côté and J.-F. Savard (eds.), *Encyclopedic Dictionary of Public Administration*. Retrieved from http://www.dictionnaire.enap.ca/dictionnaire/docs/definitions/definitions_anglais/citizen_participation.pdf
- [v] This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines ‘climate change’ as: ‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’ (see https://www.ipcc.ch/publications_and_data/ar4/wg2/en/annexessglossary-a-d.html).
- [vi] European Commission. Adaptation to climate change. Retrieved from http://ec.europa.eu/clima/policies/adaptation/index_en.htm
- [vii] European Climate Adaptation Platform. Glossary. Retrieved from http://climate-adapt.eea.europa.eu/glossary/index_html/#linkClimateChangeScenario
- [viii] IPCC (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- [ix] IPCC (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- [x] Verkerk H, Robert N, Varela E, Martinez de Arano I, Libbrecht S, Dude R, Boiten V, Broekman A, Sánchez A, Giannakis E, Bruggeman A, Zoumides C, Jebari S, Oussaifi D, Daly H, Magjar M, Krivograd Klemenčič A, Smolar-Žvanut N (2015). Four reports with the water management options and the evaluation, one per case study river basin. Deliverable D3.3, BeWater, FP7 project no. 612385-SIS.2013.1.2-1 European Commission, 308 pp.
- [xi] Verkerk H, Robert N, Varela E, Martinez de Arano I, Libbrecht S, Dude R, Boiten V, Broekman A, Sánchez A, Giannakis E, Bruggeman A, Zoumides C, Jebari S, Oussaifi D, Daly H, Magjar M, Krivograd Klemenčič A, Smolar-Žvanut N (2015). Four reports with the water management options and the evaluation, one per case study river basin. Deliverable D3.3, BeWater, FP7 project no. 612385-SIS.2013.1.2-1 European Commission, 308 pp.

- [xii] Adapted from FCMappers (2009). What is a fuzzy cognitive map? Retrieved from: http://www.fcmappers.net/joomla/index.php?option=com_content&view=article&id=56&Itemid=59
- [xiii] U.S. Global Change Research Program. Glossary. Retrieved from <http://www.globalchange.gov/climate-change/glossary>
- [xiv] Environment Agency. (2005). Ecology and the Water Framework Directive - Briefing note.
- [xv] Hufty, Marc (2011). "Investigating Policy Processes: The Governance Analytical Framework (GAF). In: Wiesmann, U., Hurni, H., et al. editors. Research for Sustainable Development: Foundations, Experiences, and Perspectives.". Bern: GeographicaBernensia: 403–424.
- [xvi] United Nations (1992). Convention on Biological Diversity. 1760 UNTS 79; 31 ILM 818 (1992).
- [xvii] Karst Waters Institute. What is karst? And why is it important? Retrieved from <http://karstwaters.org/educational-resources/what-is-karst-and-why-is-it-important/>
- [xviii] Goodwill, R.J. (2012). Engaging staff communities in a knowledge transfer strategy: a case study at the University of Melbourne. *Journal of Higher Education Policy and Management*, 34:3, 285-294.
- [xix] Saarikoski, H.; Barton, D.N.; Mustajoki, J.; Keune, H.; Gomez-Baggethun, E. and J. Langemeyer (2015): Multi-criteria decision analysis (MCDA) in ecosystem service valuation. In: Potschin, M. and K. Jax (eds): *OpenNESS Ecosystem Service Reference Book*. EC FP7 Grant Agreement no. 308428.
- [xx] Djuma, H., A. Bruggeman, M. Eliades, M.A. Lange. 2016. Non-conventional water resources research in the Middle East. *Desalination and Water Treatment* 57:5, 2290-2303.
- [xxi] Missouri Botanical Garden (2002). What is an oxbow lake? Retrieved from <http://www.mbgnet.net/fresh/lakes/oxbow.htm>
- [xxii] Mackay, M (2011). *Understanding and Applying Basic Public Policy Concepts*. University of Guelph Louise Shaxton, Delta Partnership.
- [xxiii] Gabrielsen, P., Bosch, P. (2003). *Internal Working Paper Environmental Indicators: Typology and Use in Reporting*. European Environment Agency, Copenhagen. 20 pp.
- [xxiv] European Climate Adaptation Platform. Glossary. Retrieved from http://climate-adapt.eea.europa.eu/glossary/index_html/#linkResilience
- [xxv] European Environment Agency. Glossary. Retrieved from <http://www.eea.europa.eu/themes/water/wise-help-centre/glossary-definitions/river-basin>
- [xxvi] European Commission. Introduction to the new EU Water Framework Directive. Retrieved from http://ec.europa.eu/environment/water/water-framework/info/intro_en.htm
- [xxvii] European Commission (2000). Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy (Water Framework Directive).
- [xxviii] Verkerk H, Robert N, Varela E, Martinez de Arano I, Libbrecht S, Dude R, Boiten V, Broekman A, Sánchez A, Giannakis E, Bruggeman A, Zoumides C, Jebari S, Oussaifi D, Daly H, Magjar M, Krivograd Klemenčič A, Smolar-Žvanut N (2015). Four reports with the water management options and the evaluation, one per case study river basin. Deliverable D3.3, BeWater, FP7 project no. 612385-SIS.2013.1.2-1 European Commission, 308 pp.

