Background document

Tordera River Basin Adaptation Plan

2016

Results of the identification and evaluation of water management options for the Tordera River Basin

Results of the identification and evaluation of water management options for the Tordera River Basin

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Contents

1. Introduction

Climate change is expected to affect most regions across the world. The Mediterranean region is a region where changes in climate are expected to have **strong impacts**, particularly on water resources. To address sustainable water management and adaptation to the impacts of global change in the Mediterranean, **an iterative, bottom-up approach was developed** in the BeWater project to ensure that stakeholders from local societies play an active role and become engaged in determining appropriate strategies for management of their river basins.

An adaptation plan for the Tordera River was developed containing a set of water management options to address the challenges in the basin. These options have been formulated and evaluated in a participatory approach. The objective of the current document is to describe the detailed evaluation results of the identified water management options and provide background information on the Tordera River Basin Adaptation Plan.

2. Tordera river basin dynamics

In accordance with the BeWater approach, a Fuzzy Cognitive Map (FCM) was designed in collaboration with the basin's stakeholders, providing an overview of the basin's most relevant characterizing factors and allowing to identify the main challenges Tordera society needs to face for reducing its vulnerability to global change.

Drivers of the system are climatic variables, like **temperature** and **precipitation**, as well as other aspects influencing the basin's dynamics, like **population**, **environmental legislation** and compliance with the objectives of the water framework directive (WFD)[1].

Water availability for supplying water to municipalities, touristic facilities, industry - including bottling plants - and agriculture, as well as the implications of water consumption in terms of water quality or necessary infrastructure are summarised in the factor '**water uses'**.

Very strong relation links water uses to **water quantity** in water bodies (factor referring both to surface and ground water) reflecting the structural overexploitation in the Tordera basin. On the other hand, when water is available, more uses are enhanced and later consolidated, given the possibility to integrate local resources with **external water**, transferred from other basins or produced through desalination. This management practice actually hinders the reduction of the impact of water uses on water quantity by fostering consolidation of water demand and induces high cost of **bulk water,** due to the needed infrastructure and energy consumption it entails.

Water quantity and **quality** are very strongly linked, as water flows in the river have a very strong diluting effect. Moreover, the natural capacity of the river to neutralise pollutants is linked to the water flow regime, providing the adequate habitats both for in-stream, riparian and wetland ecosystems. For groundwater this relation is expressed by the impact indicator **salt intrusion**, given that seawater permeates into the coastal aquifers due to intense extractions.

The factor **health of water ecosystems** intends to resume the environmental status of water related environments, including wetlands, riparian and in-stream ecosystems. This factor is strongly influenced by the river's **hydro-geo-morphological quality**, depicted in the fuzzy cognitive map as one factor including considerations about sediment flows and all aspects related to connectivity: a) linear –migration of species along the stream – b) lateral –riparian habitats – and c) vertical – interrelation between in-stream, wetlands and groundwater bodies. Here the map considers more intensive rainfall due to climate change may increase flood damage, especially when river space is occupied by dwellings or infrastructure, the impact of floods is higher. More in general, dwellings and industries located in sensible areas, like the river space, coastal or environmental protected zones are included in the factor **urban expansion.** This factor also refers to the growing pressure of tourism

[1] Water Framework Directive (Dir 60/2000/CE)

and population on the territory, referring both to the impacts on hydro-geo-morphology and water availability.

The factor **health of forests** reflects the rich biodiversity in the basin, as well as the importance to maintain its conditions as to avoid wildfires to occur, especially with high temperatures in summer.
Agricultural land use is expressed separately for **extensive** and **intensive** farm exploitation models, due to their different impact on the environment and different water consumption patterns.

In annex 1 of this document each factor is described, as well as the rationale behind the relations established between the factors included.

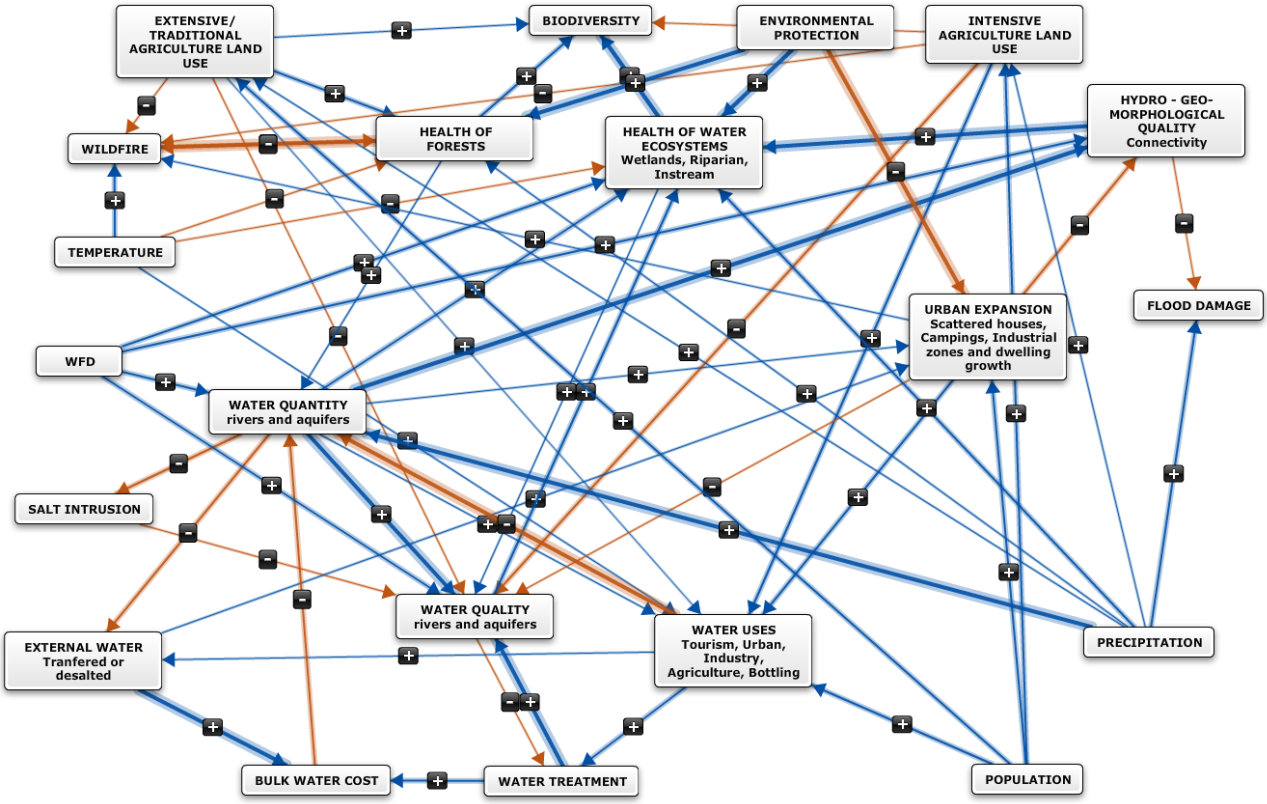

Figure 2.2: Cognitive map of the Tordera river basin (blue: +, red:-; strength: thin line: 1, medium width: 2, wide line: 3)

3. Identified water management options

To address the challenges identified by the stakeholders, potential water management options were co-produced. For the Tordera River Basin, 33 water management options were identified, which are listed in Table 3.1 and described in detail in Annex II. There are 7 options addressing Water quantity (challenge A), 10 options addressing Heath of Water and forest ecosystems (challenge B), 4 options addressing water quality (challenge C) and 9 options addressing Integrated water Management (Challenge D). Several options address more than one challenge: 2 options address both water quantity and quality challenges, and one option addressing both water quantity and integrated water management challenges.

We characterised each of the identified water management options using a set of criteria and expert assessment. This characterisation of options is shown in Table 3.2.

Table 3.1: Overview of the identified water management options for the Tordera river basin

#	Name of WMO	Challenge
1	Develop and refurbish facilities to consolidate and extend livestock grazing in the forest	B
2	Create specific branding for the commercialisation of extensive livestock products	B
3	Expand the Catalan School for Shepherds in the Tordera basin area	B
4	Promote rainfed crop production	A
5	Revise the Extractions Master Plan	A
6	Establish water use entitlement conditions	A/D
7	Promote knowledge transfer on irrigation with reclaimed water	A
8	Integrate water-saving solutions in construction protocols	A
9	Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses	D
10	Promote water recycling in production processes	A
11	Create “Water User Associations” (WUA)	D
12	Create a Permanent Participation Centre (PPC)	D
13	Develop a water traceability label for agricultural products	A
14	Create a Municipal Adaptation Coordination Board (MACB)	D
15	Promote phytotreatment plants in small municipalities and scattered houses	C
16	Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)	B
17	Foster selective fishing	B
18	Foster local use of adaptation-to-global-change indicators	D
19	Raise awareness	D
20	Modernise irrigation techniques	A
21	Integrate adaptation principles into water service provider contracts	D
22	Enhance environmental protected areas	B
23	Require guaranteed water provision as a precondition for urban expansion	D
24	Recover wetlands and their connectivity	B
25	Eliminate toxic substances used in municipal parks and gardening practices	C
26	Create a catchment agreement to reduce diffuse pollution	C
27	Centralise and facilitate access to relevant data on the basin water bodies’ status and uses	C
28	Protect groundwater recharge areas	A/C
29	Implement an environmental flow regime	A/C
30	Recover and protect river space	B
31	Revise and update water entitlements	D
32	Develop river custody agreements	B
33	Conclude adaptive forest management agreements	B

Table 3.2: Characterisation of the water management options for the Tordera river basin

WMO #	Water status				Water bodies		River section				Target water use sector								Target land use									Extreme events					Implementation scale				Implementation time horizon		
	Quantity	Chemical quality	Ecological quality	Hydrogeomorphological quality	Surface water	Groundwater	Up	Middle	Down	River as a whole	Local population	Tourism	Industry	Agriculture	Forestry	Energy	Water management	Others (please specify at the end of the row)	Arable land (rainfed)	Arable land (irrigated)	Permanent crops (rainfed)	Permanent crops (irrigated)	Grassland	Forests	Built-up	Wetlands & deltas	Beaches & salines	Other	Drought	Flooding	Storms	Wildfires	Not related	National	Regional	Municipal	Basin	Short (< 5 yrs)	Medium (5-20 yrs)	Long (> 20 yrs)
1	1				1	1				1				1	1						1		1	1								1				1	1			
2	1									1	1			1							1			1								1			1	1		1		
3	1									1	1			1	1						1		1	1									1			1	1		1		
4	1	1		1	1	1				1				1			1		1		1								1						1	1		1		
5	1					1				1							1		1	1	1	1	1	1	1								1				1	1			
6	1				1	1				1	1	1	1	1		1	1			1		1			1								1	1			1	1			
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10	1	1			1	1				1			1	1		1									1				1							1	1	1			
11	1					1				1	1	1	1	1		1	1			1		1			1				1								1	1			
12	1	1	1	1	1	1				1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1					1	1			
13	1				1	1				1				1						1		1										1			1	1	1	1		
14	1	1	1	1	1	1				1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1				1	1	1			
15		1	1		1	1				1	1	1					1								1								1			1		1			
16	1	1	1	1	1	1			1		1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1				1	1		1		
17			1		1					1	1	1		1														1					1			1	1			
18	1	1	1	1	1	1				1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1			1	1	1	1			
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25		1			1	1				1	1	1		1	1				1	1	1	1	1	1	1	1							1			1		1			
26		1	1		1	1				1	1			1					1	1	1	1	1			1							1				1	1			
27		1			1	1				1	1	1													1								1			1	1	1			
28	1	1		1		1				1	1	1	1	1			1		1	1	1	1	1	1	1	1			1	1						1	1		1		
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32	1	1	1	1	1					1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1		1	1		1				1	1	1			
33	1				1	1				1	1	1		1	1		1						1	1		1			1	1		1				1	1	1			

WMO #	Expected			Timelag between			Character				Implementation costs				Operational costs				Efectiveness				Approach to			Nature of approach							Potential		Feasibility			Acceptabili	
	Short (< 5 years)	Medium (5-20 years)	Long (> 20 years)	Short (< 5 years)	Medium (5-20 years)	Long (> 20 years)	Demand	Supply	Support	Environmental conservation	< 10,000 €	10,000 - 100,000 €	100,000 - 1,000,000 €	> 1,000,000 €	< 10,000 € / yr	10,000 - 100,000 € / yr	10,000 - 1,000,000 € / yr	> 1,000,000 € / yr	High	Medium	Low	Uncertain	Green	Grey	Soft	Bear the loss	Share the loss	Modify the threat	Prevent effects	Change use	Research	Educate, inform and encourage change	Robustness	Flexibility	No major obstacle	Minor obstacles	Serious obstacles	High	Low
1		1		1						1		1			1					1			1					1					1	1			1	
2		1		1						1	1				1					1					1						1		1	1			1	
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25			1	1						1		1			1				1						1			1					1		1		1	
26		1		1						1			1			1				1					1					1			1		1			1
27		1		1					1			1				1				1					1						1		1		1		1	
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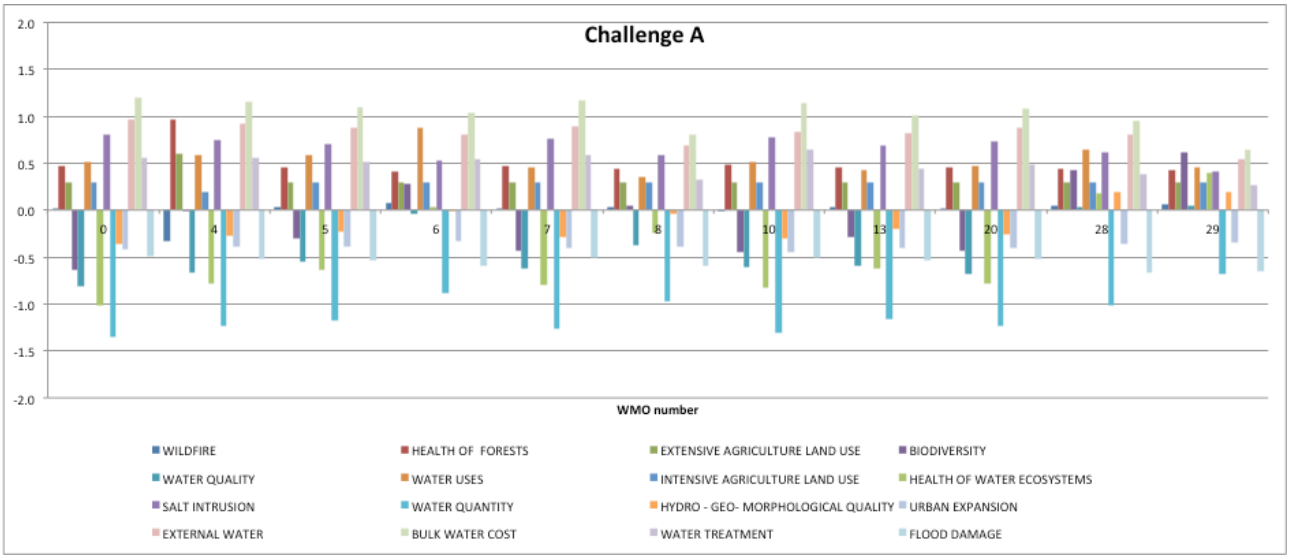
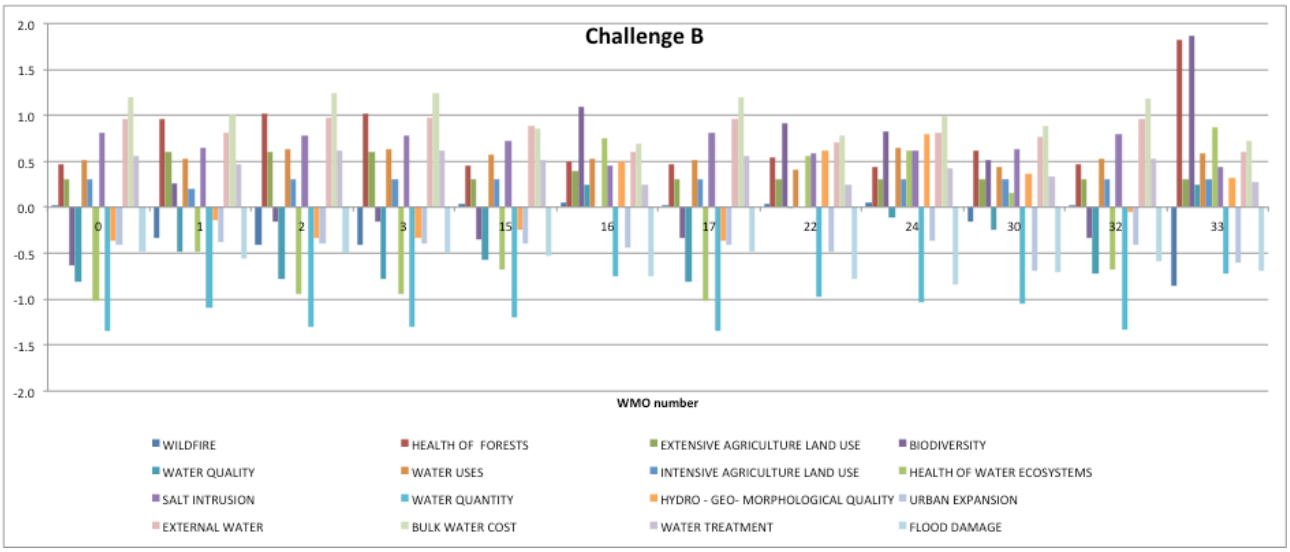
30		1		1						1			1		1				1						1				1	1		1		1		1	
31			1	1			1					1			1				1						1					1			1			1		1
32		1		1						1			1			1			1						1			1					1	1			1	
33		1			1					1			1			1				1					1				1				1	1			1	

4. Evaluation of water management options

4.1 Impact assessment

We introduced each of the water management options into the Fuzzy Cognitive Map to assess how all factors would react (see annex II on how each water management option was introduced) and the new situation it would deliver for the basin's characterizing factors. The results are shown in Figure 4.1.





