Background document

Vipava River Basin Adaptation Plan

2016

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

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

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 Vipava river basin has been recently 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.

2. Current state and challenges in the Vipava river basin

The current state and challenges in the Vipava river basin are described in its river basin adaptation plan (Magjar et al. 2016) and are graphically shown in a cognitive map of the basin in Figure 2.1. The map reflects the interactions and dynamics in the basin based on the stakeholders understanding. The cognitive map is centred on the three challenges described above and it includes eighteen (18) factors connected with each other. Based on stakeholders comments, six main drivers of the system were identified 1) precipitation, 2) industrial production, 3) wind, 4) water infrastructure and forest management, 5) river basin management, and 6) air temperature in growing season that affect either directly or indirectly the three aforementioned challenges in the basin. The definitions and the interrelationships between the factors of the basin are presented in Annex I.

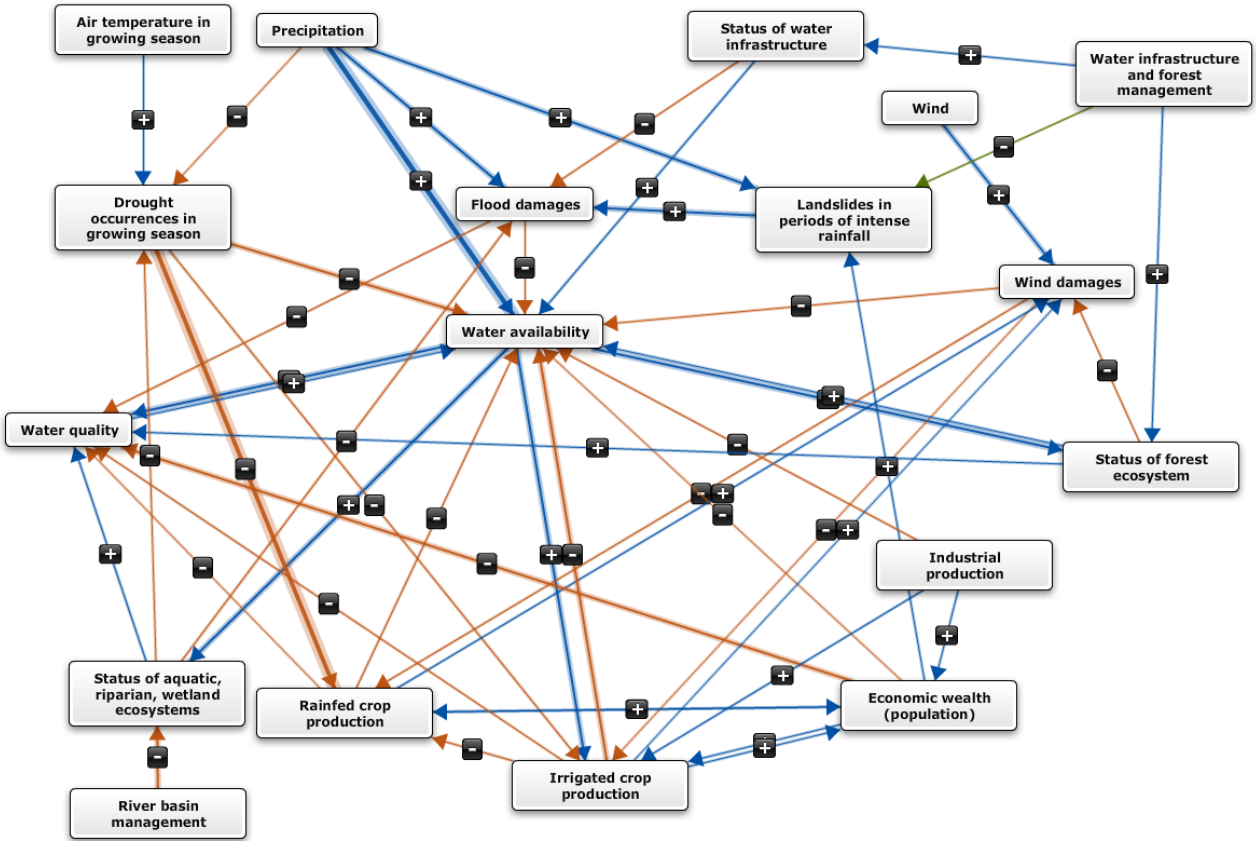

Figure 2.1: Cognitive map of the Vipava river basin (blue: +, red:-; strength: thin line: 1, medium width: 2, wide line: 3)

Water availability is the main factor in Vipava cognitive map due to the highest number of interactions with other factors (Figure 2.2). Water availability is positively affected by precipitation, water quality, status of water infrastructure and status of forest ecosystem. Precipitation has the strongest positive influence on water availability, because precipitation is the main source of water in the valley. Namely, precipitation on plateaus north and north-east side of the basin recharges numerous karst springs (e.g. Hubelj, Mrzlek) that are important for water supply. Water availability is positively (medium strength) influenced by water quality since more water of better quality means more water available for users (e.g. drinking water, water for irrigation and industry). Finally, the status of forest ecosystem positively affects water availability in the lower part of the basin, because the main catchment area of the Vipava river are plateaus in the north, north-east side covered with forest.

Water availability is most strongly negatively affected by drought occurrences in growing season, and the intensity of rainfed and irrigated crop production. More droughts occurrences result in less water being available in the basin. The strength of drought occurrences on water availability is medium as the main catchment area of the Vipava River is less vulnerable to the conditions in the flat part of the basin (from Vipava's springs downstream). In the flat part of the basin, where agricultural land is present rainfed crop production prevails. More rainfed crop production means higher water uptake by plants and less water available for water-dependent ecosystems and sectors. With regards to irrigated crop production, water used for irrigation means irreversible water use and it therefore negatively affects water availability. Irrigated crop production is present mostly in the lower part of the basin, near water reservoir Vogršček and where irrigation systems are present and functioning. In the upper part of the basin, irrigation of agricultural land is also present and the Vipava River is the only water source for irrigation.
Water availability is affecting other factors in the basin. Water availability positively influences 1) aquatic, riparian, wetland and forest ecosystems and 2) water quality. Water availability positively influences irrigation crop production in Vipava river basin and status of aquatic, riparian and wetland ecosystems. If more water is available in streams, soil and groundwater, basin ecosystems (aquatic, riparian, wetland and forest) are in better state. Furthermore, when there is more water in watercourses and groundwater, water is of better quality mostly due to dilution of (potential) pollutants. Finally, if more water is available in watercourses, which are the main water source for irrigation (the Vipava River and water reservoir Vogršček), irrigated crop production is higher. Medium strong relationship between water availability and irrigated crop production is determined as irrigation in the basin is not developed to its full capacity and other factors have bigger effect on irrigated crop production like the development and condition of irrigation systems.

Water quality beside water availability interacts with seven factors. Water quality is affected negatively by economic wealth, including population and settlements development in the basin and agriculture (rainfed and irrigated crop production). Due to small and dispersed settlements in basin with insufficient drainage and municipal wastewater treatment, organic pollution is affecting negatively the water quality. Agriculture with the use of plant protection products and fertilizers is also one the sectors affecting negatively the water quality.

Last but not least are flood damages, related to the basin challenge Flood risk reduction. Precipitation positively affect flood damages because longer periods of rainfall or even shorter periods of heavy rainfall usually lead to flood events causing damages mostly to infrastructure and also trigger landslides. When landslides trigger they move large amounts of sediments, which not only stay on slopes, but also reach the fluvial network. Under these conditions, land sliding may lead to torrential outbursts, debris flows or dam-break waves after a dam-breach of natural dams. As a result, floods of larger scope occur.

Negatively, flood damages equally strong affect water availability and water quality. Namely, floods cause damages to water supply systems and turbidity of water at the source. Due to inactivity of pumps and water treatment, less drinking water of proper quality is available for its users.

3. Identified water management options

To address the challenges identified by stakeholders preliminary Water Management Options (WMOs) were designed. Based on stakeholders input 20 WMOs were identified in total, listed in Table 3.1 and described in detail in Annex II. There are 16 options addressing *Water availability during droughts in growing season* (challenge A), 10 options addressing *Flood risk reduction* (challenge B) and 13 options addressing *Appropriate water quality* (challenge C); however several WMOs are addressing more than one challenge.