- [xxix] Government of the Republic of Slovenia (2015). Protocol on sediment management to the framework agreement on the Sava River Basin. Retrieved from:
http://www.savacommission.org/dms/docs/dokumenti/documents_publications/basic_documents/protocols/protokol_nanos.pdf
- [xxx] TnauAgritech Portal (2016). Dryland Technologies. Retrieved from
http://agritech.tnau.ac.in/agriculture/agri_majorareas_dryland_drylandtechnologies.html
- [xxxi] Glaser, M., Krause, G., Ratter, B., and Welp, M. (2008) Human-Nature-Interaction in the Anthropocene. Potential of Social-Ecological Systems Analysis. [Website], Available from:
http://www.dg-humanoekologie.de/pdf/DGH-Mitteilungen/GAIA200801_77_80.pdf
- [xxxii] Idaho Transportation Department (2014). Best Management Practices: PC-32 Terraces and Benches. Retrieved from:
<http://itd.idaho.gov/enviro/stormwater/BMP/PDF%20Files%20for%20BMP/Chapter%205/PC-32%20%20Terraces%20and%20Benches.pdf>
- [xxxiii] Paulson, LD (2015, February 25). What Is Water Scarcity? Retrieved from
<https://www.rwlwater.com/what-is-water-scarcity/>
- [xxxiv] Milwaukee Riverkeeper (2015). What's a River Basin? What's a Watershed? Retrieved from <http://milwaukeekeeper.org/whats-a-river-basin-whats-a-watershed/>
- [1] Norwegian Meteorological Institute (2013). *Extreme weather events in Europe: Preparing for climate change adaptation*. Retrieved from
http://www.easac.eu/fileadmin/PDF_s/reports_statements/Extreme_Weather/Extreme_Weather_full_version_EASAC-EWWG_final_low_resolution_Oct_2013f.pdf.
- [2] Regional Office of Agricultural Development (ROAD), 2014
- [3] Agricultural map: The Ministry of Agriculture and Water Resources is developing a farm map for each decade (2014)
- [4] République Tunisienne Ministère de l'Environnement et du Développement Durable (2007). *Etude de la vulnérabilité environnementale et socioéconomique du littoral tunisien face à une élévation accélérée du niveau de la mer due aux changements climatiques et identification d'une stratégie d'adaptation*. Retrieved from :
http://www.environnement.gov.tn/fileadmin/medias/pdfs/dgeqv/vulnerabilite_adaptation.pdf
- [5] DRE/Water Resources Department: Part of a regional office of agricultural development of Zaghuan, 2014
- [7] National Statistics Institute (<http://www.ins.nat.tn>)
- [8] Destination Tunis (2012). *Le Temple des Eaux et l'aqueduc Zaghuan – Carthage*. Retrieved from <http://destination-tunis.fr/temple-des-eaux-et-aqueduc-zaghuan-carthage>
- [9] PDAI: Etude d'une 2ème tranche du PDAI Sud-Est du Gouvernorat de Zaghuan /Centre National d'Etudes Agricoles CNEA (Mars 2014) annexe 1 pages 6-18
- [10] République Tunisienne (2001). *Code des eaux*. Retrieved from
<http://www.semide.tn/bas/Legislation.pdf>
- [11] République Tunisienne (2010) *Code Forestier*. Retrieved from <http://www.droit-afrique.com/upload/doc/tunisie/Tunisie-Code-2010-forestier.pdf>
- [12] République Tunisienne (1993) *Code des incitations aux investissements*. Retrieved from :
<http://www.tunisieindustrie.nat.tn/fr/download/CFGA/Code.pdf>