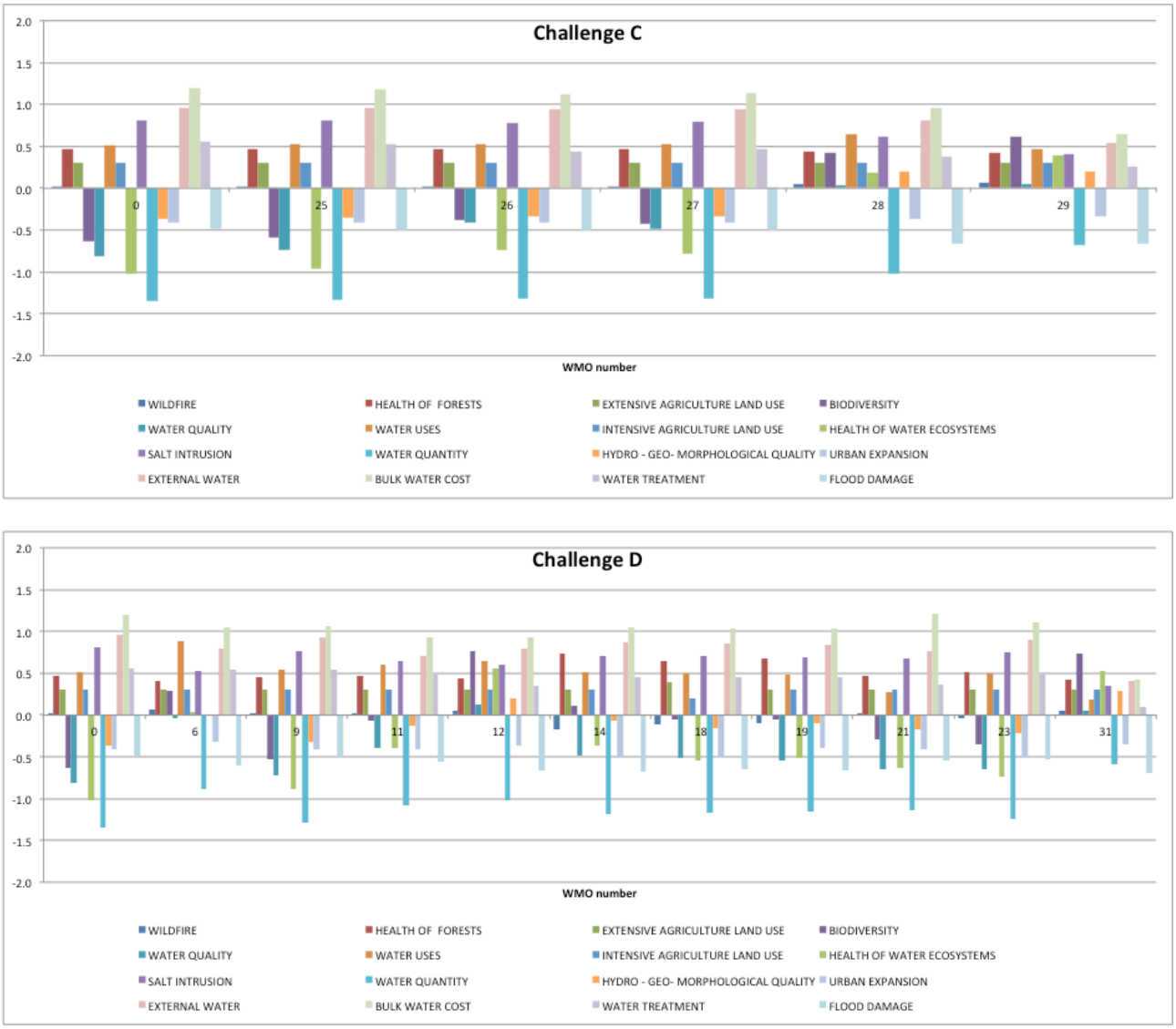


Figure 4.1: Impacts per challenge of the water management options on factors included in the Fuzzy Cognitive Map. Numbers on the x-axis refer to the water management options in Table 3.1.

As was mentioned in Chapter 2, the Fuzzy Cognitive Map includes the effects of climate change like drivers of the system. As precipitation is expected to decline and population is expected to increase, the results of the FCM suggest that *Water quantity* in rivers and aquifers would decline strongly in case no WMOs are introduced (WMO 0 in Figure 4.1). *Water quality* is also expected to decline strongly. As both water quantity and quality would decrease, also the *health of water ecosystems* is expected to decrease, in spite of the positive influence of the water framework directive (WFD DIR. 2000/60/CE). The health of forests is expected to increase, however, because of ongoing environmental protection.

When introducing the various options into the FCM, the results suggest that all water management options can change the development of the basin. In order to face the challenge to assure sufficient water quantity in Tordera water bodies (challenge A) “Protect groundwater recharge areas” (29) performs the best. Recovering a proper “Environmental flow regime” (29) and reducing consumption levels by “Integrate water-saving solutions in construction protocols” (8), also result very effective. Furthermore, good performance of option 6, “Establish water entitlement conditions”, as well as option 13, “Develop a water traceability label for agricultural products”, indicate the importance to better manage water use entitlements and proper accounting.

Some technological water saving solutions are less efficient to enhance water quantity, for example "Promote water recycling in production processes" (10), "Promote knowledge transfer on irrigation with reclaimed water " (7), "Modernization of irrigation techniques "(20).

Challenge B "health of forests and water ecosystems" is tackled by 11 options, best performing "Conclude adaptive forest management agreements" (33) because it aims to develop focused actions to restore forest health in collaboration with landowners. Options 1, 2 and 3, aiming to enhance pasturage, perform important forest health improvements as these actions would enhance improvements in the land use mosaic and reduce wildfire risk.

With respect to water related ecosystems, the best performing option calls for the creation of an Integrated Plan for the Protection of the Tordera Delta (IPPTD (16), including a citizen participation process enabling to reach a common agreement on the concrete actions this should entail. "Enhance environmental protected areas" (22) and "recover wetlands and their connectivity" (24) are options delivering improvements both of water and land ecosystems. Option 17, aiming to develop selective fishing practices in the Tordera Basin did not perform any relevant results.

In order to improve water quality (challenge C), "Protect groundwater recharge areas" (28) together with the implementation of a proper environmental flow regime (29) perform best.
Nevertheless, proposals orientated to prevent pollution, like creating a catchment agreement on diffuse pollution (26), or proposals aiming to improve monitoring of water body's status, like "Centralise and facilitate access to relevant data on the basin water bodies' status and uses" (27), also have a significant impact on water quality.

The challenge D, "integrated water management" was interpreted by looking at factors "bulk water price", "water treatment" and "hydro-geo-morphological quality" that most reflect this challenge in the fuzzy cognitive map. Results show the best performing options claim for an actualization and revision of current water use entitlements (31) and the creation of permanent centre for citizen participation (12). "Require guaranteed water provision as a precondition for urban expansion" (23) performs less impact on the baseline for this challenge. Option 9, claiming the use of renewable energy to power water management infrastructure in small towns and scattered houses, does not contribute diminishing the necessity of water treatment, improve hydro-geo-morphological quality nor reducing bulk water cost to a relevant degree.

Besides the direct impacts of the options on individual challenges, there are combined effects when all factors of the map are taken in consideration globally. For example, the strong relationship between water quantity and quality in the FCM enhances the fact that options tackling the first also has a positive effect on the latter. Moreover, all options improving ecosystems, both water and forest related, also strongly improve the factor biodiversity. Actions proposed under the umbrella of awareness rising (19) improve all factors, while an option like "develop river custody agreements" (32) strongly affects factors directly related to river space, but has little effect on other factors.

4.2 Multi-Criteria Analysis

4.2.1 Selected criteria and their preference values

The characteristics of the options (Table 3.2) and the factors from the FCM were considered as criteria for the Multi-Criteria Analysis (MCA). We pre-selected 6 characteristics and 8 factors from the FCM as potential criteria. Out of this list of 14 potential criteria, participants of the 2nd stakeholder workshop selected 12 criteria to be included in the MCA (Figure 4.2). Participants also suggested two additional criteria (*biodiversity and compatibility of land use with water management needs*). These additional criteria, however, could not be used in subsequent steps of the MCA, because their impacts could not be assessed.

On average, the stakeholders assigned the highest preference values to *water quantity* and *water quality*, which relate to challenges A and C, respectively. They assigned a medium preference value to *water uses, hydro-geo-morphological quality* and *external water*, while *wildfire* received fairly low

preference values (4). The stakeholders assigned medium preference values to all the criteria relating to the characteristics of the water management options.

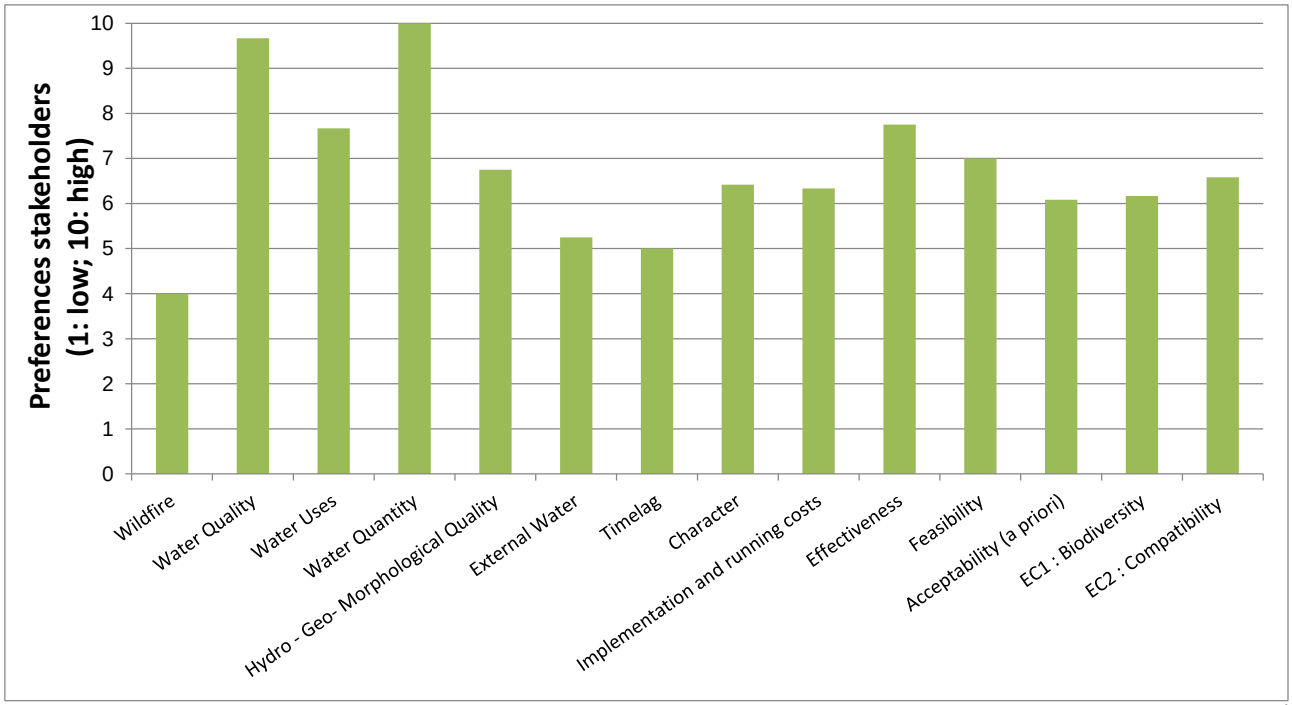


Figure 4.2: selected criteria and average preferences according to the stakeholders in the 2nd workshop. The criteria EC1 and 2 are additional criteria suggested by stakeholders, but they were not used in subsequent steps of the Multi Criteria Analysis.

4.2.2 Performance of the selected criteria

Once participants of the 2nd stakeholder workshop selected the criteria, they were asked to indicate how each criterion should change preferably. We combined this information with the estimated changes and characteristics and show the result in a heat diagram in Figure 4.3.

The heat diagram suggests that in general terms the criteria based on the WMO characteristics add little to the differentiation between options. The differentiation between options is mainly due to criteria derived from the impact assessment of WMOs, using the FCM. The criteria derived from the impact assessment are in many cases in the range from medium to least preferred outcomes, while criteria derived from the characterization are in an overall higher preference state. These results are very much influenced by the results of the impact assessment itself, given that the baseline development reveals the conditions with relation to these criteria are in a least preferred state and there are few options that result in preferred outcomes for one or more of the criteria.

Application of the selected criteria indicates that the most preferred option for almost all the criteria is “Conclude adaptive forest management agreements” (33). The option “Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)” (16) has also very positive outcome for most of the criteria, except for wildfire, as the option does not directly tackle this factor.

Options tackling environmental protection and restoration: “Protect groundwater recharge areas” (28) “Implement environmental flows” (29), “Enhance environmental protected areas“ (22), “Recover wetlands and their connectivity” (24) and “Recover and protect river spaces” (30), all have quite preferred evaluation outcomes, in different degrees with respect to the impact assessment performance. The only differences can be seen for the criterion wildfire, where all are least preferred, and for the character of option 28, being this categorised as supply orientated.

Option 31, “Revise and update water entitlements” is amongst the most preferred but affected by low acceptability and low feasibility because it affects private properties, therefore needing sound legislative reforms and strong political will to be implemented.

Option 17 “Foster selective fishing” and 25 “Eliminate toxic substances used in municipal parks and gardening practices” are the least preferred with regards to the criteria from the impact assessment.

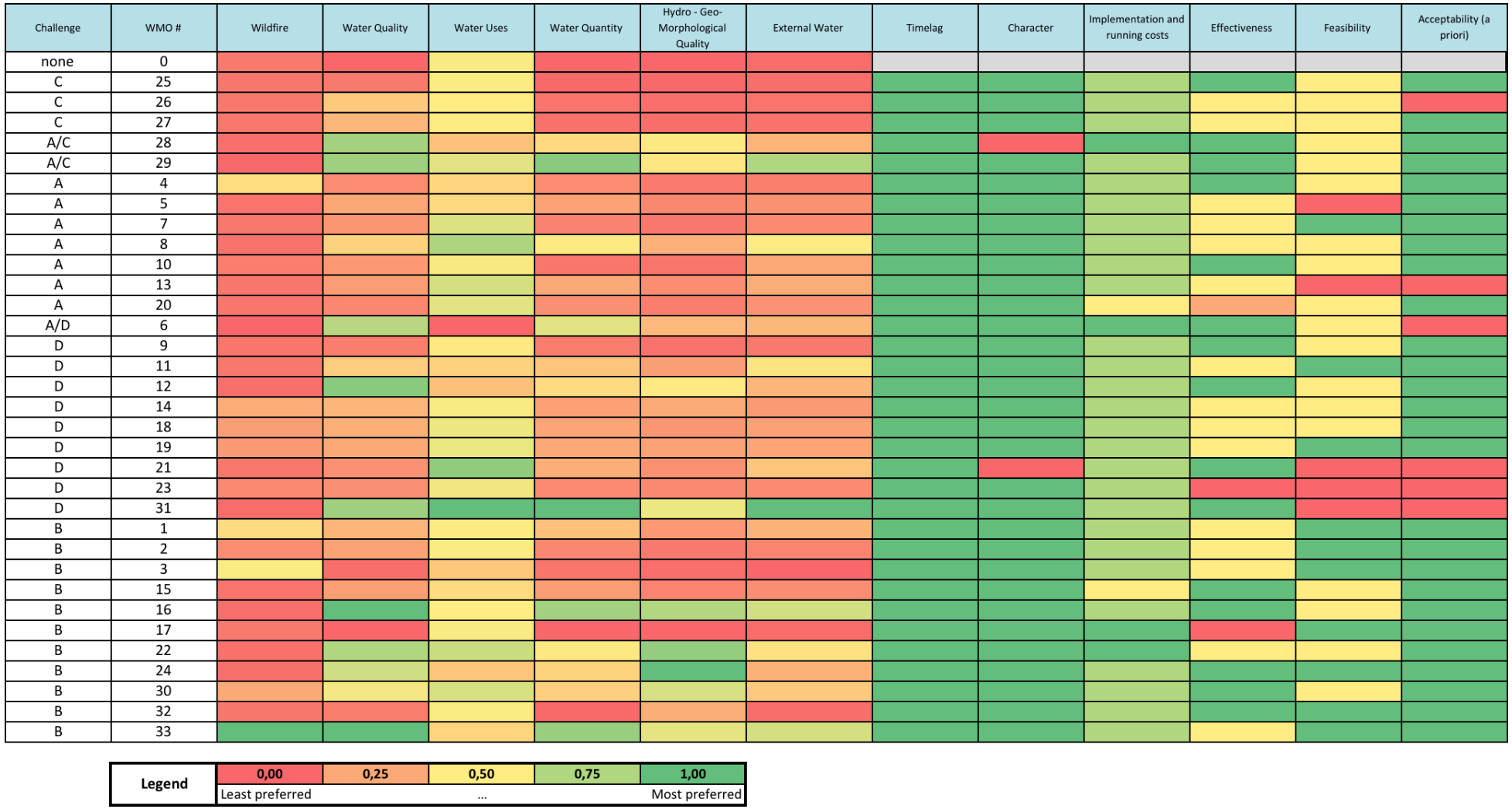


Figure 4.3: Heat diagram showing preferred changes and characteristics of the criteria included in the MCA. Numbers refer to the water management options in Table 3.1**.**

4.2.3 Multi-Criteria Analysis results

To evaluate the water management options, we combined the results of the impact assessment for each water management option, the characterisation of each water management option, the criteria selected by stakeholders and the preferences assigned to them in a Multi Criteria Analysis (MCA). Below, we show three sets of results; in Figure 4.4 we show the outcome based only on criteria derived from the Fuzzy Cognitive Map (and the impact assessment). In Figure 4.5 we show the outcome of the MCA based only on criteria from the characterisation of the options and in Figure 4.6 we show the outcomes of the MCA based on the full set of criteria as selected by participants of stakeholder workshop II.

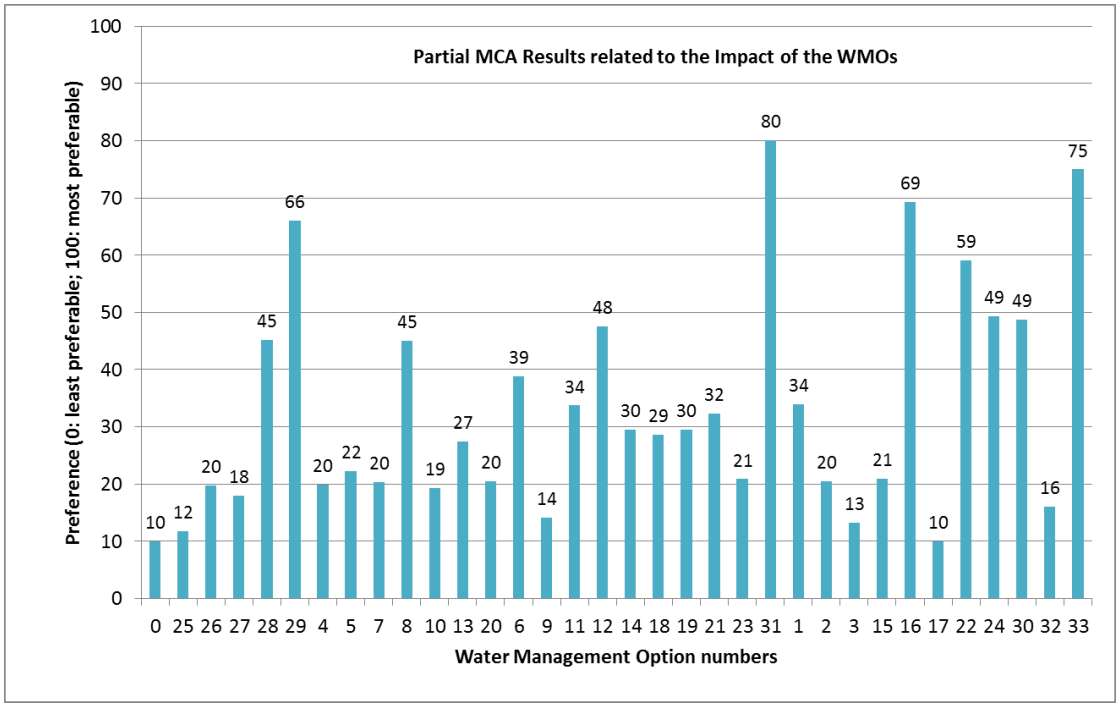


Figure 4.4: outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment. Numbers refer to the water management options in Table 3.1.