Table 3.1: overview of the identified water management options for the Vipava river basin

#	Challenges	Name of water management option
1	A, B, C	Establish an inter-municipal expert working group for the Vipava river basin
2	A, B, C	Awareness campaign focused on educating experts involved in surface water management for sustainable water management
3	A, C	Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices
4	A, B, C	Awareness campaign for local public on impact of their activities on the river
5	A, B	Improve the financing system for water infrastructure
6	A, B, C	Upgrade and update the existing network for monitoring the status of water environment
7	A, C	Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage
8	A, B	Construction of water reservoirs on the watercourses in the upper part of the river basin
9	B	Construction of dry reservoirs
10	A	Reconstruction of existing water reservoir Vogršček
11	A	Development of new irrigation systems
12	A	Reconstruction of existing irrigation system
13	A, B, C	Restoration of Vipava river and its tributaries
14	A, B, C	Restoration of old meanders and oxbows of Vipava river and its tributaries
17	B	Reconstruction of stabilizing and transverse constructions from natural stone in the smaller tributaries of Vipava river
19	A, C	Improving the system of payment for water used for irrigation
20	A, C	Preservation of existing and introduction of new shelterbelts
21	C	Removal of invasive non-native species
22	C	Construction of municipal wastewater treatment plants and sewage systems
23	A, C	The cultivation of crops that are resistant to climate changes (drought, pests and diseases)

We characterised each of the identified WMOs using a set of criteria through an expert assessment. This characterisation of WMOs is shown in Table 3.2.

About one-third of the WMOs are addressing water quantity, while chemical quality, ecological quality and hydro-geomorphological quality are addressed by 17%, 25% and 26% of the options, respectively. About two-thirds of the options target surface waters and one-third is addressing groundwater. Most of the options target the river basin as a whole (71%), while some address the upper (19%) section of the river. The majority of options target agriculture (61%), followed by wetlands (14%) and all other land uses are addressed by few options only (<10%). Droughts and flooding are the main extreme events that are addressed by the options (44% and 33%, resp.). For most of the options it is considered that they can be implemented on short (65%) to medium (35%) term with low to high operational and implementation costs. There is a balance in the options that can be characterised as being supply-, support-, or environmental conservation-oriented (30% each), but only few options are oriented towards the demand side (10%).

Table 3.2: characterisation of the water management options for the Vipava 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/Strong winds (bora)	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	1	1		1	1	1	1	1	1	1	1			1	1	1					1	1		
2	1	1	1	1	1					1							1								1			1	1	1	1					1	1		
3	1	1	1	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	1		1		
6	1	1	1	1	1	1				1							1											1	1	1	1						1	1		
7	1			1	1	1				1	1	1		1			1			1		1				1			1	1							1	1		
8	1			1	1	1	1				1	1		1			1			1		1				1			1	1							1		1	
9	1		1	1	1	1				1	1			1			1			1		1				1			1	1							1		1	
10	1				1				1		1	1		1						1		1				1			1	1							1	1		
11	1				1		1							1						1		1							1								1		1	
12	1				1		1		1					1						1		1							1								1	1		
13	1	1	1	1	1	1				1	1	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	
17				1	1					1							1											1		1	1						1	1		
19	1			1	1					1	1			1			1			1		1							1					1				1		
20	1		1	1	1		1							1					1	1	1	1	1	1							1						1	1		
21			1		1					1							1									1		1					1	1					1		
22		1	1		1	1				1	1						1								1							1		1	1			1		
23	1	1	1		1	1				1				1					1	1	1	1						1						1		1			1		

WMO #	Expected lifetime			Timelag between implementation and effectiveness			Character				Implementation costs				Operational costs				Efectiveness				Approach to adaptation			Nature of approach							Potential to address climate change		Feasibility			Acceptability (a priori)	
	Short (< 5 years)	Medium (5-20 years)	Long (> 20 years)	Short (< 5 years)	Medium (5-20 years)	Long (> 20 years)	Demand	Supply	Support	Environ. Conservation	< 10,000 €	10,000 - 100,000 €	100,000 - 1,000,000 €	> 1,000,000 €	< 10,000 € / yr	10,000 - 100,000 € / yr	100,000 - 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	1	1	1		1		1	
2			1		1				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	
5			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	
7			1	1				1				1			1				1						1			1	1				1	1		1			1
8			1	1				1						1			1		1					1				1	1							1	1		
9			1	1				1						1			1		1					1				1	1			1			1		1		
10			1	1				1						1	1				1					1				1	1						1		1		
11		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		
13			1	1						1				1			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		
17		1		1						1			1		1							1		1			1	1						1					1
19			1	1			1					1			1				1						1			1				1	1		1		1		
20			1		1					1			1			1			1				1					1				1	1		1		1		
21			1	1						1		1			1				1				1				1					1	1		1			1
22			1	1						1				1				1	1					1			1	1		1		1			1		1	
23			1		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 WMOs to the Fuzzy Cognitive Map (FCM) to assess how all factors would react (see annex II on how each WMO was introduced). The results of this impact assessment are shown in Figure 4.1. In this chapter only the results for the factors *Water availability*, *Flood damages* and *Water quality* as the factors relating to the three main challenges and *Drought occurrences in the growing season* are described.

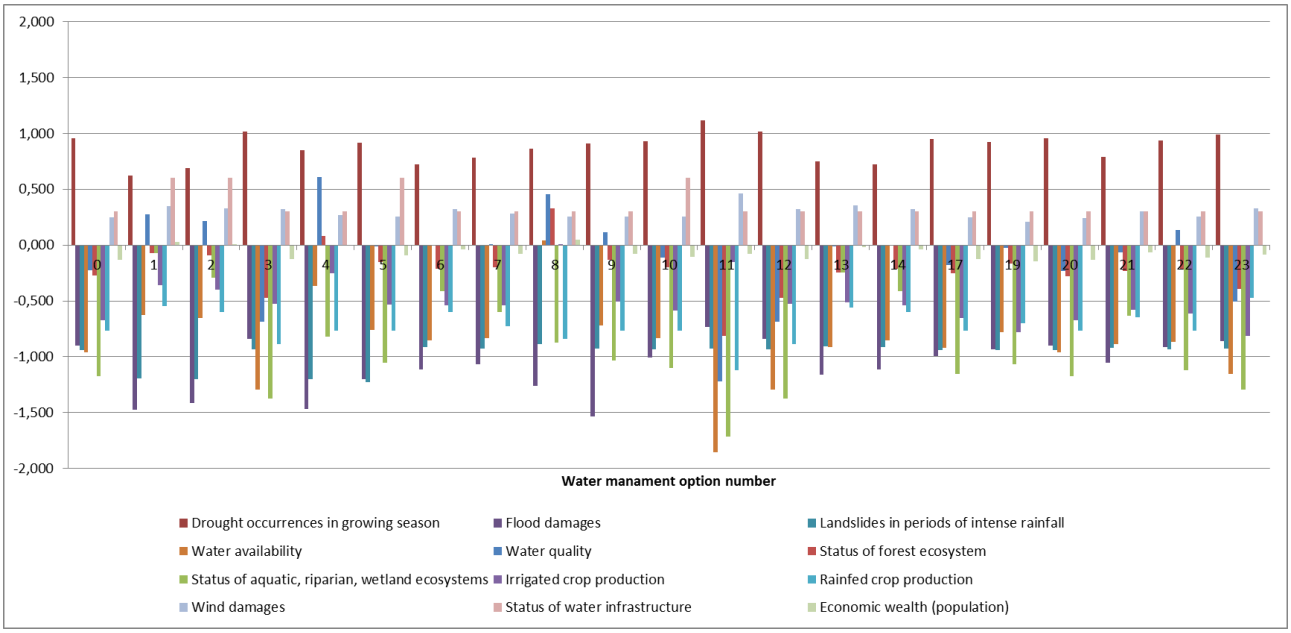

Figure 4.1: impacts of the water management options on factors included in the Fuzzy Cognitive Map. Numbers on the x-axis refer to the water management options in Table 6.1.

As precipitation is expected to decline, *Water availability* is expected to decline strongly in case no WMOs are introduced (WMO 0 in Figure 4.1). According to the results of the FCM, only the *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) is able to increase water availability. Comparing to the baseline (WMO 0), multiple options could mitigate the decline in water availability, at least to some extent. Amongst these options, the options *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) are most successful. Several options, however, also result in a further reduction of water availability compared to the baseline. The three options that results in the strongest reductions are *Development of new irrigation systems* (WMO 11), *Reconstruction of existing irrigation system* (WMO 12) and *Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices* (WMO 3). These options lead to more water being used for *Irrigated crop production* and thereby reduce the overall water availability. If not combined with other WMOs, these options can have negative impact on water availability as water is used for irrigation and thereby increase the pressure on water availability for other uses. With WMO 3, we assume it makes agriculture less dependent on water (through more efficient irrigation). Compared to the baseline development (WMO 0), this results in a smaller decline of agriculture, which allows more farmers to keep their land, but which also keeps water availability under high pressure.