-
- [13] Ministère de l'Agriculture DG-EGTH (1995) *Economie d'eau 2000, Rapport final: stratégie de gestion d'eau*.
- [14] D4.2 Four draft adaptation plans, one for each CSRB
- [15] <http://www.bewaterproject.eu/bewater-approach>
- [16] Report Workshop Rmel River Basin 24 June 2014_ 61 pages.
- [17] Second Workshop Report - Rmel River Basin 4 June 2015_40 pages
- [18] D3.3 – Four reports with the water management options and the evaluation, one per case study river basin
- [19] OECD (2002). *Glossary of Key Terms in Evaluation and Results Based Management*. Retrieved from <http://www.oecd.org/development/peer-reviews/2754804.pdf>
- [20] R. Berndtsson, S. Jebari, H. Hashemi & J. Wessels (2016). *Traditional irrigation techniques in MENA with focus on Tunisia*, *Hydrological Sciences Journal*. Retrieved from <http://dx.doi.org/10.1080/02626667.2016.1165349>
- [21] Selmi, S. and Sai M.B., (1998). *La gestion collective de l'eau d'irrigation en Tunisie: particularités des associations d'intérêts collectifs des oasis*. Séries: Sécheresse : no. Spécial oasis: Institution of Agricultural Research and Higher Education, Tunis, Vol. 9, no. 2, p.111-115.

Annex 1: List of engagement and dissemination activities held in Rmel River Basin

Dissemination/engagement activity	Content	Target group	Dates
First Rmel river basin workshop in Zaghouan	<ul style="list-style-type: none"> -Introduction to the BeWater project. -Discussion of the current water use problems in the Rmel river basin. -Identification of the issues and challenges in the medium-long term for the Rmel river basin. -Reflection on the existing water management options. 	Public authority, Academia, civil society, teachers, youth association, Farmers, water, forest management, environment, tourism, industry	24 June 2014
The Rmel awareness campaign	<ul style="list-style-type: none"> -Raising awareness on the BeWater project. -Discussion of banners that tackle several subjects (e.g. a better adaptive water management in the Rmel river basin, global change and related challenges in the Mediterranean, Adaptive Water Management in the Mediterranean, the output of the new Tunisian constitution regarding water resources management) -Discussion on the first draft of water management options and the fuzzy cognitive map 	Decision makers, engineers, Academia, civil society, Education and youth, Agriculture, water, forest management	16 December 2015
Second Rmel river basin workshop in Hammamet	<ul style="list-style-type: none"> -Introduction to the BeWater project. -Discussion of specific aspects of the basin highlighted during the first stakeholder workshop (water management options and main challenges). -Ranking of the most important criteria for characterizing the WMOs. -Evaluation of the water management options. -Discussion on the preliminary results of the MCA for each challenge. 	Regional practitioners, researchers, natural resources associations, Education and youth, Development sectors(water, forest management, rural engineering, etc.)	4 June 2015
Stakeholders event	<ul style="list-style-type: none"> -Introduction to the BeWater project. -Evaluation and validation of the water management options. -Discussion on the preliminary results of cost-effectiveness for the water management options. 	Key stakeholders, farmerunions, researchers, education and youth, agriculture, actors in water services, forest management, environment, tourism.	7 October 2015
Meeting with individual stakeholders within different Offices (central and regional)	<ul style="list-style-type: none"> -Discussion on the water management options and the fuzzy cognitive map. 	Public authority, regional NGOs, national experts, agriculture, water, forest management, environment, industry,	October / November 2015

The Rmel awareness campaign	The workshop brought together representatives of the various stakeholders involved in water resources management from different governorates of Tunisia in partnership with GWP med		13 & 14 November 2015
The Rmel awareness campaign	This awareness campaign took place at the Jradou primary school in order to present the project and to talk about the climate change impact for youth	NGOs, water associations, education and youth representatives	16 December 2015
Meeting at the DGACTA	Stakeholders meet to talk about the different activities of the project. They provide their point of view and define their contributions within the project	Water resources engineers & decision makers	7 January 2016
Third Rmel river basin workshop in Tunis	-Validation of the bundles and WMOs -Discussion about the table of the contents of RBAP Rmel	Regional and national practitioners, national and international experts, decision makers, farmers representatives, NGO's, Agriculture, water, forest management, environment, eco-tourism	7 April 2016
The Rmel awareness campaign	The youth initiative : Society , youth, water and adaptation to the climate change in partnership of the GWP med	Education and youth, national and regional associations	21 May 2016

www.bewaterproject.eu



This river basin adaptation plan was developed within the BeWater project, based on funding received from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No. 612385