The partial MCA results related to the impact of the water management options on the basin's challenges (Figure 4.4) reveals that the highest preference was for "Revise and update water entitlements" (31), given its strong benefits to improve local water quantity and quality, reducing the need to import water from other basins. High preferences (≥50) are assigned to measures related to the recovery of water and forest ecosystems in an integrated manner: "Conclude adaptive forest management agreements" (33), "Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)" (16), followed by "Implement an environmental flow regime" (29) and "Enhance environmental protected areas" (22), "Recover wetlands and their connectivity" (24) and "Recover and protect river space" (30).

Lower preferences (<15) are options: 25, "Eliminate toxic substances used in municipal parks and gardening practices", "Expand the Catalan School for Shepherds in the Tordera basin area" (3) and "Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses" (9), resulting their little effect on selected criteria. Lowest preference results are observed for option 17 related to fostering selective fishing as it only affects biodiversity, a criterion that was suggested by stakeholders, but could not be included in the analysis directly.

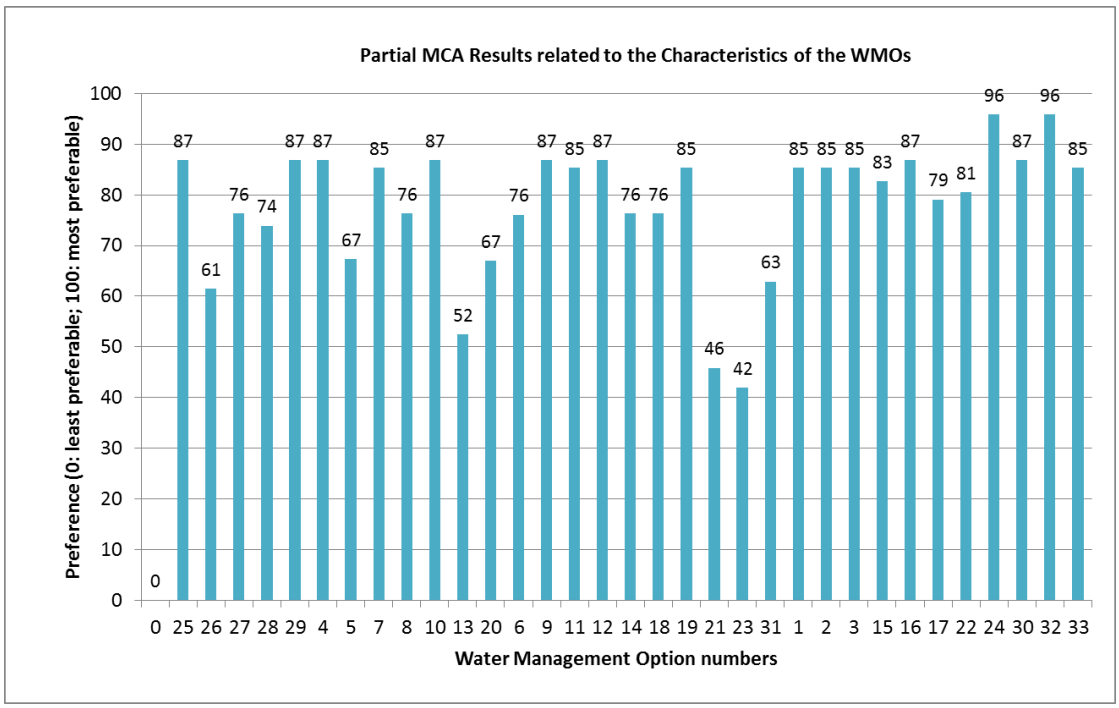


Figure 4.5: outcome of the Multi-Criteria Analysis based on the characterisation of the options. Numbers refer to the water management options in Table 5.1.

The partial MCA results related to the characterization of water management options (Figure 4.5) indicate 26 options score preference values above 70, being 100 the score for most preferred. Only 2 options score below 50: “Integrate adaptation principles into water service provider contracts” (21) and “Require guaranteed water provision as a precondition for urban expansion” (23).

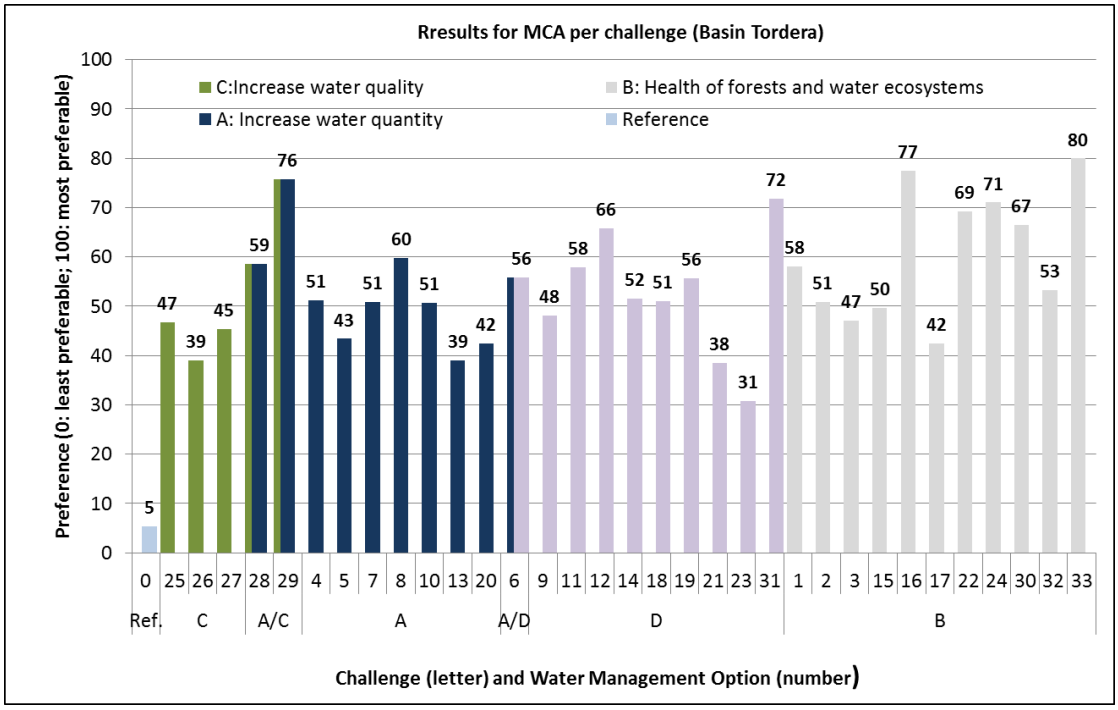


Figure 4.6: outcome of the Multi-Criteria Analysis based on the full set of criteria as selected by participants of stakeholder workshop II. Numbers refer to the water management options in Table 5.1.

The overall outcome of the Multi-Criteria Analysis (Figure 4.6) indicates that the most preferred impacts and characteristics (>70) are: “Conclude adaptive forest management agreements” (33),

“Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)” (16), “Implement an environmental flow regime” (29), “Revise and update water entitlements” (31), “Recover wetlands and their connectivity” (24). All these options perform high scores in partial MCA results based on impact criteria too, except option 24, “Recover wetlands and their connectivity”, which scored lower in the partial MCA results based on impact assessment (49), but in the partial MCA results based on characterization criteria, this option scores amongst the highest (96). Option 31, “Revise and update water entitlements”, has the highest score in the partial MCA results based on impact assessment criteria, but on the total average score this option ranks lower because in the partial MCA results based on characterization criteria it ranks as least preferred under feasibility and acceptability criteria.

The options with the least preferred impacts and characteristics (<40) are: “Require guaranteed water provision as a precondition for urban expansion” (23), “Integrate adaptation principles into water service provider contracts” (21), ”Develop a water traceability label for agriculture products” (13) and “Create a catchment agreement to reduce diffuse pollution“ (26), as the impact assessment based criteria scoring is quite low for all of them, combined with low scores for the characterization based criteria.

Observing results within each set of options tackling the same challenge, positioning of options scores may be interpreted under another perspective. Within the options tacking challenge A (water quantity) “Implement an environmental flow regime” (29) performs the highest score, while “Develop a water traceability label for agriculture products” (13) performs the lowest scores. Within the options tackling challenge B (health of forest and water ecosystems) “Conclude adaptive forest management agreements”(33) scores the highest, while option 17 claiming to “foster selective fishing” performs the lowest scores. Within the options tackling challenge C (water quality) “Protect groundwater recharge areas” (28), scores the highest, while “Create a catchment agreement to reduce diffuse pollution” (26) the lowest. Within the options tackling challenge D (Integrated water management) the highest scores are performed by “Revise and update water entitlements” (31) while the lowest are performed by “Require guaranteed water provision as a precondition for urban expansion” (23).

4.2.4 Sensitivity analysis

We conducted two sensitivity analyses to investigate how the outcomes of the MCA were related to the panel of participating stakeholders and to the list of considered criteria. These analyses provide insight if some options would have received a very different evaluation in the MCA if some stakeholders had not taken part in the evaluation or if one criterion had not been considered. The results are presented in box plots (Figures 4.7 and 4.8), which show the distribution of MCA outcomes when randomly selecting a subset of stakeholders or criteria for 1000 times. The boxes represent the middle 50% of MCA outcomes for each option. The thick line in the middle of each box shows the median value in the distribution of MCA outcomes for a WMO, i.e. half of the MCA outcomes are greater than or equal to this value and half are less.

The sensitivity of the MCA outcomes to the panel of stakeholders is shown in Figure 4.7. Little variation is shown in the MCA outcomes in connection to the stakeholders that participated in stakeholder workshop II. This suggests that the stakeholders that participated in the 2nd stakeholder workshop generally had a high level of agreement with each other with regards to their preferences for different criteria. Two stakeholders had different preferences as they gave less importance to the criteria *time lag* and the *acceptability*. However, these diverging preferences had a limited impact on the outcome of the MCA, since the options had little variability with regards to these two criteria. It should be noted that the results of this sensitivity analysis do not reflect sensitivity of the MCA outcomes to preferences of stakeholders that did not participate in the 2nd stakeholder workshop.

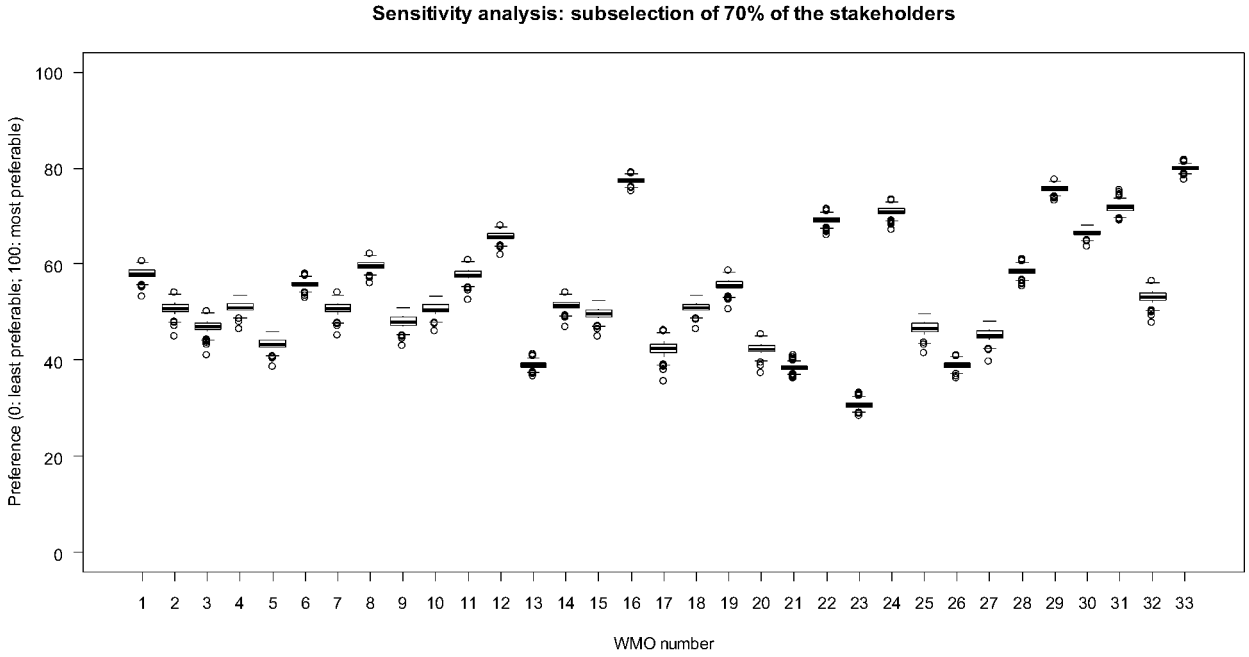


Figure 4.7: sensitivity of the MCA outcomes to the panel of stakeholders by randomly selecting for 1000 times a sub-panel of 70% of the stakeholders. Numbers refer to the water management options in Table 3.1

The sensitivity of the MCA outcomes to the panel of selected criteria is shown in Figure 4.8. In contrast to the sensitivity of the MCA results to the participants of stakeholder workshop II, the MCA outcomes were highly sensitive to the criteria used to evaluate each water management option. The options “Foster selective fishing” (17) and “Develop river custody agreements” (32) are most strongly affected by the selection of criteria, while “Enhance environmental protected areas“ (22), “Implement an environmental flow regime” (29) and “Conclude adaptive forest management agreements” (33) are least strongly affected by the selection of the criteria.

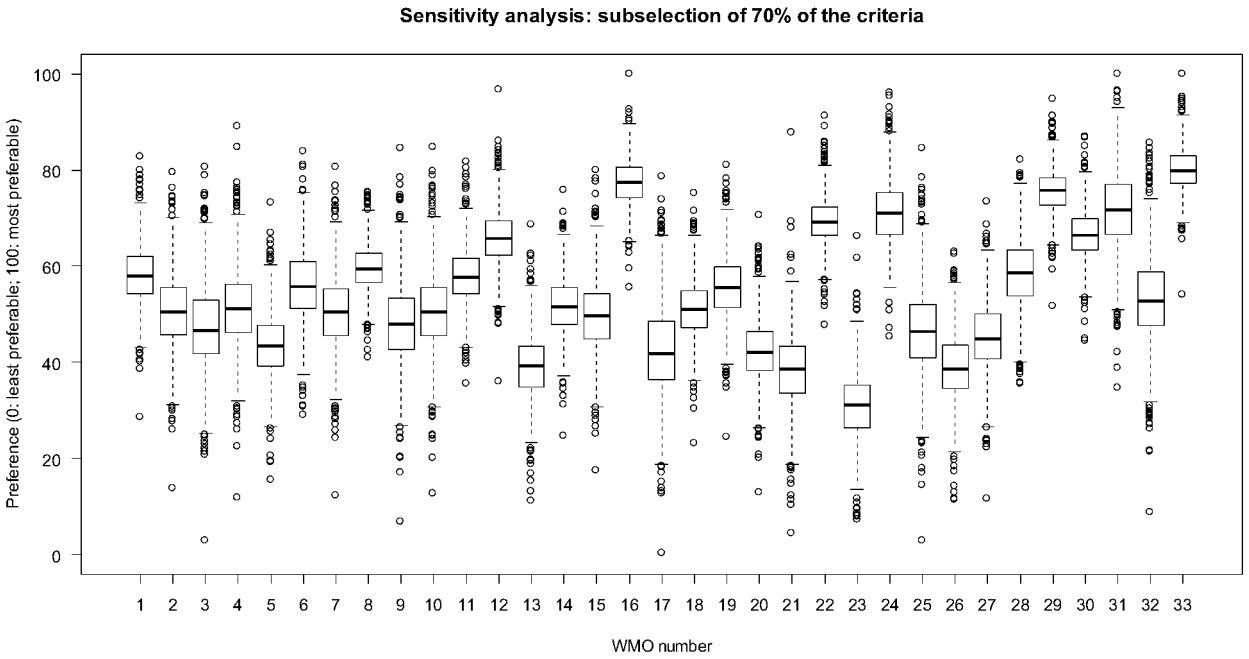


Figure 4.8: sensitivity of the MCA outcomes to the selected criteria randomly selecting for 1000 times a sub-selection of 70% of the criteria. Numbers refer to the water management options in Table 3.1

Among the impacts, *wildfires* and *external water* are criteria that have little influence on the MCA outcomes, while *water quality* and *water quantity* are important impacts to be considered as they have a large influence on the results of the MCA. With regards to the characteristic of the options, *time lag* and the *character* of the options are criteria, which have a strong influence on the MCA outcomes. It should be noted that the results of this sensitivity analysis do not reflect sensitivity of the MCA outcomes to criteria that were not selected by stakeholders during the 2nd stakeholder workshop.

4.3 Cost assessment

A cost assessment was carried out for all options. The results of this assessment are considered to be indicative only, because a detailed assessment for 33 options was not feasible with given resources. Hence, the results of the cost assessment need to be interpreted with care. Uncertainty is likely highest for soft measures, where the capacity of the WMO to tackle challenges depends on social issues (e.g. capacity of the person leading the inter-municipal working group or awareness campaign to make people agree, raise willingness to participate). There are also uncertainties for more technical measures, as the locations, scope of the implementation and impacts on the water fluxes at this stage are not known. Also, in the analysis it was not possible to determine and take into account the reduction in costs caused by natural disasters (droughts, floods, strong winds) in the event that the WMO is not implemented in future (baseline scenario, WMO 0). A more detailed assessment of costs and benefits is required before these options could be implemented.

4.3.1 Costs of water management options

The cost assessment covers the costs of different actions envisaged for implementation of the WMOs. In particular this assessment consists of the inventory of the costs of the different actions that would be needed to implement the proposed option. Both investment cost and running cost have been detected based on estimates referring to information obtained from literature, existing budget assessments from the Catalonian River Basin Management Plan, existing measures previously implemented in the basin or region or expert advice. Values are to be considered illustrative and functional to the comparative analysis of the options objective of this analysis. Costs were assessed for each identified action from year 2018 as a starting point to year 2030 that corresponds to the target in the project. The total cost was estimated as the discounted sum of the expenses for each year. We used a 5% discount rate. Each action with main identified implementation and maintenance costs is described in detail in Annex II.

In Figure 4.9 we show the estimation of total discounted cost in thousand euros for each WMO.