Due to the expected decline in precipitation, also *Flood damages* are expected to decline in case no new WMOs are introduced (WMO 0 in Figure 4.1). Here it has to be pointed out that this results needs to be interpreted with care. Climate change projections for Vipava river basin show changes in precipitation regime (redistribution) through a decrease in precipitation in summer months, and an

increase in winter months (see chapter 2). Trends show that floods occur in Vipava river basin more frequently in the last decade due to increase of periods of intense rainfall (storms). Regardless of this fact, we compared the baseline (WMO 0) with each proposed WMO. We found out that flood damages decline even more with *Construction of dry reservoirs* (WMO 9) by retaining high waters and reduce floods downstream. Slightly lower decline in flood damages compared to the impacts of WMO 9 are achieved also by introduction of soft WMOs like *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1), each presenting a way to a more coherent spatial development in RB and awareness raising among experts and inhabitants about cause/effect relation relating floods.

According to the results of the FCM, *Water quality* is expected to decline slightly in case no WMOs are introduced (WMO 0 in Figure 4.1). Less than one-third (six out of 20) WMOs are able to increase water quality. Options that lead to the strongest increase are *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8). Nine WMOs could lead to less strong reductions of water quality compared to the baseline, including for example *Reconstruction of existing water reservoir Vogršček* (WMO 10). One WMO, *Preservation of existing and introduction of new shelterbelts* (WMO 20), has the same impact as the baseline (WMO 0). About one-fifth (four out of 20) of the WMOs could reduce water quality even more as compared to the baseline (WMO 0). The WMO that reduces water quality most strongly is *Development of new irrigation systems* (WMO 11), followed by *Reconstruction of existing irrigation system* (WMO 12) and *Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices* (WMO 3). These options lead to more water used for irrigation, which decreases water availability and thereby leads to a reduction in water quality due to higher concentrations of (potential) pollutants in water.

As precipitation is projected to decline and air temperature in the growing season is projected to increase, *Drought occurrences in the growing season* are expected to increase (WMO 0 in Figure 4.1) as a result. None of the WMOs are able to lead to a reduction in drought occurrences, but multiple WMOs could lead to less strong drought occurrences, as compared to the baseline. According to the results of the FCM, *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) is the option that could increase drought occurrences the least. This option is followed by the *Awareness campaign focused on educating experts involved in surface water management for sustainable water management (impacts of their actions)* (WMO 2), *Upgrade and update the existing network for monitoring the status of water environment* (WMO 6), *Restoration of Vipava river and its tributaries* (WMO 13) and *Restoration of old meanders and oxbows of Vipava river and its tributaries* (WMO 14). Several options, however, also result in a further increase of drought occurrences. This finding is the result of negative impacts of these options on the status of aquatic, riparian and wetland ecosystems, which act as a buffer against drought occurrences. Because these options negatively affect the status of these ecosystems, the capacity of these ecosystems to mitigate drought occurrences decrease, resulting in an expected increase of drought occurrences in the growing season.

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 7 characteristics and 8 factors from the FCM as potential criteria. From the 15 potential criteria, participants of the 2nd stakeholder workshop selected 13 criteria to be included in the MCA (Figure 4.2). Participants also suggested three additional criteria (*bottom-up approach, short-decision making process, tourism*). 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 availability* and *Water quality*, which relate to challenges A and C, respectively. They assigned a medium preference value to *Flood damages*, which relates to challenge B. *Rainfed crop production* and *Wind damages* received fairly low preference values (<4). The stakeholders assigned medium preference values (4.6-5.9) to all the criteria relating to the characteristics of the WMOs.

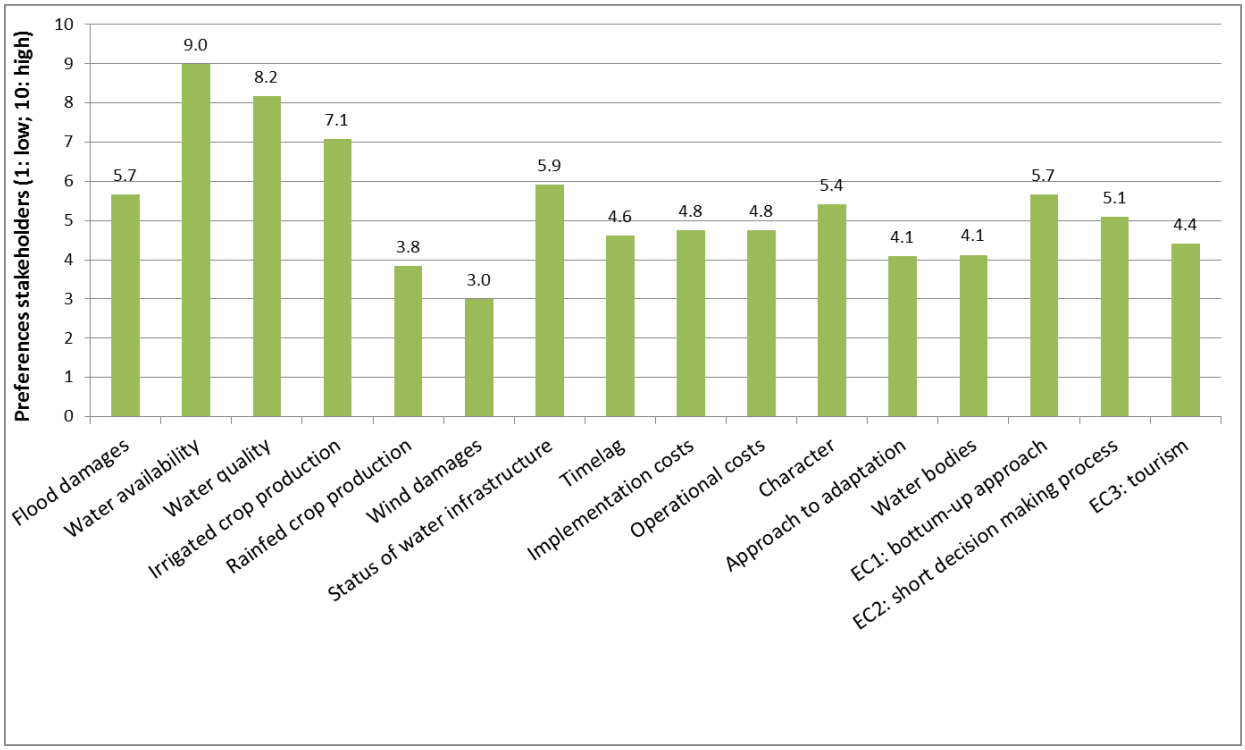

Figure 4.2: selected criteria and average preferences according to the stakeholders in the 2nd workshop. The criteria EC1-3 are additional criteria suggested by stakeholders, but they were not used in subsequent steps of the Multi-criteria Analysis.

4.2.2 Performance of the selected criteria

Once the 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.

#	Impacts (Factors in the map)								Characteristics				
	Flood damages	Water availability	Water quality	Irrigated crop production	Rainfed crop production	Wind damages	Status of water infrastructure	Economic wealth (population)	Timelag	Implementation costs	Operational costs	Character	Approach to adaptation
0													
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
17													
19													
20													
21													
22													
23													

Legend	0.00	0.25	0.50	0.75	1.00
	Least preferred		...		Most preferred

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 6.1**.**

Comparison between the proposed WMOs shows that *Development of new irrigation systems* (WMO 11) has the least preferred outcome for most of the criteria, followed by *Reconstruction of existing irrigation system* (WMO 12) and *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23). The first two options represent a technical solution (grey approach to adaptation), which were solutions less preferred by the participants, while the third one (WMO 23) represents a green approach that received medium preference. WMO 23 is also the option positively affecting rainfed crop production, which was a less preferred outcome according to the participants of the 2nd stakeholder workshop (i.e. more rainfed crop production was a less preferred outcome because workshop participants considered that rainfed crop production is already in current conditions not working in Vipava river basin). In addition, all three WMOs have high implementation costs and least preferred evaluation outcome for the main identified challenges of Vipava river basin.

The most preferred evaluation outcome for the majority of the criteria could be found for the options *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1), followed by *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8). The first three options represent a soft approach to adaptation, which was most preferred, all having low implementation and operational costs and most preferred outcome for the main identified challenges of Vipava river basin. Although *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) represents a technical solution (grey approach to adaptation) with high implementation costs, it has most preferred evaluation outcome for the main identified challenges of Vipava river basin.

4.2.3 MCA results

To evaluate the WMOs, we combined the results of the impact assessment for each WMO, the characterisation of each WMO, the criteria selected by participants of the 2nd stakeholder workshop and the preferences assigned to them in a MCA. Below, we show three sets of results; in Figure 4.4 we show the outcome based only on criteria derived from the FCM (and the impact assessment), in Figure 4.5 we show the outcome of the MCA based only on criteria from the characterisation of the WMOs and in Figure 4.6 we show the outcomes of the MCA based on the full set of criteria as selected by stakeholders (as shown in Figure 4.2).

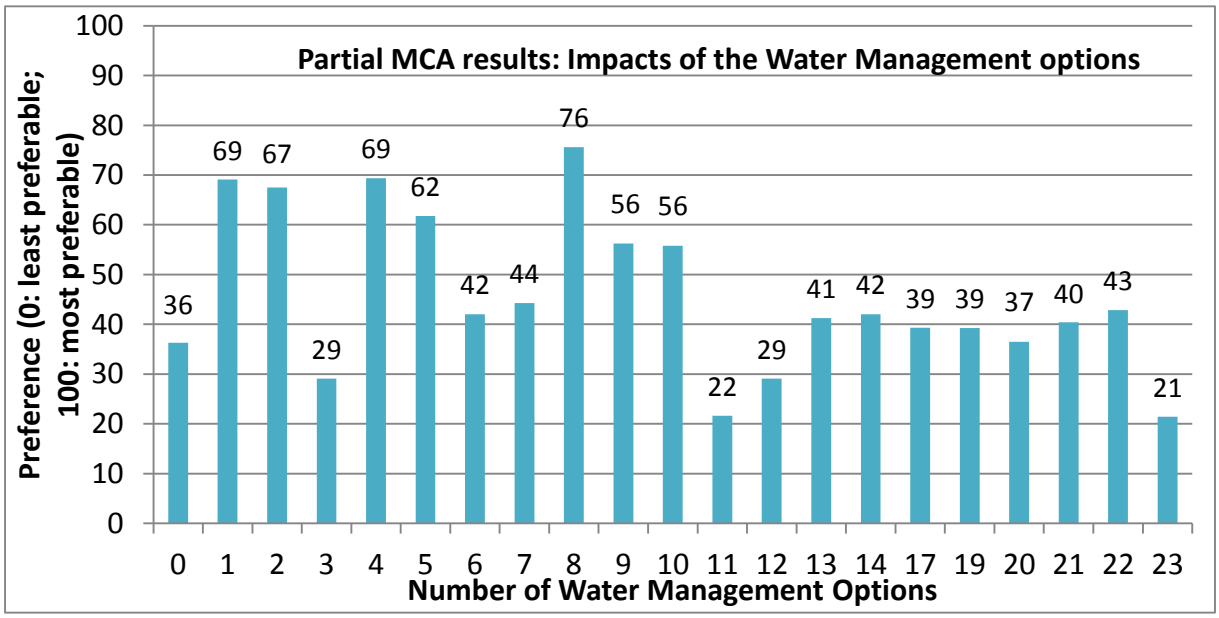

Figure 4.4: outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment. Numbers refer to the water management options in Table 2.1. These results are obtained considering only weights and scores of the criteria related to the impact assessment.

According to the criteria derived from the FCM (and the impact assessment), *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) had the most preferred evaluation outcome, followed by *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1), *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2). The lowest preference (bellow the base line of WMO 0) have *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23) and *Development of new irrigation systems* (WMO 11).

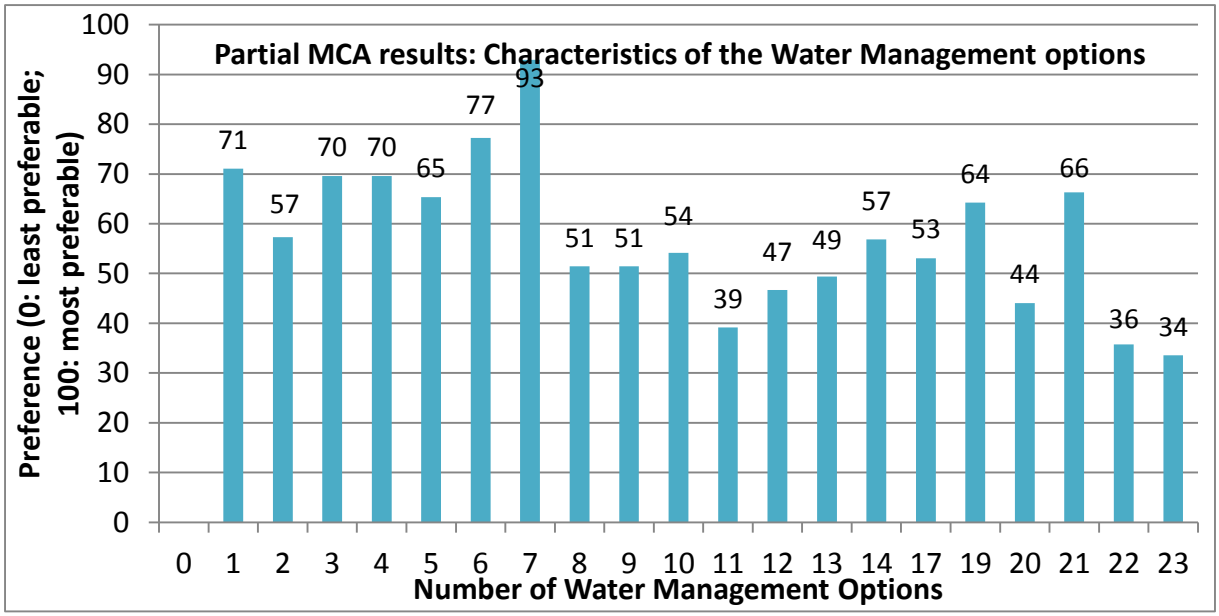

Figure 4.5: outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the characteristics of the options. Numbers refer to the water management options in Table 2.1. These results are obtained considering only weights and scores of the criteria related to the impact assessment.

The option *Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage* (WMO 7) had the most preferred characteristics of a WMO. Far behind WMO 7, but still with highly preferred characteristics are *Upgrade and update the existing network for monitoring the status of water environment* (WMO 6), *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1), *Awareness campaign for local public on impact of their activities on the river* (WMO 4) and *Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices* (WMO 3). The options with the least preferred characteristics were *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23) and *Construction of municipal wastewater treatment plants and sewage systems* (WMO 22).

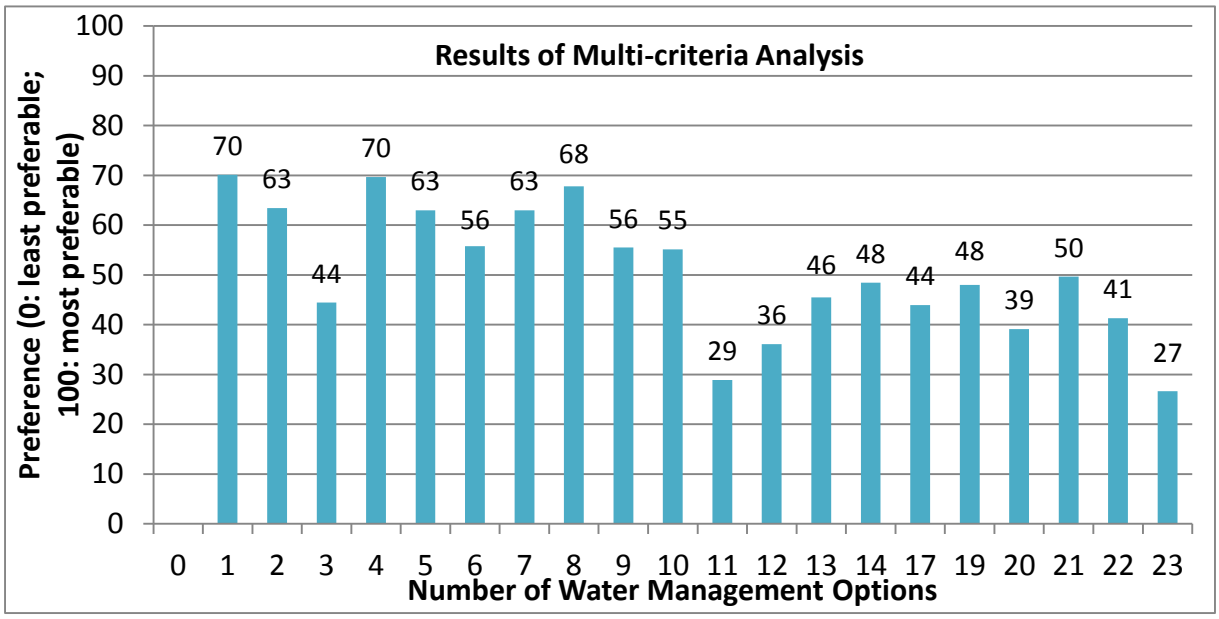

Figure 4.6: outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment. Numbers refer to the water management options in Table 2.1

Based on the full set of criteria selected by participants, the overall results of MCA (Figure 4.6) indicate that *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) and *Awareness campaign for local public on impact of their activities on the river* (WMO 4) were the most preferred options with regards to their impacts and characteristics. They are closely followed by *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8), *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Improve the financing system for water infrastructure* (WMO 5) and *Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage* (WMO 7). The least preferred options were the *Cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23) and *Development of new irrigation systems* (WMO 11).