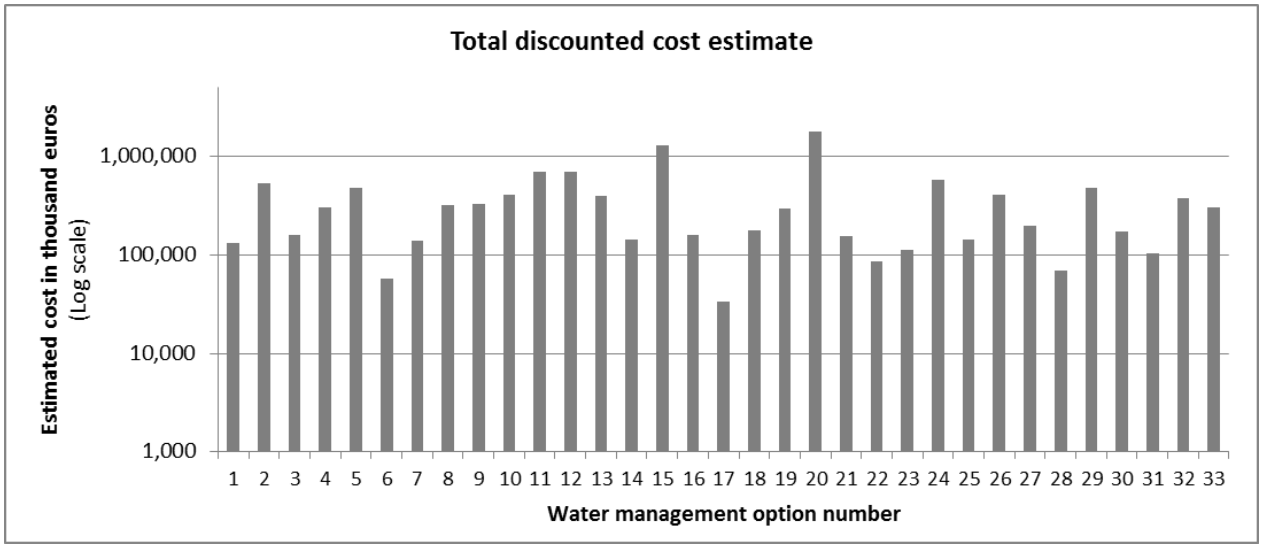


Figure 4.9: Outcome of the long scale cost assessment of each WMO expressed in thousand euros.

In order to clarify how we obtained these results we highlight few options as an example of the considerations to be taken into account when interpreting these figures. Results indicate that the most expensive options are “Promote phytotreatment plants in small municipalities and scattered houses” (15) and “Modernize irrigation techniques” (20). These results should be considered with caution. The cost estimated for option 15 was estimated with more precise reference information regarding the concrete actions proposed, different from other options where this level of detail was not possible to define. For option 20 also high costs are estimated because of high maintenance costs, estimated with reference to current Catalan Government Agriculture Department subventions to the sector for modernizing irrigation infrastructure, but the costs may be different at the time of implementation due to important cost factors such as the price of energy, which are highly uncertain.

Another example is the option “Create a Municipal Adaptation Coordination Board (MACB)” (14), which performs lower costs because of the short time horizon chosen for the action to be implemented. Most likely the consolidation of this coordination board would need a longer time lag and would entail other costs, like a fund to promote coordinated initiatives to face adaptation or expert advice or coordination efforts with other entities, which were currently not included in the estimation.

In the same line, the option proposing to “Create an Integrated Plan for the Protection of the Tordera Delta” (16) is currently designed focusing on the first step to move towards this objective, promoting a participation process to design, plan and create the conditions for the implementation of this Plan. Therefore this cost estimation has to be considered keeping in mind it relates to this concrete action, while the overall objective of implementing the Plan summing single actions this process could entail would probably give rise to the highest costs of this set of water management options.

The cheapest option results “Foster selective fishing” (17), given that it proposes a single action entailing low costs: a publication. “Establish water use entitlement conditions” (6) also has low estimated costs because the option proposes to identify juridical opportunities to improve this management tool and design specific suggestions for the Tordera basin through a focused study. The results of this action will feed in crucial gaps in decision-making processes and entail many implications for water management practices, but the estimation doesn’t include the implementation of the contractual conditionality itself, nor the training and control of the implementation process, as these actions would be developed by the Catalan Water Agency as part of its regular tasks and costs would be revealed on a case to case basis.

On the contrary, cost estimation regarding the option aiming to “Develop a water traceability label for agriculture products” (13) needs to be considered lower than the result in this analysis, given the complexity to account for commercial management required to enhance the adequate added value to the products, highly depending on local market conditions, as well as the capacity of current institutions to provide reliable data to certify the water abstraction entitlement of producers.

4.3.2 Cost-effectiveness

To be able to compare the costs of options with regards to their benefits, we performed cost-effectiveness analysis. The cost-effectiveness analysis combines results of the partial MCA results for the impact assessment (i.e. the characteristics are not considered) and the cost assessment and was calculated for each water management option as the ratio between the cost of implementation and the effectiveness indicator (the difference between the partial MCA results obtained for an option and the partial MCA result related to the baseline). The cost-effectiveness ratio in Figure 4.10; a water management option is highly cost-effective if the price per unit is low.

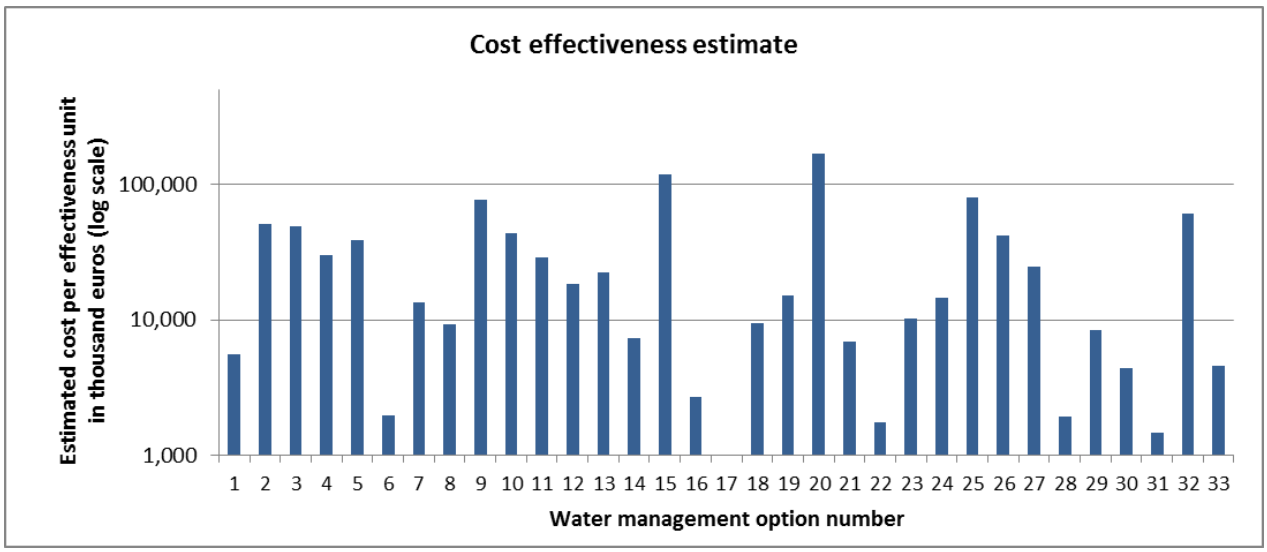


Figure 4.10: Outcomes of the cost effectiveness analysis based on total cost estimation and MCA criteria.

Results of the cost effectiveness analysis indicate expected benefits would largely override estimated costs for some crucial options related to the re-structuring of water use legislation, as well as integrated forms of environmental protection engaging the basin's society: "Establish water use entitlement conditions" (6), "Enhance environmental protected areas" (22), "Revise and update water entitlements." (31) "Protect groundwater recharge areas" (28) and "Create an Integrated Plan for the Protection of the Tordera Delta" (16). However, these results could not be integrated with opportunity costs, such as those related to land expropriation and compensations for lost benefits, as well as investments for actions entailed by the options' implementation process and future development, decreasing the precision of the estimated results. This comment is valid also for "Integrate adaptation principles into water service provider contracts" (21), mainly contemplating the gathering of information needed to promote the adoption of these principles in water service contract design, but not including the administrative costs related to its implementation, which are expected to be significantly high.

Reflecting the main preoccupation of stakeholders, results show the priority given to "Implement an environmental flow regime" (29), although high costs, expected benefits are high.

Of all the set of water management options, "Modernize irrigation technologies" (20) and "Promote phytotreatment plants in small municipalities and scattered houses" (15) deliver the lowest results for each unit of monetary investment. This is probably very much related to the high investment costs described in the previous section.

Options orientated to better information availability and access, like "Centralize and facilitate access to relevant data on the basin water bodies' status and uses" (27), "Foster local use of adaptation-to-global-change indicators (18) and "Create a Municipal Adaptation Coordination Board (MACB)" (14) perform medium efficiency, lacking to reveal the multiplying effect of benefits these kind of actions would entail through better governance.

Option 17 "Forster selective fishing" performs no results, given that it has no influence on the selected criteria.

5. Discussion of results

According to stakeholders consulted in various workshops and events, the main challenges that the Tordera River Basin has to face are water quantity, water quality, health of ecosystems and integrated water management. The general feeling according to consulted stakeholders is that

current monitoring and control on existing plans and programs aiming to recover territorial resilience to global change is insufficient, therefore claiming to strengthen local government and inclusive management practices. We structured these preoccupations in accordance to the identified challenges both in a narrative text as through a graphical tool.

The narrative of the basin expressed through the graphical tool of the FCM, depicts some specific dynamics that are important to take into account. For example, Tordera FCM includes a composition of relationships and weights between the factors “water treatment”, “bulk water cost” and “external water” which indicate a specific water management framework of the Tordera River Basin, but common to any water basin in the world. Indeed, degradation of water quality implies a reduction of water quantity at local level and increased costs of water treatment. Bulk water cost increases accordingly and induces the trend to face growing scarcity by integrating local resources with non-conventional water production, like desalting plants. High bulk water cost affects water supply service operator’s choices, inducing these to increase the quantity of water extracted from local water bodies and/or import water from other rivers, through inter-basin water transfers.

Another example is the weight and relation depicted between forest management and water quantity and quality, reflecting the opinion that thinning and clearing the forests would increase water availability in the basin. Workshop discussions revealed this assumption is not generalized amongst all actors, many of which consider forest management would not deliver water flows to feed in water bodies, but certainly increase forest ecosystem health and its regulatory capacity on local climate. It is worth mentioning that the factor “health of forest” is very strongly related to the factor “wildfire”, as well as to the indicator “biodiversity”, intensifying and multiplying the effects of options tackling the ecological state of forests. These assumptions and dynamics depicted in the FCM have a strong influence on the impact assessment analysis of the different options identified.

The set of options identified seek to answer the basin’s challenges with particular emphasis on an integrated management approach, improved citizen participation to decision-making, policy design and implementation. The vast majority of options are soft measures, indicating that the most important challenge in the basin is to improve inappropriate water management practices and legislation in the face of adaptation to global change. Indeed, participants of the different workshops and consultations suggested measures aiming to optimize focused actions, flexible to adjustments and seeking collaboration between relevant actors and competent authorities, like for example the negotiation of direct agreements, creation of deliberative spaces and fostering improved collaboration between competent authorities.

Overall result of the impact assessment analysis, based on the interaction between the set of water management options and the FCM, indicate options have been linked to challenges, but options not linked to a particular challenge may still help to improve other challenges. This is the especially visible in the case of the challenge “water quality”, where strongest improvements are obtained by the impact of the options “Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)” (16), “Conclude adaptive forest management agreements” (33) (challenge B) and “Create a Permanent Participation Centre » (PPC) (12) (challenge D). In the same line, the option that most improves water quantity is “Revise and update water entitlements.” (31), categorized as challenge (D). Options aiming to increase society’s awareness of the impacts of global change show an overall positive effect on the basin’s baseline development, but especially on forest and water ecosystem health and biodiversity in general. Other crucial factors linked to water availability for uses, like “external water”, “bulk water cost” and “salt intrusion”, are less sensitive to awareness raising, as the inertia to change water use patterns is high.

In order to develop the Multi-Criteria Analysis, participants commented the criteria used as a reference for this exercise. With regards to the character of an option, stakeholders clearly indicated demand management, and environmental protection are better approaches as compared with respect to supply orientated measures, claiming for a water management model that prioritizes self-sufficiency of the basin, taking into account the limits of the water availability of all water bodies, both inside and outside the basins’ boundaries. Participants also remarked the importance of

transparency of information and sound communication in order to better explain interventions developed to enhance adaptation to global change and therefore increase their acceptability.

Total MCA results, obtained by the average preference scoring of all criteria applied, reveal the final evaluation of all options. Results of this evaluation show that options addressing the recovery of ecosystem functionalities have much higher scores than the ones related to changing water and land use patterns. Tordera basin stakeholders are aware societal resilience to global change highly depends on the state and functionality of ecosystems.

During the 2nd stakeholder workshop, preliminary MCA results were presented to the participants. After presenting the results, participants were invited to review and comment on the outcomes. Participants commented the partial results indicating if the preference scores corresponded with their expectations.
These comments are still valid interpreting the final outcome of the MCA as presented in this report. For example, it is interesting to highlight participants commented that flow regimes would be the result of the implementation of many other options tackling water uses and shouldn't be considered as a standalone measure, like its strong link to issues related to water quality and consequences for water use entitlements. Therefore, in order to restore and protect the territory's crucial ecosystems participants called for a different approach between economic development and natural resources management.

Indeed, the strategic protection of groundwater recharge areas and the protection of the river space are considered more important than MCA results show, as well as the importance of the connectivity between ecosystems. In the same line, participants commented options aiming to create a Water User Association (11), a permanent participation centre (12) and a municipal adaptation board (14) which tackle in a complementary way the need for better communication and coordination between citizens and local entities with the central water agency. Governance issues are considered perhaps as the most important issue crucial for all other options to be implemented, as common objectives need to be envisioned by all the basin's actors.

In relation to the option claiming for the "elimination of toxic substances used in Municipal parks and gardening practices" (25) that achieved low scores, participants reflected on the fact the basin's society is not aware of the scale of this problem.

In other cases, options were considered ranking higher than expected, like the case of option 8, "Integrate water saving solutions in construction protocols", where participants considered that benefits would not outbalance the costs. Likewise, the benefits of enhancing recycled water use (7) are affected by normative, technical and economic constraints entailing quite low viability today.

Other options were considered well reflected by the analysis' results, like "Revise and update of water entitlements." (31): general result balances out the fact that the option is characterized by a low feasibility and acceptability, as it affects private water entitlements, thus reducing water availability and the related economic benefit of many of the basin's productive activities. Participants therefore clearly indicate that even if this measure would be politically conflictive and entails the restructuring of water use patterns, it is seen as a key factor reducing the vulnerability to global change of the whole community.

Annex I

Documentation of the Fuzzy Cognitive Map for the Tordera river basin

Table I.1: Definition of the factors in the cognitive map

Number	Factors	Definition
F1	Wildfire	Forest fire
F2	Health of forests	Composition of species, forest structure and functionality.
F3	Extensive/ traditional agriculture land use	Refers to enterprises with a low input exploitation model. Factor refers to land use, water use these activities enhance is considered part of the F6
F4	Biodiversity	Indicates level of biodiversity in all ecosystems
F5	Water quality	Refers to chemical and biological quality of rivers; chemical quality of aquifers.
F6	Water uses	Urban, Tourism, Industry, Agriculture, Bottling are main uses considered.
F7	Intensive agriculture land use	Refers to enterprises with a high input exploitation model. Factor refers to land use, water use these activities enhance is considered part of the F6
F8	Temperature	Temperature of the air
F9	Health of water ecosystems	Quality of wetlands, riparian, in-stream ecosystems
F10	Salt intrusion	Lowering level of freshwater in aquifers entails intrusion of seawater.
F11	Water quantity	Refers to the volumes of water flowing in rivers, the level of aquifers and feed in ratio of all related water bodies.
F12	Hydro - geo- morphological quality	Broad concept, Includes: river space, all forms of connectivity and delta/coastline morphology. This factor includes Sediment flows (mobilization of sand, gravel and all solid components)
F13	Urban expansion	Scattered houses, Camping, Industrial zones and dwelling growth
F14	External water	Refers to all input from no natural sources of the basin: Transferred from other basins or produced through desalinization or reclaiming plants.
F15	Bulk water cost	Refers to the real costs to obtain bulk water
F16	Water treatment	The presence of wastewater treatment facilities, as well as purification plants.
F17	Flood damage	Refers to the impact on people and infrastructure of floods.
F18	Precipitation	Precipitation regime
F19	Population	Refers to both resident and tourist population
F20	WFD	Refers to those management and policy measures implemented to meet WFD objectives
F21	Environmental protection	Refers to all legislation aiming at environmental protection: N2K, PEIN, Parks, etc.

Table I.2: Documentation of the relationships in the cognitive maps

	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21
F1	0	-0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F2	-0.6	0	0	0.6	0	0	0	0	0	0	-0.3	0	0	0	0	0	0	0	0	0	0
F3	-0.3	0.6	0	0.3	-0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F5	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	-0.3	0	0	0	0	0
F6	0	0	0	0	0	0	0	0	0	0	-0.9	0	0	0.3	0	0.6	0	0	0	0	0
F7	-0.3	0	0	-0.3	-0.6	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F8	0.6	-0.3	0	0	0	0.3	0	0	-0.3	0	0	0	0	0	0	0	0	0	0	0	0
F9	0	0	0	0.9	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F10	0	0	0	0	-0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F11	0	0	0	0	0.9	0.3	0	0	0.6	-0.6	0	0.9	0.3	-0.6	0	0	0	0	0	0	0
F12	0	0	0	0	0	0	0	0	0.9	0	0	0	0	0	0	0	-0.3	0	0	0	0
F13	0.3	0	0	0	-0.3	0.6	0	0	0	0	0	-0.6	0	0	0	0	0	0	0	0	0
F14	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.9	0	0	0	0	0	0
F15	0	0	0	0	0	0	0	0	0	0	-0.6	0	0	0	0	0	0	0	0	0	0
F16	0	0	0	0	0.9	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0
F17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
F18	0	0.3	0.3	0	0	0	0.3	0	0.6	0	0.9	0	0	0	0	0	0.6	0	0	0	0
F19	0	0	0.6	0	0	0.6	0.6	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0
F20	0	0	0	0	0.6	0	0	0	0.6	0	0.6	0.6	0	0	0	0	0	0	0	0	0
F21	0	0.9	0	0	0	0	0	0	0.9	0	0	0	-0.9	0	0	0	0	0	0	0	0

Table I.3: Documentation of the reasoning behind the relationships in the cognitive maps

Relationship	Explanation
F1 Wildfire to F2 Health of Forests	Strong negative relation because where forest fires occur, it destroys the whole ecosystem.
F2 Health of Forests *to* F1 Wildfire	Medium negative relation because the structure of forests determinate the conditions for wildfires to occur.
F2 Health of Forests *to* F4 Biodiversity	Medium positive relation because forest ecological quality and functionality are crucial for biodiversity to develop.
F2 Health of Forests *to* F11 Water Quantity	Light negative relation because the level of water consumption of the forest evapotranspiration is influenced by its structure and composition.
F3 Ext. Agric. *To* F1 Wildfire	Light negative relation because extensive agriculture increases quality of land use mosaic and reduces fuel load in forests through livestock grazing.
F3 Ext. Agric. *to* F2 Health of Forests	Medium positive relation because extensive agriculture helps reducing understory vegetation through livestock grazing.
F3 Ext. Agric. *to* F4 Biodiversity	Light positive relation because traditional agricultural practices generate specific ecosystems and may function as ecological niche and corridor.
F3 Ext. Agric. *to* F5 Water Quality	Light negative relation because extensive agriculture uses little pesticides and fertilizers (niche products), uses more adapted crops, has better soil quality and may allow riparian / wetlands to co-exist in plots (bio-depuration).
F2 Health of Ecosystems *to* F1 Wildfire	Medium negative relation because healthy ecosystems the probability of wildfires occurrence, although this is not the only factor involved in prevention conditions.
F2 Health Of Ecosystems *to* F4 Biodiversity	Strong positive relation, as this factor is the main condition for biodiversity to develop.
F2 Health Of Ecosystems *to* F5 Water Quality	Medium positive relation because healthy ecosystems related to water bodies have a strong depurative function until a certain degree of pollution.
F3 Ext. Agric. *to* F6 Water Uses	Light negative relation because extensive agriculture land use is rainfed or supplied by gravity irrigation. The latter consumes much water, but also has very big return rates. In Tordera hydrogeology return rates go directly back to water bodies.
F5 Water Quality *to* F9 Health of Water Ecosystems	Light positive relation because clean water enhances ecosystem health, while pollution may be only partially absorbed by ecosystems.
F5 Water Quality *to* F16 Water Treatment	Light negative relation because purification treatment is less intensive when water quality is higher, but still needed in most cases.
F6 Water Uses *to* F11 Water Quantity	Strong negative relation because Tordera basin suffers strong overexploitation.
F6 Water Uses *to* F14 External Water	Light positive relation because demand is the main impulse for unconventional water production.
F6 Water Uses *to* F16 Water Treatment	Medium positive relation because all uses affect water quality and most wastewater should be treated.
F7 Intensive Agr. *to* F1 Wildfire	Light negative relation because intensive agriculture farming clears the land and contributes to land use mosaic, reducing wildfire fuel.
F7 Intensive Agr. *to* F4 Biodiversity	Light negative relation because intensive agriculture farm practices strongly degrade biodiversity
F7 Intensive Agr. *to* F5 Water Quality	Medium negative relation because intensive farming practices are highly polluting and occupy riparian areas (no buffer strips) increasing direct runoff into rivers
F7 Intensive Agr. *to* F6 Water Uses	Medium positive relation because intensive agriculture has a strong and consolidated demand, in the lower part of the river.
F5 Water Quality *to* F6 Water Uses	Light positive relation because water quality is a limiting factor to water uses, due to high treatment costs. Especially relevant aspect in Tordera.
F5 Water Quality *to* F15 Bulk Water Cost	Light negative relation (actually could be stronger) because salt intrusion and nitrate pollution in groundwater are very costly processes to be developed for drinkwater production.
F8 Temperature *to* F1 Wildfire	Medium positive relation because especially in summer, high temperatures generate the conditions for wildfires to occur.
F8 Temperature *to* F2 Health of Forests	Light negative relation because forest ecosystems suffer from high temperature, even though some species are adapted.