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 WMOs 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 WMO. 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 2nd workshop. However, stakeholders have quite contrasted preferences; all of them consider *water availability* and *water quality* to be important, but the variability in the importance given to *rainfed crop production* and *wind damages* generate large differences in the individual MCA outcomes. Three stakeholders appear to prefer soft options targeting reduced water consumption and solving conflicts. Another stakeholder focusses almost exclusively on water quality and water quantity issues, leading to a clear rejection of WMOs that do not improve these two challenges. 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 workshop.

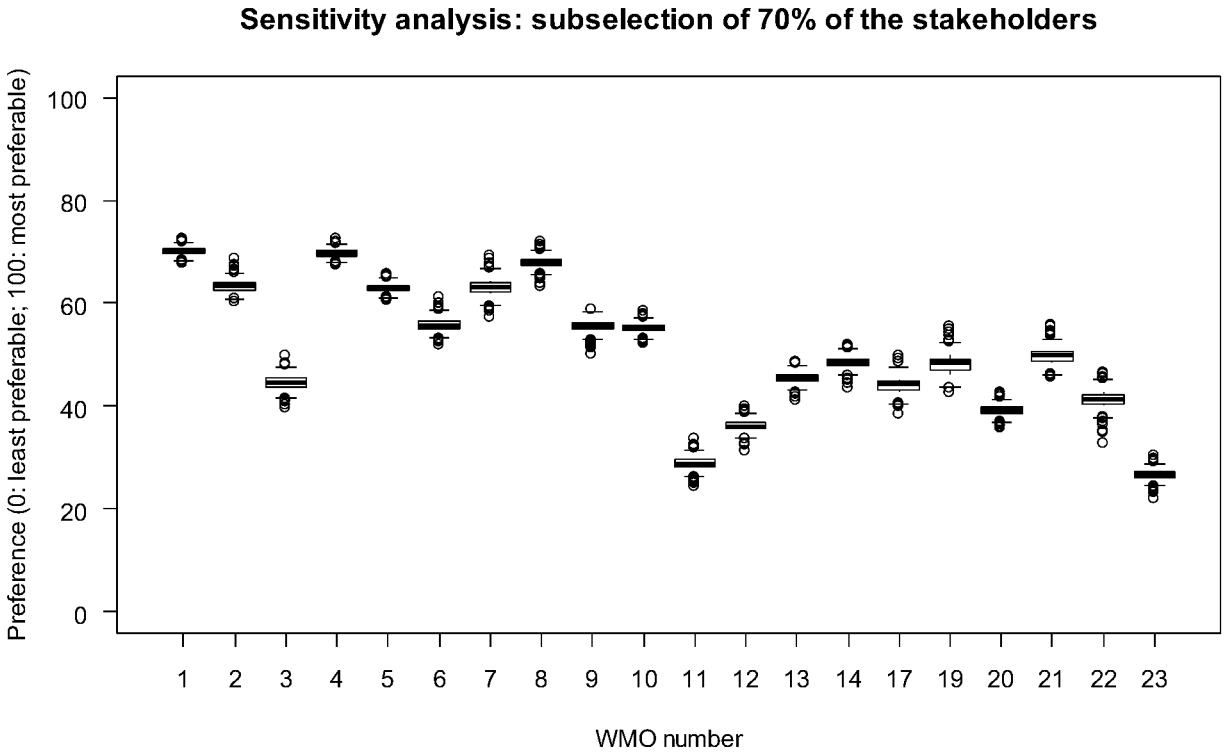

Figure 4.7: sensitivity of the MCA outcomes to the panel of stakeholders by randomly selecting for 1000 times a sub-panel of 70% of the stakeholders. Numbers refer to the water management options in Table 2.1.

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 2nd workshop, the MCA outcomes were more sensitive to the criteria used to evaluate each WMO. The options *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) and *Development of new irrigation systems* (WMO 11) are most strongly affected by the selection of criteria, while *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2) and *Preservation of existing and introduction of new shelterbelts* (WMO 20) are least strongly affected by the selection of the criteria.

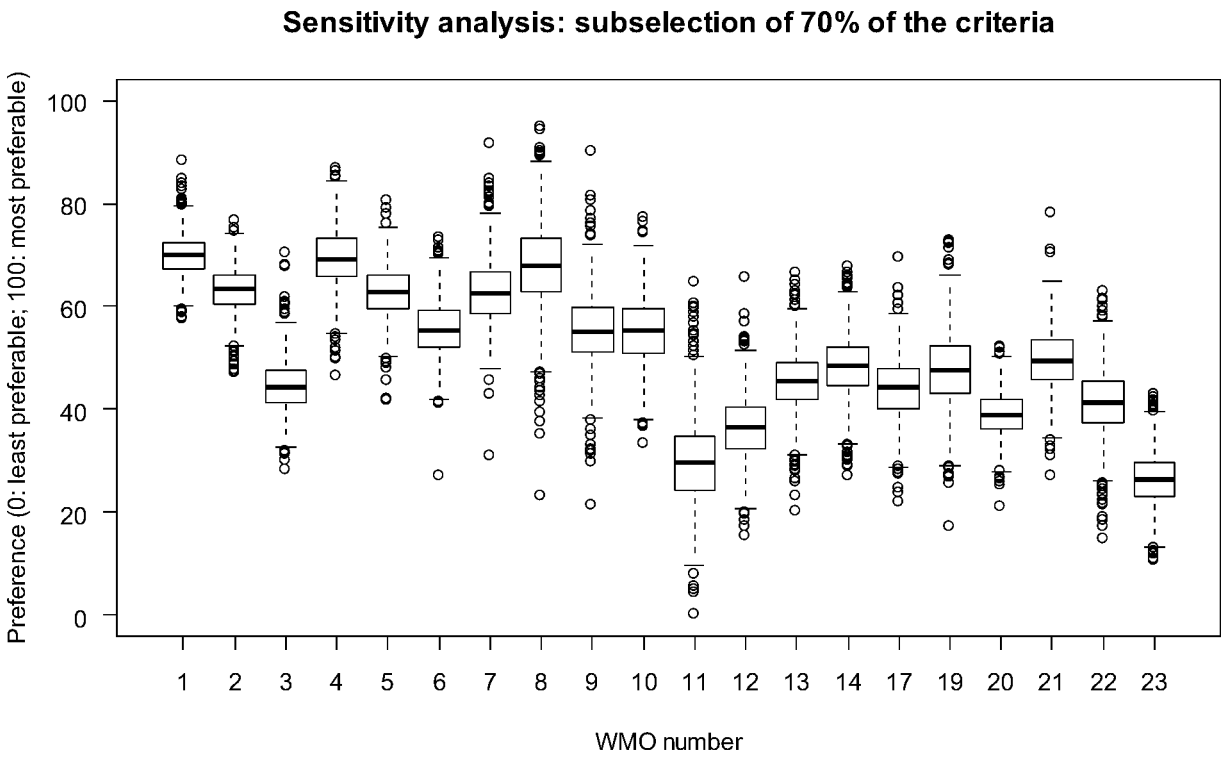

Figure 4.8: sensitivity of the MCA outcomes to the selected criteria randomly selecting for 1000 times a sub-selection of 70% of the criteria. Numbers refer to the water management options in Table 2.1.

Among the impacts, the *Status of water infrastructure* is a factor that biases the results. This is due to the fact that this criterion is not dynamic in the FCM. With regards to the characteristic of the options, the criterion *timelag* generally leads to a more preferred outcome of the MCA, with little overall impact on the MCA results. This factor receives the highest score in most options according to the characterisation but contributes little to the differentiation between WMOs. 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 workshop.

During the 2nd stakeholder workshop, participants indicated more *rainfed crop production* would be less preferred. Workshop participants, mostly representing the agricultural sector, explained that rainfed production leads to extensive farming, which is not economically justifiable and is against the desired development of agriculture in Vipava RB. It should be noted that not all participants agreed with this view. Hence, we investigated the implications of this decision by calculating the overall MCA score in case more *rainfed crop production* would be more preferred (Figure 4.9). The results suggest that the direction of change of *rainfed crop production* had a marginal effect on the overall outcome and that some WMOs would perform slightly better and others slightly worse.