F8 Temperature *to* F6 Water Uses	Light positive relation because agriculture and urban (tourism) water demands increase with high temperature, but this is not valid for bottling plants and industry.
F8 Temperature *to* F9 health of water Ecosystems	Light negative relation because temperature increases evaporation and temperature of the water, but the effect on water ecosystems depends on many factors.
F9 Health of Water Ecosystems *to* F4 Biodiversity	Strong positive relation because water ecosystems highly contribute to quality of biodiversity.
F9 Health of Water Ecosystems *to* F5 Water Quality	Light positive relation because the capacity of water depuration by water ecosystems is constraint to many environmental conditions.
F10 Salt intrusion *to* F5 Water Quality	Light negative relation because the phenomenon is limited to the lower part of the basin. In those areas this is a crucial factor and relationship is strong.
F11 Water Quantity *to* F5 Water Quality	Strong positive relation because quantity determinates water quality at all levels.
F11 Water Quantity *to* F6 Water Uses	Light positive relation because water quantity is a limiting factor to all uses, but the availability of external water may reduce this weight.
F11 Water Quantity *to* F9 Health of Water Ecosystems	Medium positive relation because adequate flow regime is a precondition to ecosystems to exist.
F11 Water Quantity *to* F10 Salt intrusion	Medium negative relation because the phenomenon is limited to the lower part of the basin. In those areas this is a crucial factor and relationship is strong.
F11 Water Quantity *to* F14 External Water	Medium negative relation because Tordera is an overexploited Basin and external water is partially compensating the lack available flows for some uses.
F12 Hydro-Geo-m. *to* F9 Health of Water Ecosystems	Strong positive relation because river morphology is crucial to enhance habitats for the ecosystem to develop
F12 Hydro-Geo-m. *to* F17 Flood Damage	Light negative relation as flood damage to dwellings and people is directly proportional to the quality of river morphology.
F13 Urban Expansion *to* F1 Wildfire	Light positive relation because the more people living in scattered houses or touristic dwellings, the more the risk of wildfire increases
F13 Urban Expansion *to* F5 Water Quality	Light negative relation because the expansion of dwellings also implies more wastewater pollution and most small settlements do not have any treatment facilities.
F13 Urban Expansion *to* F6 Water Uses	Medium positive relation because increased settlements entail increased urban water use.
F13 Urban Expansion *to* F12 Hydro-Geo-m.	Medium negative relation because much urban expansion - especially industrial areas in the middle part of the basin - are positioned in the river space.
F14 External Water *to* F13 Urban expansion	Light positive relation because when there is no water availability for new demands, unconventional water resources are produced.
F14 External Water *to* F 15 Bulk Water Cost	Strong positive relationship, because water desalting and reclaiming plants are costly investments and entail energy consumption.
F 15 Bulk Water Cost *to* F11 Water Quantity	Strong negative relation, as direct catchments from water bodies are cheaper than external water, when bulk water price is high, water service entities will increase direct catchments, reducing the water quantity in water bodies.
F16 Water Treatment *to* F5 Water Quality	Strong positive relation as the presence of water treatment facilities are the main precondition for enhancing water quality.
F16 Water Treatment *to* F 15 Bulk Water Cost	Medium positive relation because water treatment facilities are costly investments and entail energy consumption.
F 18 Precipitation *to* F2 Heath of Forests	Light positive relation because Mediterranean forests ecosystems are sensible to variations in precipitation
F 18 Precipitation *to* F3 Ext. Agric.	Light positive relation because extensive agriculture depends a lot on precipitation but also has more resilience due to the use of native species.
F 18 Precipitation *to* F7 Intensive Agr.	Light positive relation because intensive agricultural practices depend on precipitation, but integrate natural resources with irrigation from regulated water bodies.
F 18 Precipitation *to* F9 Health of Water Ecosystems	Medium positive relation because water related ecosystems are highly dependent on precipitation, especially those in wetlands and smaller streams.
F 18 Precipitation *to* F11 Water Quantity	Strong positive relation because water flows in all water bodies depends on precipitation.

F 18 Precipitation *to* F17 Flood Damage	Medium positive relation because flood intensity is highly related to the intensity of precipitation, although the damage largely depends on the presence of infrastructure and people in the flooding zone.
F19 Population *to* F3 Ext. Agric.	Medium positive relation because extensive agriculture engages a high number of people and food produced is mostly consumed locally.
F19 Population *to* F6 Water Uses	Medium positive relation because this is the direct pressure on urban demand, the most relevant demand in the Basin.
F19 Population *to* F7 Intensive Agr.	Medium positive relation because in the lower part of the basin intensive horticulture is the main agriculture activity and engages many people.
F19 Population *to* F13 Urban Expansion	Medium positive relations because touristic facilities are growing in the basin and so do interregional transport facilities.
F20 WFD *to* F5 Water Quality	Medium positive relation because this legal framework has many actions orientated to directly increase water quality, but it is only partially implemented.
F20 WFD *to* F9 Health of Water Ecosystems	Medium positive relation because this legal framework has many actions orientated to directly increase water related ecosystems, but it is only partially implemented.
F20 WFD *to* F11 Water Quantity	Medium positive relation because this legal framework has many actions orientated to directly increase water flows in rivers and aquifers, but it is only partially implemented.
F20 WFD *to* F12 Hydro-Geo-m.	Medium positive relation because this legal framework has many actions orientated to directly increase Hydro-geo-morphological quality, but it is only partially implemented.
F21 Environmental protection *to* F2 Heath of Forests	Strong positive weight because in Tordera most healthy forests are those with more protection strategies.
F21 Environmental protection *to* F9 Health of Water Ecosystems	Strong positive weight because environmental protection strategies are crucial to avoid complete destruction of Tordera water bodies.
F21 Environmental protection *to* F13 Urban Expansion	Strong negative weight because constructions are prohibited or limited in environmentally protected areas.

Annex II

Detailed descriptions of the water management options for the Tordera river basin

Water Management option 1

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

Challenge(s): Health of forests and water ecosystems

Description

The lack of active forest management entails an increase of the density of plant cover, increasing in this way total forest biomass. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health.

Grazing activities are expected to contribute to a reduction of biomass in forests. In order to facilitate livestock management in the forest, this option includes the building of fences to host the cattle in the forest, beverage and foddering points for cattle, as well as specific agreements on pathways to be used by shepherds to move in the territory.

Reference/Source

- "Sustain extensive livestock" was mentioned in 1st workshop and Hostalric event.
- Indications on the importance of facilities and difficulties to recover livestock farming were highlighted during Interviews with stakeholders involved with these issues.

Implementation in cognitive map

Relationships are changed from:

- Extensive agriculture to Water uses from 1+ (+0.3) to (0.1)

The factor “Livestock grazing “ is added with relationships to:

- Extensive agriculture 1+ (+0.3)
- Intensive agriculture (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- A study will be conducted to identify areas where interventions/grazing would be optimal to obtain the desired effects. This requires 6 person-months of a technician;
- 300 ha of forest will be fenced to host cattle (about 200 km of fence); 80 beverage and foddering points will be established;
- The initial agreement for will require an investment of 6 person-months of a technician;
- The animation of the programme will require 3 person-month of a technician.

Investment made by shepherds (cattle and time as well as maintaining the infrastructures) is not considered since returns on this activity are supposed to compensate for the costs. Therefore, only supporting costs (mandatory to make the sustainable grazing activity economically possible) are considered.

Table 1.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Study to identify strategic areas	limited quantity of person month[2] (6 PM technician) in charge of gathering information on ancient pastures in the forest that should be recovered and new areas to be developed. Natural park authorities already have input material.	**15000**	first years investment (Gradual implementation: first year investment : 10 000, second year 15 000, third year 14 000)
Fences	total 600 Km2 forested area in the basin, the measure would affect 300Ha, plot size 15 Ha each, resulting in 10 km fence +1 km fence extra to optimize. 11 000 Km fence at 3€/m [3]	**33000**	
Beverage / food	20 beverage points at 300 euro each[4]	**6000**	
Total		**39000**	
Agreements	cost of a facilitation process, in order to contact and negotiate with relevant actors. (ex. 6 PM)	**15000**	first year investment
Maintenance	3PM per year to maintain the program	**7500**	running costs

Table 1.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	40,000 €		40,000 €
2019	15,000 €	7,500 €	21,429 €
2020	14,000 €	7,500 €	19,501 €
2021		7,500 €	6,479 €
2022		7,500 €	6,170 €
2023		7,500 €	5,876 €
2024		7,500 €	5,597 €
2025		7,500 €	5,330 €
2026		7,500 €	5,076 €
2027		7,500 €	4,835 €
2028		7,500 €	4,604 €
2029		7,500 €	4,385 €
2030		7,500 €	4,176 €
Total costs in 2018 value			**133,459 €**

[2] Salaries in all options: Technician: 30k€/year; Scientist/professional: 50k€/year; Manager/senior: 70k€/year, PhD student: 99k€/3 years

[3] http://edis.ifas.ufl.edu/pdffiles/AN/AN25800.pdf and http://courses.missouristate.edu/WestonWalker/AGA375_Forages/Forage%20Mgmt/References/1Guides/5Grazing/5FencWater/ISUFm1855Estimatecostlivestockfencing.pdf

[4] http://www.fdasrl.com/department/45/Abbeveratoi-per-stalle-e-soluzioni-antigelo.html

Water Management option 2

Create specific branding for the commercialization of extensive livestock products

Challenge(s): Health of forests and water ecosystems

Description

The lack of active forest management entails an increase of the density of plant cover, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health. In order to contribute consolidating forest management related livestock farms, this option proposes to create an association of producers and therefore increase added value of products, improving visibility and sharing costs for product transformation.

Reference/Source

- "Sustain extensive livestock" was mentioned in 1st workshop. Indications on the importance of the commercialization to recover livestock farming were highlighted during interviews with stakeholders involved with these issues.

Implementation in cognitive map

The factor “Brand of extensive livestock products” is added with relationships to:

- Extensive agriculture (+0.1)
- Water quality (+0.1)
- Intensive agriculture (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- A specific association would be constituted to manage and promote the brand. Current cost estimation could be increased by additional administrative costs, up to a maximum of 15 000 €.
- Running costs include administrative costs, management and branding as well as communication tasks. Cost estimation of commercial actions could also be increased due to local market constrains, but was currently not possible to evaluate with more precision.

Table 2.1: cost elements and cost unit estimation (source: Montseny park interview).

Components of the cost estimation		Cost unit estimation (euro)	Budget structure
Constitute association	administrative costs	**5000**	first year investment
Maintenance	administrative costs of the association	**300**	running costs
	manager of the branding program, full time salary (scientist/professional)	**50 000**	running costs
	communication: website, advertisement, commercial actions	**10 000**	running costs

Table 2.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	5,000 €		5,000 €
2019		60,300 €	57,429 €
2020		60,300 €	54,694 €
2021		60,300 €	52,089 €
2022		60,300 €	49,609 €
2023		60,300 €	47,247 €
2024		60,300 €	44,997 €
2025		60,300 €	42,854 €
2026		60,300 €	40,813 €
2027		60,300 €	38,870 €
2028		60,300 €	37,019 €
2029		60,300 €	35,256 €
2030		60,300 €	33,577 €
Total costs in 2018 value			**539,454 €**

Water Management option 3

Expand the Catalan School for Shepherds in the Tordera basin area

Challenge(s): Health of forests and water ecosystems

Description

The lack of active forest management entails an increase of the density of plant cover, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health. Currently there is an urgent need for generational turnover in the livestock farming sector, therefore this option aims to contribute consolidating the model developed by the Catalan School for Shepard's as to foster new people into the profession. The option proposes to identify farms willing to collaborate with the school and potential new farms to be exploited; teach and encourage sustainable shepherds' activities.

Reference/Source

- "Sustain extensive livestock" was mentioned in 1st workshop and "Settle rural population".
- The success and good practices promoted by the Catalan school for Shepard's was indicated by stakeholders involved with these issues.

Implementation in cognitive map

Relationships are changed from

- Population to Extensive agriculture from 2+ (+0.6) to 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- One-year program by a manager specialized in the sector to create the conditions to extend the number of livestock farmers collaborating with the Catalan school of shepherds project in the Tordera basin area.
- A specialized manager for 3 PM/year dedicates specific follow up to enhance and consolidate the program.
- Communication tasks are not included, given that the network of partners of the shepherds' school would provide these.

Table 3.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
This measure does not have any structural cost, it aims to strengthen and disseminate the opportunities of this project with local entities.	Establish and manage contacts between farms of the basin, natural parks, municipalities and the shepherd school. (ex. 12 PM professional)	**50 000**	first year investment
Maintenance	maintenance of the relationships established 3PM/year professional	**12 500**	Running costs

Table 3.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	50,000 €		50,000 €
2019		12,500 €	11,905 €
2020		12,500 €	11,338 €
2021		12,500 €	10,798 €
2022		12,500 €	10,284 €
2023		12,500 €	9,794 €
2024		12,500 €	9,328 €
2025		12,500 €	8,884 €
2026		12,500 €	8,460 €
2027		12,500 €	8,058 €
2028		12,500 €	7,674 €
2029		12,500 €	7,308 €
2030		12,500 €	6,960 €
Total costs in 2018 value			**160,791 €**

Water Management option 4

Promote rainfed crop production

Challenge(s): Increase water quantity

Description

The expansion and consolidation of irrigated agriculture implies a strong pressure on the water bodies of the basin. Rainfed crops are not sufficiently promoted to become a viable alternative. In order to promote practices aiming at increased economic viability of rainfed crop production, this option proposes to create specific knowledge transfer programs in the framework of Farm Advisory Services, including assistance with crop selection, soil management (structure and fertility), green water management, exploitation design and commercialization of products.

Reference/Source

- "Sustain low water consumption agriculture exploitations" and “Incentives for crop reconversion” were mentioned in 1st workshop
- Interviewed stakeholders indicated challenges related to rainfed crop production.

Implementation in cognitive map

A factor is added with relationships to:

- Enhance rainfed crops to Extensive agriculture 1+ (+0.3)
- Enhance rainfed crops to Intensive agriculture (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Integration with specialized professional advise service by integrating existing Farmers Advisory Service, provided under the Common Agriculture Policy implementation standards, with a half time contract at manager level.
- Combination of communication tools and actions for knowledge transfer to farmers on how to increase economic viability of rainfed crops in the basin.
- Cost estimation includes a publication to disseminate the knowledge acquired to other basins in Catalonia.

Table 4.1: cost elements and cost unit estimation

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Integration of existing FAS program	technical advisor FAS service half time (professional)	**25000**	first year investment & running cost
knowledge transfer program:	publication	**3000**	fifth year investment
	dissemination	**10000**	first year investment
	maintenance	**5000**	running cost

Table 4.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	35,000 €		35,000 €
2019		30,000 €	28,571 €
2020		30,000 €	27,211 €
2021		30,000 €	25,915 €
2022	3,000 €	30,000 €	27,149 €
2023		30,000 €	23,506 €
2024		30,000 €	22,386 €
2025		30,000 €	21,320 €
2026		30,000 €	20,305 €
2027		30,000 €	19,338 €
2028		30,000 €	18,417 €
2029		30,000 €	17,540 €
2030		30,000 €	16,705 €
Total costs in 2018 value			**303,366 €**

Water Management option 5

Revise the Extractions Master Plan

Challenge(s): Increase water quantity

Description

The declaration of over-exploitation of the alluvial aquifer in the central and lower section of the River Tordera through the 2003 edict[5], decreed developing an “Extractions Master Plan” for these water bodies POE, DOGC 11/2/2003).

In the context of this master plan a specific IT management tool was developed that allows to establish an overall water accountability of the basin’s uses in accordance to specific river sections, with the aim to regulate extraction rates.

This option wants to promote:

- Updating of the management tool: increase the quality and scope of data included, increase the level of detail and gathering relevant information that can be available for local entities.
- Amplifying the territorial scope where the tool is used, like for example the Arbúcies and Santa Coloma streams, with the aim to extend the extraction master plan to the whole basin.
- Delegation for the use and maintenance of the IT tool to local entities.

Reference/Source

- Optimize the use and availability of water” and "increase water saving" were mentioned in 1st workshop
- The importance of sound use accounting was mentioned by different stakeholder interviews.

Implementation in cognitive map

Relationships are changed from:

- Water uses to Water quantity from 3- (+0.9) to 2- (-0.6)

Cost estimation:

The cost estimation is based on the assumption that the actual revision process of this master plan would be at the expense of the Catalan Water Agency in its normal functions, while the Tordera River basin Adaptation Plan would complement and consolidate actions towards increased water accounting, through:

- Coordination for data gathering with local entities with the help of a specialized technician to set up a common platform.
- In order to expand the area managed under the conditions of the master plan, juridical advice is needed to set up and develop the negotiations with municipalities from the Arbucies and la Selva region.
- Enable the Water User Association - WMO 11 – to be in charge to use, maintain and update the water accounting tool provided by the Extraction Master Plan.

[5] http://aca-web.gencat.cat/aca/documents/ca/legislacio/edicte/edicte_26092003.pdf

Table 5.1: cost elements and cost unit estimation

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Coordination effort, existing data would be shared between local entities and ACA	12PM IT (technician) to insert data into tool	**30 000**	first year investment
coordination effort, engaging municipalities of these areas and negotiating their participation in the extractions master plan.	2PM juridical work (senior professional) to establish conditions to participate in the master plan	**12 000**	first year investment
	10PM negotiations (professional)	**42 000**	first year investment
coordination effort, would be managed by WUA (measure 11); one person of this association to manage the tool.	tool management part time (6 PM technician)	**15 000**	running cost
	data gathering and fostering the feed in to the program full time (12 PM technician)	**30 000**	running cost

Table 5.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	84,000 €		84,000 €
2019		45,000 €	42,857 €
2020		45,000 €	40,816 €
2021		45,000 €	38,873 €
2022		45,000 €	37,022 €
2023		45,000 €	35,259 €
2024		45,000 €	33,580 €
2025		45,000 €	31,981 €
2026		45,000 €	30,458 €
2027		45,000 €	29,007 €
2028		45,000 €	27,626 €
2029		45,000 €	26,311 €
2030		45,000 €	25,058 €
Total costs in 2018 value			**482,846 €**

Water Management option 6

Establish water use entitlement conditions.

Challenge(s): Increase water quantity/ IWM

Description

Investments in water saving technologies don't deliver the expected results due to the *rebound effect*: saved water is re-invested in production until the entitled volumes are met, therefore savings don't return to water bodies. When public administration awards subsidies to foster water saving practices and decrease the pressure on the environment, specific conditions can be introduced in the entitlement in order to guarantee effective savings. For example: adopting flow limiting devices, adopting complementary environmental protection measures, realizing technological improvements, installing piezometers, increasing the time lag of the entitlement in exchange of a reduction of volumes entitled, etc…

An adequate normative structure exists, but there is the need to amplify, innovate and consolidate the available options that can be used when new conditions are negotiated.

This option wants to promote a participatory process / open debate targeting municipalities, big water users and relevant actors with the aim to:

- Disseminate information about the opportunities to modify/integrate entitlements (existing and new) contemplated in current legal framework;
- Gather experiences from citizens, administration and academia on the effectiveness of the different conditions;
- Design new specific proposals for the Tordera basin.

Reference/Source

- "Revise water use entitlements" and "revise concessions: updated and adjusted to actual use" were mentioned in 1st workshop.
- Importance to revert saved flows into water bodies was remarked by different stakeholder interviews.

Implementation in cognitive map

Relationships are changed from:

- Water uses to Water quantity from 3- (-0.9) to (-0.1)
- Water quantity to Water uses from 1+ (+0.3) to (+0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Material and information production for the participatory process developed by the Catalan Water Agency with professional facilitators.
- Specialized professional advice (technician and manager part time) to structure received information and design concrete proposals for the basin.
- Special communication program to disseminate the results and the lessons learned of the process itself to transfer knowledge to other Catalonian and Spanish basins.

Table 6.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
participatory process 1 year	preparation of material and design of the process by specialized agency (source: ACA interview)	**13000**	first year investment
	technician part time	**15000**	first year investment
	Scientist part time	**25000**	first year investment
total		***53000***	
dissemination of results		**5000**	second year investment

Table 6.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	53,000 €		53,000 €
2019	5,000 €		4,762 €
2020			
2021			
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**57,762 €**

Water Management option 7

Enhance knowledge transfer on irrigation with reclaimed water

Challenge(s): Increase water quantity

Description

Irrigation with reclaimed water is considered a big opportunity to avoid using water of higher quality for crops, but it is crucial to evaluate limitations and opportunities of these solutions in terms of agronomic, infrastructural, energy consumption and managerial parameters, as well as coordination between competent authorities and normative issues.

This option aims to promote:

- The elaboration of a study to evaluate the effectiveness of currently existing irrigation plots reducing the pressure on water bodies in the basin, including an evaluation of the entailed energy consumption, in order to increase the information available on the limitations and opportunities of this projects for the Tordera Basin.
- Realize a knowledge transfer program on the use of regenerated water for irrigation targeting public administration, academia and relevant actors.

Reference/Source

- "Increase water reutilization" was mentioned in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Intensive agriculture to Water uses from 2+ (+0.6) to 1+ (+0.3)
- Water uses to Water treatment from 2+ (+0.6) to 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- Full PhD program student during three years in order to elaborate the information object of a knowledge transfer program
- Development of a knowledge transfer program based on 10 field visits for around 20 people and a publication to report the experience and disseminate the lessons learned.

Table 7.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
irrigation with reclaimed water evaluation study	3 year PhD student (with technical material 26k€)	**126000**	spread over the first 3 years
Knowledge transfer program	10 field trips with demonstrations for an audience of 20 people	**15000**	fourth year investment
	publication	**3000**	fifth year investment
	dissemination	**5000**	fifth year investment

Table 7.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	42,000 €		42,000 €
2019	42,000 €		40,000 €
2020	42,000 €		38,095 €
2021	15,000 €		12,958 €
2022	8,000 €		6,582 €
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**139,634 €**

Water Management option 8

Integrate water saving solutions in construction protocols

Challenge(s): Increase water quantity

Description

Urban water consumption has a significant impact on the basin. Water savings could be maximized in urban and touristic buildings, both if refurbished or new constructions, reducing current water consumption levels.

This option wants to promote:

- Dissemination of good practices in the design of grey installations in buildings.
- A basin specific study aiming at:
  - identifying opportunities for water reutilization in buildings,
  - identifying opportunities and barriers to optimize operation and maintenance conditions for installations,
  - minimize energy consumption for water reutilization installations.
- Revision of management patterns and local normative orientated to support this kind of initiatives.

Reference/Source

- "Increase water saving in buildings" was mentioned in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Population to Water uses from 2+ (+0.6) to 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Preparation of material for dissemination re-editing existing material developed by the Barcelona Council.
- Elaboration of a diagnostic study specific for the Tordera by employing an engineer full time during three years.
- Foster take-up by municipalities through the work of a full time coordinator, moving around the basin to establish pertinent agreements during three years.

Table 8.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
dissemination	re-editing existing material from Diputació	**5000**	first year investment
diagnostic study	engineer full time	**50000**	3 year investment for first 3 years
program for take up by municipalities	coordinator full time (manager)	**70000**	3 year investment starting 2021
	take up	**1000**	running cost (3 years from 2021 to 2023

Table 8.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	55,000 €		55,000 €
2019	50,000 €		47,619 €
2020	50,000 €		45,351 €
2021	70,000 €	1,000 €	61,332 €
2022	70,000 €	1,000 €	58,412 €
2023	70,000 €	1,000 €	55,630 €
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**323,345 €**

Water Management option 9

Promote the use of renewable energy to power water management infrastructure in small towns and scattered houses

Challenge(s): Integrated water management

Description

Disposing of the necessary energy supply for correct functioning of water management infrastructure, like water treatment plants, impulsion and/or pumping, can be problematic in small urbanizations and scattered houses. In these cases, locally produced renewable energy supply could enhance better water management practices.

This option aims to promote:

- Pilot cases on the use of renewable energy in water treatment plants, water heating, impulsion and/or pumping in small towns and scattered houses.
- Dissemination of the information obtained targeting public administration, academia and relevant actors.

Reference/Source

- "Tend towards sustainable energy consumption" and "enhance renewable energy production in the basin" were mentioned in in the 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

- A factor is added with relationships to Renewables in water management to bulk water cost (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Two pilot cases of renewable energy installation to power soft depuration plants proposed in measure 15, developed and designed by a researcher during 3 years.
- Development of a knowledge transfer program and publication on lessons learned after the first 3 years of pilot running.
- Maintenance of the pilot cases is accounted for in the description of option 15.

Table 9.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Two potential pilot cases: Montseny municipality and Park information centre, associated to soft depuration mentioned in measure 15	pilot case renewable energy installation of tertiary wastewater treatment facilities		
pilot case design and development	1 senior researcher	**70000**	first 3 years investment
infrastructure:	typical installation 3 KW cost 6000 euro - 12 000 for two plots[6]	**12000**	first year investment
energy consumption [7]	PILOT 1 = small town 2000 people consuming 100 L/person/day =36 000 litre/year* 2000=72 000 000 litre/year 72000 m3/year* 0,79 = **56 880 kWh** PILOT 2 = Park interpretation centre 100 people 100 L/person/day =36 000 litre/year* 100= 3 600 000 litre/year 3600 m3/year * 0,79 =2844 **Kwh**		
energy cost[8]	0,20 euros /Kwh		
Running costs for plot 1		**11376**	running costs
Running costs for plot 2		**569**	running costs
total for all pilots		***11945***	
Knowledge transfer from pilots	publication	**3000**	4th year investment
	dissemination	**10000**	4th year investment

Table 9.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	82,000 €		82,000 €
2019	70,000 €	11,945 €	78,043 €
2020	70,000 €	11,945 €	74,326 €
2021	13,000 €	11,945 €	21,548 €
2022		11,945 €	9,827 €
2023		11,945 €	9,359 €
2024		11,945 €	8,913 €
2025		11,945 €	8,489 €
2026		11,945 €	8,085 €
2027		11,945 €	7,700 €
2028		11,945 €	7,333 €
2029		11,945 €	6,984 €
2030		11,945 €	6,651 €
Total costs in 2018 value			**329,258 €**

[6] http://energias-renovables-y-limpias.blogspot.com.es/2013/02/como-calcular-tiempo-de-amortizacion-de-una-inversion-en-instalacion-de-energias-renovables.html
[7] http://www.ccbgi.org/docs/publicacions_revistes/Chelsea%20Burns%20water%20energy%20nexus%20report.pdf
[8] http://energias-renovables-y-limpias.blogspot.com.es/2013/02/como-calcular-tiempo-de-amortizacion-de-una-inversion-en-instalacion-de-energias-renovables.html

Water Management option 10

Promote water recycling in production processes

Challenge(s): Increase water quantity

Description

There are different production systems in the basin that have a water consumption pattern that could include closed water recycling systems.

This option aims to promote:

- Concrete pilot cases for industries as a reference for best practices and innovation projects on closed water recycling systems.
- Dissemination of the information obtained targeting public administration, academia and relevant actors.

Reference/Source

- "Increase water saving" and "increase water recycling" were mentioned in the 1st workshop.
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Water uses to Water treatment from 2+ (+0.6) to 3+ (+0.9)
- Water uses to External water from 1+ (+0.3) to (+0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Full PhD program student during three years in order to elaborate the information and engage industries in the initiative.
- Development of a publication reporting lessons learned and dissemination of findings to target audience.

Table 10.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
2 pilot cases: recycling in industry	3 year PhD student	**99000**	spread over the first 3 years
Pilot investment	cost of installations[9]	**80000**	first year investment
total pilot investment for two pilot cases		**160000**	
Pilot maintenance for two pilot cases	10% of investment	**8000**	running cost
total pilot maintenance for two pilot cases		**16000**	
Knowledge transfer from pilots	publication	**2000**	4th year investment
	dissemination	**10000**	4th year investment

Table 10.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	193,000 €		193,000 €
2019	33,000 €	16,000 €	46,667 €
2020	33,000 €	16,000 €	44,444 €
2021	12,000 €	16,000 €	24,187 €
2022		16,000 €	13,163 €
2023		16,000 €	12,536 €
2024		16,000 €	11,939 €
2025		16,000 €	11,371 €
2026		16,000 €	10,829 €
2027		16,000 €	10,314 €
2028		16,000 €	9,823 €
2029		16,000 €	9,355 €
2030		16,000 €	8,909 €
Total costs in 2018 value			406,539 €

[9] http://www.selva.cat/selwa/wp-content/uploads/2007/09/croda_iberica_sa.pdf

Water Management option 11

Create Water User Associations (WUA)

Challenge(s): Integrated water management

Description

Groundwater bodies in the Tordera Basin are over-exploited, given that the level of extractions is superior to the recharge rate. Even if recent figures indicate a positive trend, new forms of governance are needed in order to allow generating a balance between extractions and good status of the water bodies. The creation of a Water User Association was promoted in the past, decreed by the 2003 edict of over-exploitation[10], without success.

This option wants to promote:

- Elaborate a study to evaluate the barriers and opportunities to build a WUA in the Tordera basin, including:
  - Literature review on the role of WUA in adaptive management,
  - Analysis of the history of WUA in Tordera engaging relevant actors,
  - Formulation of proposals to promote a WUA in the Tordera basin.
- Interventions to increase the availability and transparency of information on the extractions in the basin.
- Promotion of a specific deliberative space and decision taking of people/entities that have an entitlement (WUA) in order to:
  - Coordinate and agree on sustainable extraction rates,
  - Manage the IT water management/accounting tool described in option number 5,
  - Monitor and follow up the measures agreed,
  - Behave as an interlocutor between the water authority and local entities.

Reference/Source

- "Build communities of users for joint management", "Favour User associations"
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Water uses to Water quantity from 3- (-0.9) to 2- (-0.6)
- Water uses to External water from 1+ (+0.3) to (+0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Researcher dedication during two years to elaborate the diagnostic study.
- A permanent staff at manager level to run and coordinate the WUA.
- Promotion of the WUA with 4 annual meetings.

[10] http://aca-web.gencat.cat/aca/documents/ca/legislacio/edicte/edicte_26092003.pdf

Table 11.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
study elaboration and design of association	1 researcher	**50000**	first two years investment
implement and maintain association & information gathering	1 professional	**50000**	first year investment & running cost
Constitute association	administrative costs [11]	**1000**	first year investment
Maintenance	administrative costs of the association	**300**	running costs
promotion of the association	4 meetings / year	**10000**	first year investment & running cost

Table 11.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	111,000 €		111,000 €
2019	50,000 €	60,300 €	105,048 €
2020		60,300 €	54,694 €
2021		60,300 €	52,089 €
2022		60,300 €	49,609 €
2023		60,300 €	47,247 €
2024		60,300 €	44,997 €
2025		60,300 €	42,854 €
2026		60,300 €	40,813 €
2027		60,300 €	38,870 €
2028		60,300 €	37,019 €
2029		60,300 €	35,256 €
2030		60,300 €	33,577 €
Total costs in 2018 value			**693,073 €**

[11] ACA interview

Water Management option 12

Create a "Permanent Participation Centre" (PPC)

Challenge(s): Integrated water management

Description

Currently there is a gap between calls for participation established by the WFD implementation calendar for Catalan River Basin Management Plans, developed every 6 years. This disconnection implies citizens are not engaged in flowing up the implementation of measures, don't have access to relevant information in accessible formats and communication is hindered between the territory and public administration.

This option wants to promote:

- The constitution of a "Permanent Participation Centre" with the objective to enhance better conditions for citizens to participate in the design and revision of water policies.
- Create a documentation centre allowing:
  - To promote dissemination of relevant information for the basin,
  - To promote local debate and coordinate citizen's contributions,
  - Inform about the uptake of those contributions,
  - Foster conflict mediation.

Reference/Source

- Mentioned as "guarantee public and participatory management of the basin", "informed and capacitated citizen participation" and "generate mechanisms for territorial participation with Catalan Water Agency" in 1st workshop.
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- WFD to Water quality from 2+ (+0.6) to 3+ (+0.9)
- WFD to Water quantity from 2+ (+0.6) to 3+ (+0.9)
- WFD to Health of water ecosystems from 2+ (+0.6) to 3+ (+0.9)
- WFD to Hydro-morphologic quality from 2+ (+0.6) to 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- Creation of local office where a documentation centre is created and correspondent activities can be developed.
- Specialized professional at manager level to implement and maintain the activities developed at the documentation centre.

Table 12.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
creation of a local office	conditioning of a space	**10000**	first year investment
	office material, dissemination of produced information, organisation of events…	**20000**	running costs
documentation centre	Professional	**50000**	first year investment & running cost

Table 12.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	80,000 €		80,000 €
2019		70,000 €	66,667 €
2020		70,000 €	63,492 €
2021		70,000 €	60,469 €
2022		70,000 €	57,589 €
2023		70,000 €	54,847 €
2024		70,000 €	52,235 €
2025		70,000 €	49,748 €
2026		70,000 €	47,379 €
2027		70,000 €	45,123 €
2028		70,000 €	42,974 €
2029		70,000 €	40,928 €
2030		70,000 €	38,979 €
Total costs in 2018 value			**700,428 €**

Water Management option 13

Develop a water traceability label for agriculture products

Challenge(s): Increase water quantity

Description

For different reasons, like land ownership patterns, exploitation agreements and difficulties constituting irrigation community organizations, many farmers lack formalized water entitlements. These situations entail significant problems for proper water accounting and extraction management, provoking salt intrusion in groundwater bodies of the coastal area.

In order to penalize farmers lacking a proper entitlement, this option proposes to develop a "water traceability label" allowing consumers to recognize and reward producers contributing to the protection of the basin's resources.

Reference/Source

- Mentioned as "All water uses appropriately regulated" in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Extensive agriculture to Water uses from 1+ (+0.3) to (+0.1)
- Intensive agriculture to Water uses from 2+ (+0.6) to 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Creation of the label and pertinent communication tools
- Full time technician engaged to manage and promote the label for commercialization strategy development.

Current cost estimation may be increased by additional costs related to the establishment of the water traceability protocols, where close collaboration and information sharing between competent authorities, local entities and farmers needs to be put in place. These elements were not possible to estimate at this stage.

Table 13.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
creating label	design of the label, administrative costs…	**3 000**	first year investment
promotion & management of the label	technician	**30 000**	first year investment & running costs
Communication	website, advertisement, commercial actions	**10 000**	first year investment & running costs

Table 13.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	43,000 €		43,000 €
2019		40,000 €	38,095 €
2020		40,000 €	36,281 €
2021		40,000 €	34,554 €
2022		40,000 €	32,908 €
2023		40,000 €	31,341 €
2024		40,000 €	29,849 €
2025		40,000 €	28,427 €
2026		40,000 €	27,074 €
2027		40,000 €	25,784 €
2028		40,000 €	24,557 €
2029		40,000 €	23,387 €
2030		40,000 €	22,273 €
Total costs in 2018 value			**397,530 €**

Water Management option 14

Create Municipal Adaptation Coordination Board (MACB)

Challenge(s): Integrated water management

Description

Lack of resources obstacle planning, funding, implementation and monitoring the effectiveness of adaptation to global change policies at municipal level. In order to foster collaboration between Municipalities enhancing the implementation of Municipal adaptation plans and/or adaptation measures, this option proposes the creation of a permanent adaptation board.

Reference/Source

- Mentioned as " increase Municipal coordination" and “Integrated water management” in 1st workshop

Implementation in cognitive map

A factor is added with relationships to:

- Adaptation board to healths of forests (+0.1)
- Adaptation board to health of ecosystems (+0.1)
- Adaptation board to bulk hydro-morphologic quality (+0.1)
- Adaptation board to urban expansion (-0.1)
- Adaptation board to flood damage (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- In order to promote the participation of municipalities to the board, a kick off conference is organized.
- For the duration of the WMO, 4 meetings per year and specific communication material and actions put in place.