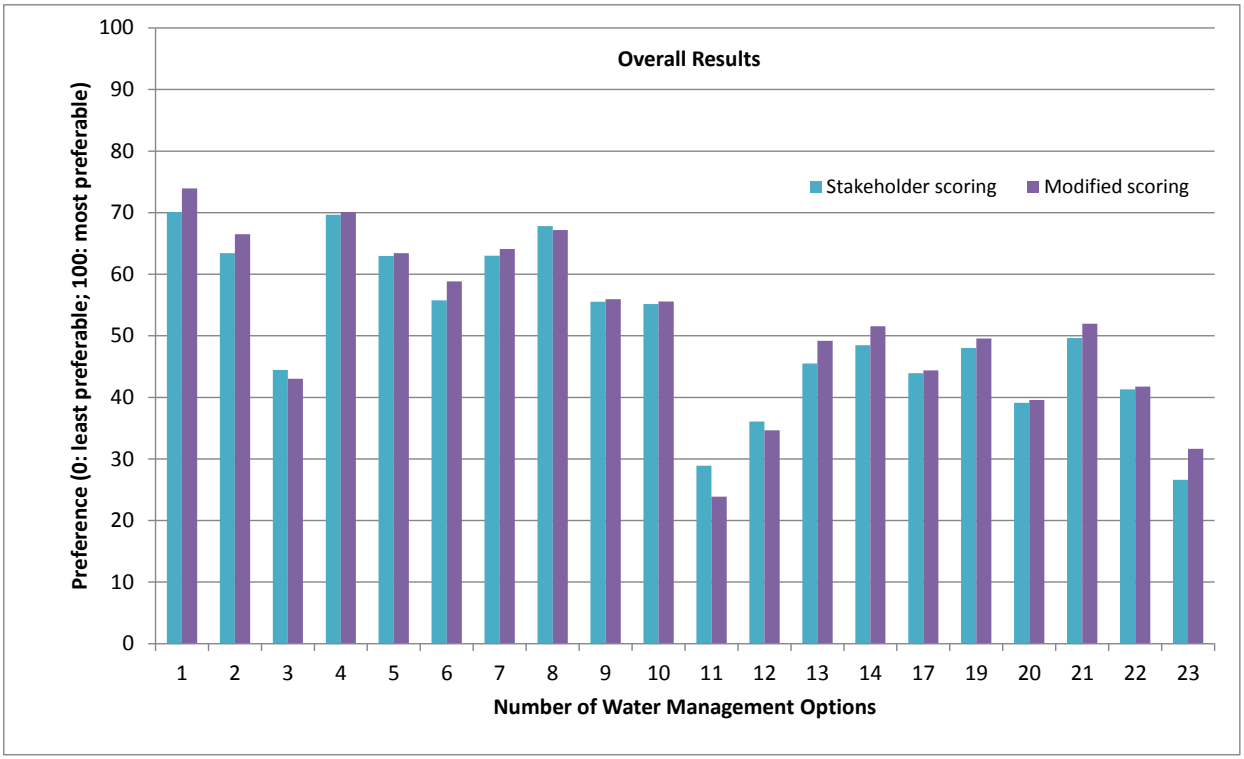

Figure 4.9: outcome of the Multi-Criteria Analysis based on criteria (and their changes) derived from the Fuzzy Cognitive Map and the impact assessment. Numbers refer to the water management options in Table 2.1.

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 20 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. Each action with main identified (implementation and maintenance) costs are described in detail in Annex II. 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.

The main costs categories in the cost assessment were:

- costs of human resources (depending if public employee, expert, scientist) and travel costs (meetings, workshops);
- costs of main infrastructures (documentation, implementation, maintenance) and construction works.

Data used for cost assessment were obtained from:

- common database used for assessing costs of measures envisaged for National River Basin Management Plan (in preparation);

- similar WMOs already implemented in Slovenia;
- similar WMOs planned in scientific or grey literature;
- consultations with experts from the Institute (Institute for Water of the Republic of Slovenia);
- consultations with (expert) stakeholders.

In some cases the costs of already planned "projects" were used:

- *Reconstruction of existing water reservoir Vogršček* (WMO 10) – the reconstruction of the water reservoir (its 2nd phase) is already planned by ministry responsible for environment. With a "Conceptual plan" (slo: "projektna naloga" of terms of reference) the WMO is (in time of writing this report) in the process of public procurement for "Reconstruction of barrier Vogršček and its accompanying facilities" (MKO, 2013). The estimated value of the implementation is known and has been used in cost assessment.
- *Development of new irrigation systems* (WMO 11) – all of mentioned irrigation systems in WMO are also planned on strategical level with *Action plan for the development of irrigation in the RS until 2020* (MKGP, 2015). This plan still needs to go through inter- ministerial harmonization and Strategic Environmental Assessment process. Plan also indicated costs for implementation of irrigation systems per ha, that were used in cost assessment.
- *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) – all of mentioned water reservoirs are planned on strategical level with *Action plan for the development of irrigation in the RS until 2020* (MKGP, 2015). This plan still needs to go through inter- ministerial harmonization and Strategic Environmental Assessment process. Water reservoir Košivec is one of the reservoirs that has been placed in current Spatial Plan of Municipality Ajdovščina and its amendments (Official Gazette of the Municipality of Ajdovščina, no. 7/1997).

In Figure 4.10 we show the estimation of total discounted cost in thousand euros for each WMO.

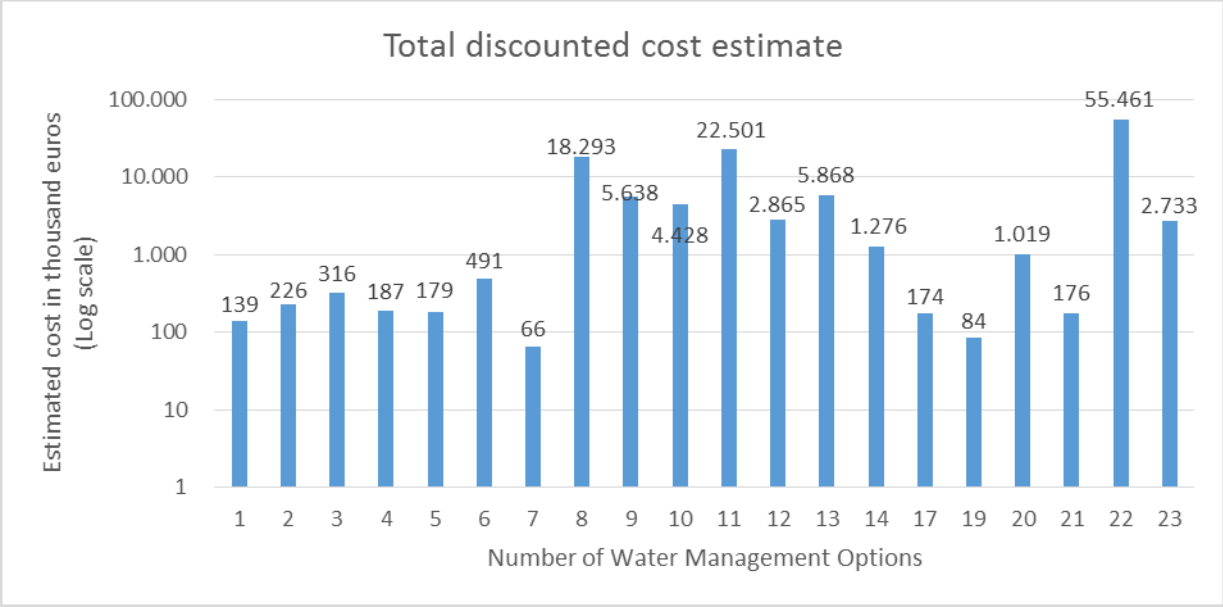

Figure 4.10: outcome of the cost assessment of Water management options in thousand euros. Numbers refer to the water management options in Table 2.1.

As shown in Figure 4.10 the highest (implementation and maintenance) costs are expected for technical options (grey approach to adaptation) among which *Construction of municipal wastewater treatment plants and sewage systems* (WMO 22) with approx. 55 million euros is the most expensive option, followed by *Development of new irrigation systems* (WMO 11) with approx. 22.5 million euros and *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) with approx. 18.3 million euros. The least expensive options are soft options with the cheapest

Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage (WMO 7) at 66,000.00 euros and *Improving the system of payment for water used for irrigation* (WMO 19) at 84,000.00 euros.

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 WMO as the ratio between the cost of implementation and the effectiveness indicator (the difference between the partial MCA results obtained for an WMO and the partial MCA result related to the baseline). The cost-effectiveness ratio in Figure 4.11; a WMO is highly cost-effective it the price per unit is low.