The cost estimation does not include any funding for the development of the activities the board may decide to implement as these will be an outcome of the water management option implementation and is currently not possible to estimate.

Table 14.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
promotion of the board	Kick off conference	**5000**	first year investment
	dissemination/invitation/outreach to basin's municipalities	**5000**	first year investment & running costs
	4 meetings per year	**10000**	running costs

Table 14.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	10,000 €		10,000 €
2019		15,000 €	14,286 €
2020		15,000 €	13,605 €
2021		15,000 €	12,958 €
2022		15,000 €	12,341 €
2023		15,000 €	11,753 €
2024		15,000 €	11,193 €
2025		15,000 €	10,660 €
2026		15,000 €	10,153 €
2027		15,000 €	9,669 €
2028		15,000 €	9,209 €
2029		15,000 €	8,770 €
2030		15,000 €	8,353 €
Total costs in 2018 value			**142,949 €**

Water Management option 15

Promote phytotreatment plants in small municipalities and scattered houses

Challenge(s): Increase water quality

Description

Sanitation of wastewater produced by small towns and scattered houses are a significant challenge in the basin. Soft depuration, like artificial wetlands, green filters and similar, can be a valuable option to overcome design and funding problems of adequate water treatment plants, but currently there are few references underpinning the viability of such solutions.

This option aims to promote:

- Pilot cases in small municipalities (< 2000 inh.) and scattered houses in order to potentiate data availability on different examples of soft depuration.
- A specific knowledge transfer program to disseminate information obtained targeting public administration, academia and relevant actors.

Reference/Source

- Mentioned as “enhance soft depuration” in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Water treatment to Bulk water cost from 2+ (+0.6) to (+0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Three pilot cases, established in the upper part of the basin
- 6 years of pilot design and development with support of a researcher and a technician with full time dedication.
- The elaboration of a publication indicating lessons learned and dissemination to enhance the application of soft depuration in similar conditions.

This cost estimation does not include the cost of property of land where soft depuration plants would be installed, as in the current assumption these are already owned by municipalities.

Table 15.1: cost elements and cost unit estimation.

Description	Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Pilot cases Potential cases Montseny municipality, Hotel Santa Fe, Can Casades,	Investment in 3 pilot cases[12]:	surface of wetlands for pilots: 1case 0,3 Ha , 1case 0,5 Ha, 1case 1 Ha =1,7 Ha TOTAL 17 000 m2		
		30 euros/m2 average[13]	**510 000**	first year investment
	Pilot cases last 6 years	technician	**30 000**	six year investment
		researcher	**50 000**	six year investment
Knowledge transfer program	Maintenance for 3 wetlands after pilot	technician	**30 000**	
		material, energy	**10 000**	running cost
	knowledge transfer program:	publication	**3 000**	7th year investment
		dissemination	**10 000**	7th year investment

Table 15.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	590,000 €		590,000 €
2019	80,000 €	40,000 €	114,286 €
2020	80,000 €	40,000 €	108,844 €
2021	80,000 €	40,000 €	103,661 €
2022	80,000 €	40,000 €	98,724 €
2023	80,000 €	40,000 €	94,023 €
2024	13,000 €	40,000 €	39,549 €
2025		40,000 €	28,427 €
2026		40,000 €	27,074 €
2027		40,000 €	25,784 €
2028		40,000 €	24,557 €
2029		40,000 €	23,387 €
2030		40,000 €	22,273 €
Total costs in 2018 value			**1,300,589 €**

[12] Cost of land is 0 as these are already in property of those who would install the plant

[13] http://water.epa.gov/type/wetlands/restore/upload/constructed-wetlands-design-manual.pdf

Water Management option 16

Create an Integrated Plan for the Protection of the Tordera Delta (IPPTD)

Challenge(s): Health of forests and water ecosystems

Description

In order to protect the whole delta area in an integrated manner, this option proposes to enhance a specific process of elaboration of an Integrated Protection Plan. The proposal involves a set of actions to recover sediment dynamics of dunes and beaches, constrain land uses, decrease water extractions, increase depuration and enhance biodiversity protection.

Reference/Source

- Mentioned as “Regulate land use with legal restrictions relevant to river dynamics and to the morphology of the river course and riparian systems”” transversal and coherent policies” in first workshop, as well as “reserve and protection of water in shallow aquifer and water regenerated used by agriculture” ;
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor (“PIP delta Tordera”) is added with relationships to:

- Extensive agriculture (+0.1)
- Intensive land use (-0.3)
- Water quantity (+0.3)
- Hydro-geo-morphologic quality (+0.3)
- Urban expansion (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Cost estimation focuses on the development of a 3-year participation process, with professional facilitation.
- Specialized technician would be hired to design the process and develop the necessary information, as well as a manager to coordinate and promote the process, both with part time dedication.
- One-year communication program to disseminate results.

The cost estimation does not contemplate a fund to implement the actions resulting the participation process, which was not possible to envision today.

Table 16.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
participatory process (three year program)	preparation of material and design of the process by specialized agency (source: ACA interview)	**13000**	first year investment
	technician part time	**15000**	first year investment & running costs
	manager part time	**25000**	first year investment & running costs
total for one year program		**53000**	three year program
dissemination of results		**10000**	4th year investment

Table 16.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	53,000 €		53,000 €
2019	13,000 €	40,000 €	50,476 €
2020	13,000 €	40,000 €	48,073 €
2021	10,000 €		8,638 €
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**160,187 €**

Water Management option 17

Foster selective fishing

Challenge(s): Health of forests and water ecosystems

Description

In order to engage citizens in the protection of the basin's biodiversity and help reducing the pressure of alien species in the river, this option proposes selective fishing programs entailed by fisher associations.

Reference/Source

- Hostalric workshop by fisher association representative.

Implementation in cognitive map

A factor is added with relationships to:

- Selective fishing to Biodiversity 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- The elaboration of a specific fishing guide for the Tordera basin.
- Dissemination of the publication and awareness rising amongst target audience of the key messages.

Table 17.1: cost elements and cost unit estimation.

Action	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
development of guidelines	information gathering and publication	**5 000**	first year investment
adoption of good practices	awareness raising program	**10 000**	first years investments

Table 17.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	15,000 €		15,000 €
2019	10,000 €		9,524 €
2020	10,000 €		9,070 €
2021			
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**33,594 €**

Water Management option 18

Foster local use of adaptation-to-global-change indicators.

Challenge(s): Integrated water management

Description

Global change is a complex challenge and currently is not sufficiently taken into account when building infrastructure and developing interventions in the territory. General indicators have been developed to evaluate the effects of global change[14], but these are not integrated into local decision making processes.

These options aim to promote:

- A study to evaluate the opportunities to adapt existing indicators to the specific reality of the Tordera Basin and identify opportunities to integrate its use in local development decision-making processes.
- Design pilot cases on the application of these indicators in a local vulnerability to global change analysis.
- A specific knowledge transfer program to disseminate information obtained targeting public administration, academia and relevant actors.

Reference/Source

- Mentioned as " reduce impact of infrastructures" in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Adaptation indicators to Extensive agriculture (+0.1)
- Adaptation indicators to Intensive agriculture (-0.1)
- Adaptation indicators to Urban expansion (-0.1)
- Adaptation indicators to Flood damage (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Researcher developing during the first year a diagnostic study
- A three-year PhD program dedicated to design and development of the pilot cases
- Elaboration of a publication and dissemination of the lessons learned.
- Promotion of the uptake of findings at municipal level, employing for 1 person-month a specialized technician of the Catalan office for climate change.

[14] http://canviclimatic.gencat.cat/web/.content/home/actualitat/docs/Doc-Index-complet.pdf

Table 18.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
develop study	Researcher	**50000**	first year investment
design and development of pilot cases	PhD student	**99000**	investment spread over first 3 years
Knowledge transfer from pilots	publication	**3000**	4th year investment
	dissemination	**10000**	4th year investment
uptake	advice from OCCC 1 PM technician	**2500**	running cost

Table 18.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	83,000 €		83,000 €
2019	33,000 €	2,500 €	33,810 €
2020	33,000 €	2,500 €	32,200 €
2021	13,000 €	2,500 €	13,389 €
2022		2,500 €	2,057 €
2023		2,500 €	1,959 €
2024		2,500 €	1,866 €
2025		2,500 €	1,777 €
2026		2,500 €	1,692 €
2027		2,500 €	1,612 €
2028		2,500 €	1,535 €
2029		2,500 €	1,462 €
2030		2,500 €	1,392 €
Total costs in 2018 value			**177,749 €**

Water Management option 19

Awareness raising

Challenge(s): Integrated water management

Description

In order to offer concrete opportunities for people to be involved in the river's protection, this option proposes a set of actions, such as: design specific programs at basin scale for schools and adult education, create environmental pathways, fostering natural heritage, strengthen voluntary services and promote initiatives aiming at diversifying seasonal tourism.

Reference/Source

- Mentioned as "lack of awareness of water scarcity" "environmental education" and "raising awareness", "making tourism aware of the importance of the water cycle" and " nature discovery and education tracks" in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Awareness rising to Health of forests (+0.1)
- Awareness rising to Water uses (-0.1)
- Awareness rising to Hydro-geomorphological quality (+0.1)
- Awareness rising to Flood damage (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- Compilation of existing data to feed in different awareness raising programs.
- Specialized communication work, including the development of pertinent material.
- Elaboration of an APP by employing a technician for 6 person month
- Development of educational pathways along the river areas by employing a technician for 6 person month and developing information panels.
- Development of a specific program "Foster your river" employing a full time technician.
- Increased coordination between existing volunteer programs employing full time technician.
- A conference on adaptation seasonal opportunities for tourism sector 6 person month of a technician to foster the uptake of the proposal that arise and a dissemination program to enhance results to be implemented.

Table 19.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
child education material	compilation of existing and new educational resources for schools	**5000**	first year investment
adult education material	compilation of existing and new educational resources for lifelong learning programs	**5000**	first year investment
Pathways:	identification of missing trails and info design: 6PM technician	**15000**	first year investment
	development of information panels	**5000**	second year investment
	APP design: 6PM technician	**15000**	second year investment &
	APP maintenance	**1000**	running costs
	creation of pathways: 6PM technician	**15000**	second year investment &
	pathway maintenance	**3000**	running costs
	dissemination to promote use of pathways	**5000**	third year investment &
	maintenance of dissemination	**1000**	running costs
program for "foster your river"	design of program, management of collected donations, coordination for the realization of interventions:	**50000**	first year investment & running cost
program to raise volunteers	contact and coordination with volunteer associations	**30000**	first year investment & running cost
diversifying tourism:	one conference to identify opportunities	**5000**	first year investment
	conference for touristic sector	**5000**	first year investment
	engagement of relevant actors from public administration: 6PM technician	**15000**	first year investment
	dissemination of results	**5000**	second year investment &
	maintenance of dissemination	**1000**	running costs

Table 19.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	130,000 €		130,000 €
2019	120,000 €	6,000 €	120,000 €
2020		6,000 €	5,442 €
2021		6,000 €	5,183 €
2022		6,000 €	4,936 €
2023		6,000 €	4,701 €
2024		6,000 €	4,477 €
2025		6,000 €	4,264 €
2026		6,000 €	4,061 €
2027		6,000 €	3,868 €
2028		6,000 €	3,683 €
2029		6,000 €	3,508 €
2030		6,000 €	3,341 €
Total costs in 2018 value			**297,465 €**

Water Management option 20

Modernize irrigation techniques

Challenge(s): Increase water quantity

Description

In order to optimize water use by agriculture sector, this option proposes to install pressurized irrigation devices or refurbish gravity irrigation systems in accordance with option 5 on entitlement conditions and option 6 on the basin water accounting tool.

Reference/Source

- Mentioned as “Modernization of uses” and “bring on board management measures to optimize the use and availability of water in the basin”, “encourage infrastructure improvement for irrigation structures”
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Intensive agriculture to Water uses from 2+ (+0.6) to 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- The water management option targets 25% of current irrigation area potentially to be modernized (156 Ha)
- Investment and running cost are estimated taking as a reference existing subventions to the sector in Catalonia.

Table 20.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Diagnosis of irrigation efficiency at basin level and identification of potential plots for refurbishment of their practices can be done in cooperation with new RDP program of DAAAM	Total irrigated surface potentially to be modernized is currently 624 Ha. 25% would be 156 Ha [15]		
Investment	investment cost estimated 2500 euro/ha[16]	**390000**	first year investment
Maintenance	1000 euro/ha/year[17]	**156000**	running costs

Table 20.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	390,000 €		390,000 €
2019		156,000 €	148,571 €
2020		156,000 €	141,497 €
2021		156,000 €	134,759 €
2022		156,000 €	128,342 €
2023		156,000 €	122,230 €
2024		156,000 €	116,410 €
2025		156,000 €	110,866 €
2026		156,000 €	105,587 €
2027		156,000 €	100,559 €
2028		156,000 €	95,770 €
2029		156,000 €	91,210 €
2030		156,000 €	86,867 €
Total costs in 2018 value			**1,772,667 €**

[15] Link to potentially irrigated surface http://www.idescat.cat/pub/?id=censag&n=5084&geo=mun:082845

[16] http://www.selva.cat/selwa/wp-content/uploads/2007/09/vivers_planas_pubol.pdf

[17] link to subventions asked for modernization this year: http://www.elpuntavui.cat/article/-/18-economia/68380-la-jarc-planteja-ajuts-de-fins-a-6000-euros-per-hectarea-per-modernitzar-les-explotacions-de-fruita-seca.html?tmpl=component&print=1&page=

Water Management option 21

Integrate adaptation principles into water service provider contracts

Challenge(s): Integrated water management

Description

Currently water service provider contracts handed out by public administration to private companies include binding conditions on sources entitled, quantities allowed to extract and have very long duration. In case any variation is needed on these contractual conditions, companies would have the right to claim refunding equal to lost benefits. Under the predicted global change conditions for Catalonia it is crucial to dispose of the needed water management and exploitation regime flexibility to allow the protection of general interest.

This option aims to promote:

- A study on the opportunities to integrate adaptation to global change principles into current juridical framework regulating externalization of water provision services.
- Dissemination of the results of the study with a specific knowledge transfer program targeting relevant actors.

Reference/Source

- Mentioned as "guarantee public and participatory management of the basin" in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Integrate service contracts to Bulk water cost 1+ (+0.3)
- Integrate service contracts to Water uses 1- (-0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Three year full time research program
- Publication and dissemination of results to target audience at the end of the research program.

Table 21.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
study	1 researcher: three year program	**50000**	first year investment
knowledge transfer program:	publication	**3000**	third year investment
	dissemination	**10000**	third year investment

Table 21.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	50,000 €		50,000 €
2019	50,000 €		47,619 €
2020	50,000 €		45,351 €
2021	13,000 €		11,230 €
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**154,200 €**

Water Management option 22

Enhance environmental protected areas

Challenge(s): Health of forests and water ecosystems

Description

The Tordera basin is characterized by special habitat richness, but territorial development and related infrastructures have fragmented strategic areas for many species, reducing its mobility. This option wants to promote:

- A participatory process with relevant actors with the aim to revise the current cartography of protected areas and integrate strategic ecologic corridors to connect terrestrial ecosystems.
- Gather results obtained aiming at establishing adequate forms of environmental protection in the identified areas (new and existing).

Reference/Source

- Mentioned as “Guarantee environmental functions of river networks" “Recovery of basin specific habitats” in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Increase protection to Health of forests (+0.1)
- Increase protection to Intensive agriculture 1- (-0.3)
- Increase protection to Hydro-geomorphological quality 2+ (+0.6)
- Increase protection to Urban expansion (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- One-year participation process with professional facilitation and design by employing a technician, half time.
- Design and maintenance of the process by employing a specialized manager, half time.
- Elaboration of communication material and dissemination activities.
- Uptake of produced information fostered by employing a technician, full time.

Table 22.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
participatory process 1 year	preparation of material and design of the process by specialized agency (ref. ACA interview)	**13000**	first year investment
	technician part time	**15000**	first year investment
	manager part time	**25000**	first year investment
Total		***53000***	
dissemination of results		**5000**	second year investment
uptake - negotiation	technician full time	**30000**	second year investment

Table 22.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	53,000 €		53,000 €
2019	35,000 €		33,333 €
2020			
2021			
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**86,333 €**

Water Management option 23

Require guaranteed water provision as a precondition for urban expansion

Challenge(s): Integrated water management

Description

Urban expansion entails a significant challenge for local authorities to warrant adequate water supply service. Current legislation decrees water authorities should elaborate a viability report evaluating the water supply and sanitation provision for new buildings, but its results are not binding. This condition causes the construction of buildings without water supply guarantee, boosting new water demand based on *fait accompli* policies.

This option aims to promote:

- A specific program targeting municipalities evaluating:
  - The level of water supply provision guarantee of new urban planning,
  - Limitations and opportunities for a better supply guarantee,
  - Availability of legal tools to reduce pressure on water bodies by urban expansion.
- Dissemination of the results of the study with a specific knowledge transfer program targeting public administration, academia and relevant actors.

Reference/Source

- Mentioned as " increase IBI tax on scattered houses" in 1st workshop

Implementation in cognitive map

A factor is added with relationships to:

- Water supply warrant to Urban expansion (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- One-year full time researcher program to design proposals
- One-year juridical advice from water agency staff dedicated to the program
- Elaboration of a publication and dissemination of results to target audience

Table 23.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
evaluate juridical opportunities	person from legal department in ACA	**50 000**	first year investment
	1 researcher	**50 000**	first year investment
total 1 year program		**100 000**	
knowledge transfer program:	publication	**2 000**	second year investment
	dissemination	**10 000**	second year investment

Table 23.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	100,000 €		100,000 €
2019	12,000 €		11,429 €
2020			
2021			
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**111,429 €**

Water Management option 24

Recover wetlands and their connectivity

Challenge(s): Health of forests and water ecosystems

Description

In different areas of the basin wetlands are degraded – inter alia – because of lacking hydrologic connectivity with related aquifers. Its recovery is also crucial to maintain adequate habitats for many species.

This option aims to promote:

- Strategic pilot cases aiming to
  - test different ways to optimize ecologic and hydrologic functionality of water bodies recovering their connectivity.
  - Analyse appropriate indicators for the Tordera basin to evaluate the ecologic status of wetlands.
- Dissemination of the results of the study with a specific knowledge transfer program targeting public administration, academia and relevant actors.

Reference/Source

- Mentioned as “Guarantee environmental functions of river networks" “Recovery of basin specific habitats” in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Wetland recovery to Water quantity 1+ (+0.3)
- Wetland recovery to Hydro-geomorphological quality 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- Development of 3 pilot cases, employing a full time technician and researcher for a 6-year period for design and implementation.
- Three-year lasting dissemination program.