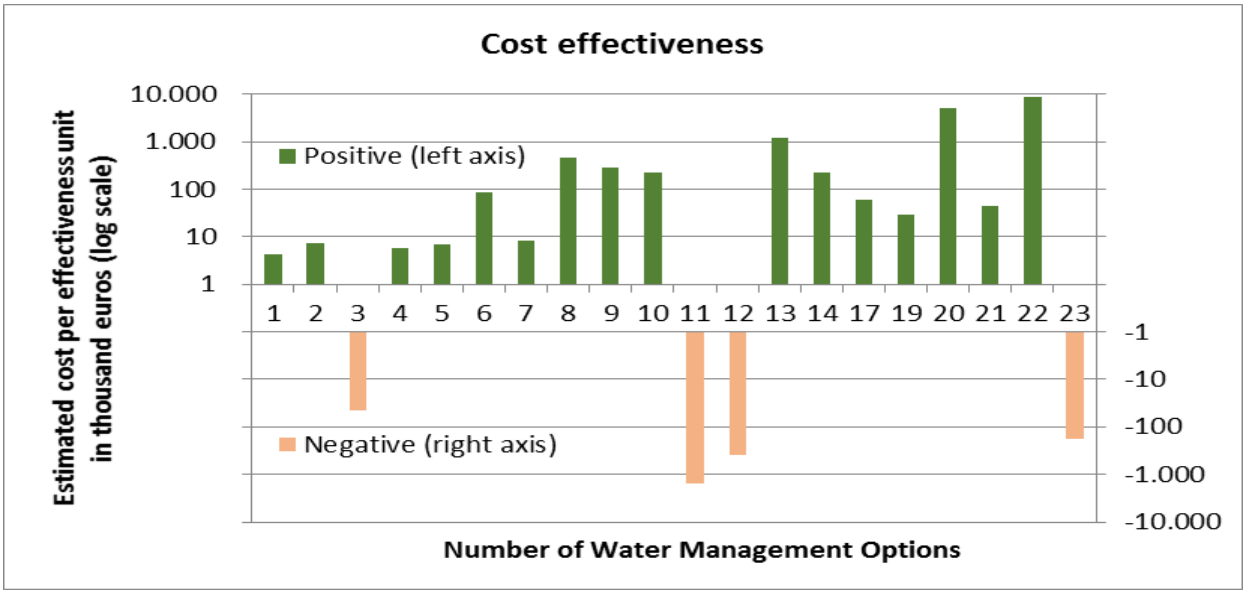

Figure 4.11: outcome of Cost effectiveness of the Water management options per 1,000 euros spent. Numbers refer to the Water management options in Table 2.1.

According to our analysis, *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) with the lowest ratio is most cost-effective with regards to its impacts. This option is followed by *Awareness campaign for local public on impact of their activities on the river* (WMO 4), *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Improve the financing system for water infrastructure* (WMO 5) and *Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage* (WMO 7). The least effective with regards to impacts are the WMOs with the highest ratio; *Construction of municipal wastewater treatment plants and sewage systems* (WMO 22) and *Preservation of existing and introduction of new shelterbelts* (WMO 20).

Several options have a negative ratio, indicating that efforts and costs involved in the implementation of these options could result in outcomes that are worse as compared to not implementing the options. For options that have a negative ratio (*Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices* (WMO 3), *Development of new irrigation systems* (WMO 11), *Reconstruction of existing irrigation system* (WMO 12) and *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23)) due to negative outcome of impact assessment (lower evaluation outcome compared to the baseline (WMO 0)) are depended on the implementation of other, complementary WMOs.

5. Discussion of results

Vipava is a dynamic basin with many water management challenges connected with each other. Based on the stakeholders statements by stakeholders, three main challenges in Vipava river basin were identified; Water availability during droughts in growing season (challenge A), Flood risk reduction (challenge B) and Appropriate water quality (challenge C). Water Management Options (WMOs), already indicated by stakeholders on 1st stakeholder workshop, have been formulated to address these three challenges. At the beginning of the process 23 WMOs were identified, which were reduced to 20 based on the but were later on, in a refinement process and based on the comments from stakeholders input (2nd stakeholder workshop)., reduced to the number 20. Due to traceability, the original numbers of WMOs are kept in all documents.

Assessment of WMOs impacts of WMOs on river basin dynamics and its main challenges showed (with minor differences between the challenges) that soft measures such as awareness campaigns (WMO 2, WMO 4) and inter-municipal expert working group (WMO 1) are most preferred as potential solutions for adapting and/or mitigating the impacts of global changes. Among grey options, Construction of water reservoirs on the watercourses in the upper part of the river basin (WMO 8) could potentially, compared to baseline scenario (WMO 0), contribute to address issue related to two main challenges, water availability (challenge A) and water quality (challenge C). This option has also the most preferred evaluation outcome when assessing impacts on ecosystem services. For challenge of floods (challenge B), Construction of dry reservoirs (WMO 9) appears a better, or more preferred option. By assessing impacts of global changes on Drought occurrences in the growing season, we found out that none of the proposed WMOs is able to prevent droughts, but several soft WMOs could mitigate drought occurrence to some extent as compared to the baseline like for example inter-municipal expert working group (WMO 1), awareness campaign for experts (WMO 2) and upgrading the existing measurement network (WMO 6). Not to mention also green measures like restoring Vipava river and its tributaries (WMO 13) or just its meanders and oxbows (WMO 14) with the aim of allowing aquatic and its related ecosystems to better cope with upcoming global changes.

In Vipava river basin there are some WMOs that have a negative impact on the main identified challenges. This options are aimed at one sector only (the agricultural sector) and are grey measures focusing on construction of new or reconstruction of existing irrigation systems (WMO 11, WMO 12, resp.), soft measure with raising awareness of farmers (WMO 3) or green measure with cultivating crops more resistant to climate changes (WMO 23). These options lead to more intensive agriculture that uses water for irrigation, further decreases water availability, which potentially leads to further decrease in water quality. All of these options are lacking a complementary WMO and would need to be planned with options that can for example ensure water for irrigation (WMO 8).

The overall results of Multi-Criteria Analysis (MCA), that combined the results of the impact assessment for each WMO, the characterisation of each WMO, the criteria selected by stakeholders and the preferences assigned to these criteria, showed similar results to impact assessment of WMOs. The most preferred outcome have soft measures, *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) and *Awareness campaign for local public on impact of their activities on the river* (WMO 4), closely followed by grey measure *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8), and soft measures *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Improve the financing system for water infrastructure* (WMO 5) and *Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage* (WMO 7). The lowest preference are assigned to *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23) and *Development of new irrigation systems* (WMO 11).

The economic assessment shows that soft measures like *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1), *Awareness campaign for local public on impact of their*

activities on the river (WMO 4), *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2), *Improve the financing system for water infrastructure* (WMO 5) and *Setting up monitoring to reduce pressures on aquatic ecosystems resulting from water abstraction and water storage* (WMO 7), are most cost-effective options to tackle the challenges in the Vipava river basin. As for grey measures (e.g. *Construction of municipal wastewater treatment plants and sewage systems,* WMO 22) and green measures (e.g. *Preservation of existing and introduction of new shelterbelts*, WMO 20), they are least cost-effective. In case of a negative cost-effectiveness ratio (*Awareness campaign focused on optimizing water use for farmers, for proper irrigation and minimize impacts on water quality through proper agricultural practices* (WMO 3), *Development of new irrigation systems* (WMO 11), *Reconstruction of existing irrigation system* (WMO 12) and *The cultivation of crops that are resistant to climate changes (drought, pests and diseases)* (WMO 23)), WMOs need to be implemented with other, complementary WMOs (e.g. *Construction of water reservoirs on the watercourses in the upper part of the river basin*, WMO 8) to ensure water for irrigation.

During the 2nd stakeholder workshop, preliminary MCA results were presented to the participants. After presenting the results, participants were divided into three groups (based on the three different challenges), checked the ranking of WMOs that showed the result of the scoring of individual criteria. The first group discussed ranking of WMOs that tackle challenge A (*Water availability*), the second group discussed ranking of WMOs that tackle challenge B (*Flood risk reduction*) and the third group discussed ranking of WMOs that tackle challenge C (*Appropriate water quality*). Overall, two groups discussing challenge A (*Water availability*) and challenge C (*Appropriate water quality*) commented that outcomes of the MCA show the opposite of expected outcomes. Group discussing challenge B (*Flood risk reduction*) had no comments on MCA results for first three WMOs but had comments regarding using proper technical terms for one of the option which was taken into account later on (*Reconstruction of stabilizing and transverse constructions from natural stone in the smaller tributaries of Vipava river*, WMO 17). Due to strong disapproval of participants representing agricultural sector and further consultations with experts on the actual impact on reducing floods, the option *Redirection of high waters from watercourses to amelioration ditches* (WMO 18), was deleted from the list. Experts were of an opinion that amelioration ditches would fill up too quickly and do not represent a good option for flood risk reduction.

For options tackling challenge A (*Water availability*), the preliminary MCA results, as presented during the 2nd stakeholder workshop, indicated the following top-three of best ranked options: *Construction of dry reservoirs* (WMO 9), *Construction of water reservoirs on the watercourses in the upper part of the river basin* (WMO 8) and *Awareness campaign for local public on impact of their activities on the river* (WMO 4). Participants of the workshop were of opinion that *Reconstruction of existing water reservoir Vogršček* (WMO 10), *Reconstruction of existing irrigation system* (WMO 12) and *Development of new irrigation systems* (WMO 11) should be ranked higher. They indicated that these three WMOs (WMO 10, WMO 8, WMO 11) are measures that should be placed on first three places. As there are many factors (variables) that influence the results, we checked the main variables that affected the outcome. All three options are grey options with high implementation costs and would target only surface water, all receiving the minimum number of points (scoring of the criteria) from stakeholders. Additionally all three options are assumed to make agriculture less dependent on water (through more efficient irrigation) and compared to the baseline development (WMO 0), this results in a smaller decline of agriculture, which allows more farmers to keep their land, which keeps water availability under a high pressure (impact assessment). Participants also commented that *Construction of dry reservoirs* (WMO 9) was evaluated incorrectly as it does not address water availability. Based on this feedback, the implementation of the WMO in the FCM was changed accordingly.