Table 24.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
design and implementation of 3 pilot cases - program lasting 6 years	technician of ACA	**30 000**	first year investment & running cost
	researcher	**50 000**	first year investment & running cost
total per year 3 pilot cases (6 years)		**80 000**	
control of extractions	control of extractions in Bancells wetlands in the same basin is budgeted 2 500 euro in RBMP[18]	**2500**	first year investment one pilot
recovery of water body connectivity	studies on hydrologic functionality of wetlands is budgeted 80 000 for all 17 Catalonian Basins	**4706**	first year investment one pilot
total investment costs	5000 + (2500*3)	**12500**	
Maintenance	custody agreements for wetlands (maintenance) (150 000/17)= 88 235 euros for the basin. We suppose 3 pilots to be maintained after pilot with 5000 each	**15 000**	running cost starting 7th year
dissemination		**10 000**	8th year investment
maintenance of dissemination program	1000 *3	**3000**	running cost starting second year

Table 24.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	92,500 €		92,500 €
2019	80,000 €	3,000 €	79,048 €
2020	80,000 €	3,000 €	75,283 €
2021	80,000 €	3,000 €	71,699 €
2022	80,000 €	3,000 €	68,284 €
2023	80,000 €	3,000 €	65,033 €
2024	80,000 €	3,000 €	61,936 €
2025	10,000 €	15,000 €	17,767 €
2026		15,000 €	10,153 €
2027		15,000 €	9,669 €
2028		15,000 €	9,209 €
2029		15,000 €	8,770 €
2030		15,000 €	8,353 €
Total costs in 2018 value			**577,703 €**

[18] http://aca-web.gencat.cat/aca/appmanager/aca/aca?_nfpb=true&_pageLabel=P46600176421381934582085

Water Management option 25

Eliminate toxic substances used in municipal parks and gardening practices

Challenge(s): Increase water quality

Description

In different areas of the basin, Municipal Park and gardening maintenance protocols use water-polluting substances entailing health risks. In particular, the highly toxic component glyphosate is generally used in municipal playgrounds, provoking serious citizen concerns.

This option aims to:

- Develop a guide indicating alternative products and best practices that allow avoiding the use of agro-toxic substances for gardening purposes.
- Disseminate the guide to general public.
- Foster a compromise signed by the basin's municipalities to adopt the advice contained in the guide.

Reference/Source

- Mentioned as "reduce pollution" in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Intensive agriculture to Water quality from 2- (-0.6) to (-0.1)
- Urban expansion to Water quality from 1- (-0.3) to (-0.1)

Cost estimation:

The cost estimation is based on the following assumptions:

- One year research full time program for the development of a guide to substitute currently used agro-toxic substances
- 3 person months for a technician to enhance municipalities to change management practices with new products.
- Elaboration of a publication and a specific dissemination program

Table 25.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
guide content development	Study and guidelines	**75000**	spread over 1,5 years
Knowledge transfer	publication	**2000**	second year investment
	dissemination	**5000**	second year investment
additional maintenance costs in the parks	3PM technitian	**7500**	running costs

Table 25.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	50,000 €		50,000 €
2019	32,000 €	3,750 €	34,048 €
2020		7,500 €	6,803 €
2021		7,500 €	6,479 €
2022		7,500 €	6,170 €
2023		7,500 €	5,876 €
2024		7,500 €	5,597 €
2025		7,500 €	5,330 €
2026		7,500 €	5,076 €
2027		7,500 €	4,835 €
2028		7,500 €	4,604 €
2029		7,500 €	4,385 €
2030		7,500 €	4,176 €
Total costs in 2018 value			**143,379 €**

Water Management option 26

Create a catchment agreement to reduce diffuse pollution

Challenge(s): Increase water quality

Description

Diffuse pollution caused by crop fertilization is a relevant challenge for water quality in the basin entailing an important environmental degradation and high drinkwater purification costs. The lack of co-responsibility between sectors to increase water quality implies continuous environmental degradation and urban users carrying most of the economic burden for needed water treatments. This option aims to engage both the agriculture sector and urban water users in recovering water quality through a specific agreement that would allow changing to a lower impact production pattern.

Reference/Source

- Mentioned as “reduce pollution” in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- Intensive agriculture to Water quality from 2- (-0.6) to (-0.1)
- Urban expansion to Water quality from 1- (-0.3) to (-0.1)
- WDF to Water quality from 2+ (+0.6) to 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- During the first year of implementation, the agreement protocol is designed employing for the duration of one year a full time researcher and a technician from the agriculture department and one from the water agency who would operate in collaboration.
- 2 person-month of specific juridical advice for the negotiation process.
- Maintenance of the agreement employing a full time technician.
- Dissemination program to inform society about the process.
- Revision of the process and agreement at 6 year from first implementation.

Table 26.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
agreement protocol design	1 researcher	**50000**	first year investment
	1 technician of ACA	**30000**	first year investment
	1 technician of DAAAM	**30000**	first year investment
total one year program		**110000**	
negotiation process	juridical consultancy	**10000**	first year investment
maintenance of the protocol	1 technician (monitoring)	**30000**	running cost
Knowledge transfer	publication	**3000**	second year investment
	dissemination	**10000**	second year investment
revision of the program		**15000**	6th year investment

Table 26.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	120,000 €		120,000 €
2019	13,000 €	30,000 €	40,952 €
2020		30,000 €	27,211 €
2021		30,000 €	25,915 €
2022		30,000 €	24,681 €
2023	15,000 €	30,000 €	35,259 €
2024		30,000 €	22,386 €
2025		30,000 €	21,320 €
2026		30,000 €	20,305 €
2027		30,000 €	19,338 €
2028		30,000 €	18,417 €
2029		30,000 €	17,540 €
2030		30,000 €	16,705 €
Total costs in 2018 value			**410,031 €**

Water Management option 27

Centralize and facilitate access to relevant data on the basin water bodies' status and uses.

Challenge(s): Increase water quality

Description

Different relevant data series exist about the Tordera basin elaborated by different entities monitoring the river's conditions, like public authorities, NGOs or research projects. BeWater project detected that the basin's actors often are not informed about the nature, scope, update and publication access of these figures, and consultancy is hindered by publication format. This option aims to promote the creation of a webpage were all relevant information concerning the Tordera River basin produced by public authorities, NGOs or research projects is published in an accessible format.

Reference/Source

- Mentioned as "increase monitoring by all actors" in 1st workshop

Implementation in cognitive map

A factor is added with relationships to:

- Publish water quality data to Water quality 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Full time employed technician in order to gather existing information and formulate this in accordance with website and dissemination necessities.
- 2 person-month technician dedicated to maintain the webpage for the rest the duration of the program.

Table 27.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
contact entities, gather information and develop the website	Technician (12 PM)	**30 000**	first year investment & running cost
Knowledge transfer	publication	**3 000**	third year investment
	dissemination	**5 000**	first year investment & running cost
maintenance of the site (update of the content and infrastructure)	Technician (2 PM)	**15000**	
	web	**3000**	

Table 27.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	35,000 €		35,000 €
2019		18,000 €	17,143 €
2020	3,000 €	18,000 €	19,048 €
2021		18,000 €	15,549 €
2022		18,000 €	14,809 €
2023		18,000 €	14,103 €
2024		18,000 €	13,432 €
2025		18,000 €	12,792 €
2026		18,000 €	12,183 €
2027		18,000 €	11,603 €
2028		18,000 €	11,050 €
2029		18,000 €	10,524 €
2030		18,000 €	10,023 €
Total costs in 2018 value			**197,260 €**

Water Management option 28

Protect groundwater recharge areas

Challenge(s): Increase water quantity and quality

Description

Current legislation provides specific protection of catchment areas around drink-water wells, but in the basin there are different specific areas where rainwater infiltrates in the subsoil and recharges aquifers. Often these areas are not taken into account in zone planning, positioning infrastructure, industrial areas, parking, fuel stations, etc. in these sensible areas. This option aims to integrate Municipal zone planning protocols with special protection measures, based on existing groundwater cartography, and aiming to avoid the degradation of strategic recharge areas in the territory.

Reference/Source

- Mentioned as ”aquifer control” in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Groundwater recharge protection to Water quantity 1+ (+0.3)
- Groundwater recharge protection to Water quality 1+ (+0.3)
- Groundwater recharge protection to Hydro-geomorphological quality 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Specific communication program to enhance administrative and normative coordination.
- A fund to provide resources for the implementation of protection zones.
- Organization of a conference to evaluate if the program has been successful.

This cost estimation did not include the opportunity costs of land where groundwater recharge areas to protect are identified.

Table 28.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
coordination effort between ACA and municipalities	awareness raising/uptake program for municipalities of the basin.	**10000**	first year investment
Instituting protection programs	Fund	**50000**	first year investment
consolidation of the initiative	conference with monitoring results	**10000**	4th year investment

Table 28.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	60,000 €		60,000 €
2019			
2020			
2021	10,000 €		8,638 €
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			
Total costs in 2018 value			**68,638 €**

Water Management option 29

Implement an environmental flow regime

Challenge(s): Increase water quantity and quality

Description

The River Tordera has a torrential flow regime and is characterized by high hydrological variability. Moreover water demand pressures obstacle the implementation of an environmental flow regime in coherence with its ecological necessities. This option aims to promote actions along the river focussed on recovering flows, taking into account different possibilities of intervention:

- Elimination of direct catchments in the high river section (farmers, scattered houses…)
- Elimination of in stream barriers (Montclùs, Santa Fe and other dam permeability)
- Interventions for better catchment efficiency
- Flow limiting and peak flow control devices in catchment points
- Refurbishment of gauging stations
- Creation of regulation ponds for irrigation systems
- Increased coordination between relevant public administration
- Calibration between local and regional supply systems
- Enforcement of public hydraulic domain regulation

Reference/Source

- Mentioned as ”Maintain environmental flows” and as “ recover stream flow” and “recover natural flow regime in 1st workshop.
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Environmental flow regime to Water uses 1- (-0.3)
- Environmental flow regime to Water quantity 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Implementation of combined measures for environmental flow regime restoration as planned in the Catalan River Basin Management Plan currently in place, including compensation costs for hydropower plants and other users as well as a negotiation process on water title adjustments needed.
- Better water efficiency at catchment level through technological adaptation
- Monitoring and control of implementation by 1 person-month technician for the whole period.

Table 29.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
negotiation of entitlements	RBMP indicates 500 000 support on negotiation for 17 basins in Catalonia [19]	**29412**	first year investment
refund lost benefit of the 3 hydropower plants in Tordera (> 250 KW)	123 118 euro budget[20]	**123118**	first year investment
for tech adaptation of infrastructure	RBMP indicates 8 000 000 for 17 basins in Catalonia. estimation assigns total 300 000 (100 000 per hydroplant)	**300000**	first year investment
total investment		**452530**	
monitor the implementation	technician 1PM	**2500**	running cost

Table 29.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	452,530 €		452,530 €
2019		2,500 €	2,381 €
2020		2,500 €	2,268 €
2021		2,500 €	2,160 €
2022		2,500 €	2,057 €
2023		2,500 €	1,959 €
2024		2,500 €	1,866 €
2025		2,500 €	1,777 €
2026		2,500 €	1,692 €
2027		2,500 €	1,612 €
2028		2,500 €	1,535 €
2029		2,500 €	1,462 €
2030		2,500 €	1,392 €
Total costs in 2018 value			**474,688 €**

[19] http://aca-web.gencat.cat/aca/appmanager/aca/aca?_nfpb=true&_pageLabel=P46600176421381934582085

[20] http://aca-web.gencat.cat/aca/documents/ca/aigua_medi/cabals_manteniment/Documentacio_Tecnica_es_Cab_Mant.pdf

Water Management option 30

Recover and protect river space

Challenge(s): Health of Forests and water ecosystems

Description

The presence of a high quantity of infrastructures in the basin implies the necessity to protect and recover river spaces in coherence with its strategic ecologic and hydraulic functionality in the territory. This option aims to promote:

- The protection of concrete areas with high strategic value, like for example:
  - The river section called “La Ferreria”
  - Most important flooding zones in the central and lower sections of the basin
  - Headwaters
- The creation of river sections declared as “River Reserve”

Reference/Source

- Mentioned as “increase and restore the river space” and ”recover riparian vegetation” in 1st workshop.
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- River space protection to Hydro-geomorphological quality 1+ (+0.3)
- River space protection to Urban expansion 1- (-0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Two technicians and one engineer half time employed to identify areas with high strategic value.
- Fund for restoration and protection of identified areas.
- Identification and establishment of a specific “River Reserve” in upstream sections of the basin employing 6 person-months researcher program and a full time technician during one year for the formalization and implementation of reserve protocols.
- Maintenance of the River Reserve employing 1 person- month technician during whole period of the program.
- Organization of a conference to evaluate and disseminate results of the actions.
- Publication of a brochure on the experience.

Table 30.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
coordination effort between public administration (ACA, Municipalities and local entities)	2 technicians part time 6PM	**12 500**	first year investment
	1 engineer part time 6PM	**15 000**	first year investment
projects in the areas to protect	Fund for project calls	**50 000**	first year investment
total		**77500**	
identify areas of interest to declare as "river reserve"	1 researcher 6 PM	**25 000**	first year investment
formalisation	1 technician of ACA	**30 000**	first year investment
River reserves maintenance	material (500) and control (1PM technician)	**3000**	running cost
conference on monitoring results		**10 000**	4th year investment
dissemination	brochure on river reserves	**5 000**	4th year investment

Table 30.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	132,500 €		132,500 €
2019		3,000 €	2,857 €
2020		3,000 €	2,721 €
2021	15,000 €	3,000 €	15,549 €
2022		3,000 €	2,468 €
2023		3,000 €	2,351 €
2024		3,000 €	2,239 €
2025		3,000 €	2,132 €
2026		3,000 €	2,031 €
2027		3,000 €	1,934 €
2028		3,000 €	1,842 €
2029		3,000 €	1,754 €
2030		3,000 €	1,671 €
Total costs in 2018 value			**172,047 €**

Water Management option 31

Revise and update water entitlements

Challenge(s): Integrated water management

Description

In order to tackle the high number of outdated entitlements, many containing important irregularities, this option aims to support the updating process of entitlements promoted by the water authority. In order to enhance the reduction of extractions and increase the availability and transparency of information, this option aims to promote:

- The creation of a communication and coordination channel between local entities and the water authority in order to foster a pro-active collaboration of municipalities and local entities updating the water use entitlement register in accordance with actual uses.
- Online publication of water entitlement register.

Reference/Source

- "Revise water use entitlements" and “revise concessions: updated and adjusted to actual use” were mentioned in 1st workshop
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

A factor is added with relationships to:

- Integrated entitlements to Water uses 2- (-0.6)

Cost estimation:

The cost estimation is based on the following assumptions:

- Coordination between local entities and the water authority through the organization of 4 meetings with around 50 participants, during 2 years and including working material.
- Fund to enhance actions to revise and reformulate concrete entitlements.
- Creation of an online access to the Tordera water entitlement register.

Table 31.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Coordination between local entities and the water authority	4 meetings/ during 2 years (2000 per meeting + material to be prepared; estimated 50 participants)	**10 000**	first & second year investment
revision implementation	Fund for initiatives	**50000**	first year investment
online publication	1 PM technician	**3 000**	running cost
consolidation of the measure	conference on results	**5 000**	4th year investment

Table 31.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	63,000 €		63,000 €
2019	10,000 €	3,000 €	12,381 €
2020		3,000 €	2,721 €
2021	5,000 €	3,000 €	6,911 €
2022		3,000 €	2,468 €
2023		3,000 €	2,351 €
2024		3,000 €	2,239 €
2025		3,000 €	2,132 €
2026		3,000 €	2,031 €
2027		3,000 €	1,934 €
2028		3,000 €	1,842 €
2029		3,000 €	1,754 €
2030		3,000 €	1,671 €
Total costs in 2018 value			**103,433 €**

Water Management option 32

Develop River custody agreements

Challenge(s): Health of forests and water ecosystems

Description

In order to foster citizens and local entities to collaborate recovering and protecting river space, this option proposes generating the conditions for creating and providing continuity to effective River Custody Agreements.

Reference/Source

- Mentioned as “increase and restore the river space” and ”recover riparian vegetation” (in 1st workshop.
- Issue remarked by interviewed stakeholders.

Implementation in cognitive map

Relationships are changed from:

- WFD to Hydro-geomorphological quality from 2+ (+0.6) to 3+ (+0.9)

Cost estimation:

The cost estimation is based on the following assumptions:

- Full technician employed to manage funding opportunities and custody projects in the basin.
- Funding by Catalan River Basin Management Plan to implement and maintain the custody programs for 6 years.

Table 32.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
Manage funding opportunities and projects at basin level	Technician (12 PM/year)	**30000**	first year investment & running cost
investment from RBMP	RBMP indicates for all 17 Catalonian basins 1 55 000 euro. For Tordera total investment would be 88 235 euro (6 years) = 14 705 euro/year[21]	**14705**	investment lasting 6 years

Table 32.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	44,705 €		44,705 €
2019	44,705 €		42,576 €
2020	44,705 €		40,549 €
2021	44,705 €		38,618 €
2022	44,705 €		36,779 €
2023	44,705 €		35,028 €
2024		30,000 €	22,386 €
2025		30,000 €	21,320 €
2026		30,000 €	20,305 €
2027		30,000 €	19,338 €
2028		30,000 €	18,417 €
2029		30,000 €	17,540 €
2030		30,000 €	16,705 €
Total costs in 2018 value			**374,268 €**

[21] http://aca-web.gencat.cat/aca/appmanager/aca/aca?_nfpb=true&_pageLabel=P46600176421381934582085

Water Management option 33

Conclude adaptive forest management agreements

Challenge(s): Health of forest and water ecosystems

Description

The lack of active forest management entails an increase of the density of plant cover, increasing in this way total biomass in the forest. Reducing uncontrolled biomass can help to reduce forest evapotranspiration and wildfire risk, as well as improving its health.

In order to enhance adaptive measures to be implemented, this option proposes to foster pilot cases for specific adaptive forest management agreements between forestland owners and the administration.

Reference/Source

- Mentioned as “recover forest management” and “adaptation of forest management models” in the 1 st workshop and later events, as well as different interviews.

Implementation in cognitive map

A factor is added with relationships to:

- Adaptive forest management to Health of forests 1+ (+0.3)

Cost estimation:

The cost estimation is based on the following assumptions:

- Amplification of agreement patterns already available by a three-year PhD program.
- Negotiation and agreements established employing a full time technician.
- Fund to establish specific actions included in the agreements.
- Organization of a conference on results obtained and presentation of monitoring data.

Table 33.1: cost elements and cost unit estimation.

Actions	Components of the cost estimation	Cost unit estimation (euro)	Budget structure
agreements already exist, patterns should be amplified	1 PhD	**99000**	first year investment spread over 3 year
negotiation and agreement process	1 technician (12 PM/year)	**15000**	first year investment & running cost
agreement implementation	Fund	**50000**	first year investment
consolidate the initiative	conference on results	**10000**	4th year investment

Table 33.2: Total cost estimation

Costs/year	Investment	Maintenance / running costs	Discounted costs
2018	98,000 €		98,000 €
2019	33,000 €	15,000 €	45,714 €
2020	33,000 €	15,000 €	43,537 €
2021	10,000 €	15,000 €	21,596 €
2022		15,000 €	12,341 €
2023		15,000 €	11,753 €
2024		15,000 €	11,193 €
2025		15,000 €	10,660 €
2026		15,000 €	10,153 €
2027		15,000 €	9,669 €
2028		15,000 €	9,209 €
2029		15,000 €	8,770 €
2030		15,000 €	8,353 €
Total costs in 2018 value			**300,948 €**

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