For options tackling challenge C (*Appropriate water quality*), the preliminary MCA results indicated the following top-three of best ranked options: *Awareness campaign for local public on impact of their activities on the river* (WMO 4), *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) and *Awareness campaign focused on educating experts involved in surface water management for sustainable water management* (WMO 2). There was not much disagreement on the outcome for first three WMOs, as group proposed same all options on awareness campaign

(WMO 2, WMO 3, WMO 4), but would need to be followed by *The creation of inter-municipal expert working group for the Vipava RB* (WMO 1). The group believed that *Construction of municipal wastewater treatment plants and sewage systems* (WMO 22) should be placed on 5th place and not on 10th place as shown in preliminary MCA results. Although WMO 22 is targeting surface and groundwater (with assigned 5 out of 5 points) it represents grey option with high implementation costs and so receiving the minimum number of points (scoring of the criteria).

During 2nd workshop stakeholders also suggested three additional criteria (*bottom-up approach, short-decision making process, tourism*). These additional criteria could not be used in subsequent steps of the MCA, because their impacts could not be assessed. Compared to the criteria that were used in MCA (factors from FCM and WMO characteristics), stakeholders assigned medium preference values to all additional criteria: *bottom-up approach* got 5.7 points, *short-decision making process* got 5.1 points and *tourism* got 4.4 points. The main WMO affecting *bottom-up approach* and *short-decision making process* would be *Establish an inter-municipal expert working group for the Vipava river basin* (WMO 1) that could perform slightly even better in overall MCA result. There are more possible WMOs that would be affecting *tourism*. Tourism due to many conflicts in water/space use and water quality in Vipava RB is not yet developed to such an extent as wished by stakeholders. WMOs that could perform better in overall MCA result would be: *Construction of municipal wastewater treatment plants and sewage systems* (WMO 22) by making water of better quality, *Preservation of existing and introduction of new shelterbelts* (WMO 20) by creating a rich cultural landscape, *Restoration of Vipava river and its tributaries* (WMO 13) and *Restoration of old meanders and oxbows of Vipava river and its tributaries* (WMO 14) by creating a nature learning paths for sustainable tourism.

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Annex I

Documentation of the Fuzzy Cognitive Map for the Vipava river basin

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

Number	Name of factor	Definition
f1	Precipitation	Annual average precipitation.
f2	Air temperature in growing season	Growing season - the period of time in a given year when the climate is prime for both indigenous and cultivated plants experience the most growth.
f3	Wind	Strong bora wind, cold and gusty north-eastern wind, especially in the cold half of the year (October to March).
f4	Water infrastructure and forest management	Management of water infrastructure of aquatic and riparian area, forests.
f5	Drought occurrences in growing season	Droughts that occur in growing season. Meaning meteorological and hydrological droughts.
f6	Flood damages	Damages caused by floods along the Vipava river and its tributaries.
f7	Landslides in periods of intense rainfall	Landslides on the slope of the Vipava valley – mostly associated with geological and morphological conditions.
f8	Wind damages	Damages caused by strong bora wind.
f9	Status of water infrastructure	Physical condition of existing water infrastructure – e.g. accumulation with dam (Vogršček), river embankments, check dams (storage of sediments)
f10	Status of forest ecosystems	Ecological condition of forest ecosystems.
f11	Status of aquatic, riparian, wetland ecosystems	Ecological, Hydrological, Morphological, Biological status of aquatic, riparian and wetland ecosystems
f12	Water availability	The availability of the water at its source (river, spring, accumulation) for all users – ecosystems and needs arising from human activities.
f13	Water quality	Physical-chemical parameters of water.
f14	River basin management	Management of surface waters and groundwater; e.g. the status, program of measures, maintenance and investment work planned and carried by concessionaire with confirmation of ministry responsible for the environment.
f15	Rainfed crop production	Crops that are not irrigated and they are dependent only from rain.
f16	Irrigated crop production	Crops that are irrigated (also in closed spaces – glasshouses).
f17	Economic wealth (population)	Including population and settlements development in the RB.
f18	Industrial production	Mostly food processing and textile industry.

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

	Air temperature in growing season	Drought occurrences in growing season	Precipitation	Flood damages	Landslides in periods of intense rainfall	Water availability	Water quality	Status of forest ecosystem	Status of aquatic, riparian, wetland ecosystems	Irrigated crop production	Rainfed crop production	Wind	Wind damages	Status of water infrastructure	Economic wealth (population)	Industrial production	Water infrastructure and forest management	River basin management
Air temperature in growing season	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drought occurrences in growing season	0	0	0	0	0	-0,6	0	0	0	-0,3	-0,9	0	0	0	0	0	0	0
Precipitation	0	-0,3	0	0,6	0,6	0,9	0	0	0	0	0	0	0	0	0	0	0	0
Flood damages	0	0	0	0	0	-0,3	-0,3	0	0	0	0	0	0	0	0	0	0	0
Landslides in periods of intense rainfall	0	0	0	0,6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Water availability	0	0	0	0	0	0	0,6	0,6	0,6	0,6	0	0	0	0	0	0	0	0
Water quality	0	0	0	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0	0
Status of forest ecosystem	0	0	0	0	0	0,3	0,3	0	0	0	0	0	-0,3	0	0	0	0	0
Status of aquatic, riparian, wetland ecosystems	0	-0,3	0	-0,3	0	0	0,3	0	0	0	0	0	0	0	0	0	0	0
Irrigated crop production	0	0	0	0	0	-0,6	-0,3	0	0	0	-0,3	0	0,3	0	0,3	0	0	0
Rainfed crop production	0	0	0	0	0	-0,3	-0,3	0	0	0	0	0	0,3	0	0,3	0	0	0
Wind	0	0	0	0	0	0	0	0	0	0	0	0	0,6	0	0	0	0	0
Wind damages	0	0	0	0	0	-0,3	0	0	0	-0,3	-0,3	0	0	0	0	0	0	0
Status of water infrastructure	0	0	0	-0,3	0	0,6	0	0	0	0	0	0	0	0	0	0	0	0
Economic wealth (population)	0	0	0	0	0,3	-0,3	-0,6	0	0	0,3	0,3	0	0	0	0	0	0	0
Industrial production	0	0	0	0	0	-0,3	0	0	0	0,3	0	0	0	0	0,3	0	0	0
Water infrastructure and forest management	0	0	0	0	-0,3	0	0	0,3	0	0	0	0	0	0,3	0	0	0	0
River basin management	0	0	0	0	0	0	0	0	-0,6	0	0	0	0	0	0	0	0	0

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

From	To	Justification	Strength of the relationship
f1	f5	more precipitation mean less drought occurrences	1-: weak negative relationship
f1	f6	longer periods of rainfall or even shorter periods of heavy rainfal cause flood events that cause damages mostly to infrastructure	2+: medium positive relationship
f1	f7	longer periods of rainfall or even shorter periods of heavy rainfal can trigger landslides; in Vipava RB it has been observed that most landslides are triggered in periods of heavy rainfall, due to impacts of water on the geological structure and formation of the terrain	2+: medium positive relationship
f1	f12	more precipitation mean more water available in streams, soil and groundwater; for ecosystems (aquatic, riparian, wetland and forest) and water users (agriculture, households, industry)	3+: strong positive relationship
f2	f5	if air temperature (average annual or monthly) in growing season is getting higher, more droughts occur (weak relationship as droughts are not affected just by the air temperature, there are other factors like changes in precipitation patterns – temporal, spatial)	1+: weak positive relationship
f3	f8	strong Bora wind (mostly from October to March) cause wind damages, mostly to infrastructure and vegetation, it does not affect the whole basin	2+: medium positive relationship
f4	f7	current management of water infrastructure is present in the basin, but is not efficient enough, not optimal drainage and maintenance of existing water infrastructure. Still management of water infrastructure is present (weak negative relationship) with the objective to decrease landslides	1-: weak negative relationship
f4	f9	current management of water infrastructure is present in the basin, but is not efficient enough, so weak positive relationship is defined as status of water infrastructure is not optimal; only important (most needed) intervention works are done and less maintenance works are carried out	1+: weak positive relationship; example for water reservoir Vogršček – leakage on the dam - intervention works were carried out but due to lack of funding only 1st phase was carried out; water infrastructure on torrents are in poor state not serving its purpose, etc.
f4	f10	forest management is present in the basin and is positively affecting status of forest ecosystem, as most of the forest is in the hinterlands of the basin (sparsely populated) and only present in small parts of the valley where established protected areas of forest along Vipava river; weak positive relationship was determined	1+: weak positive relationship; (Forest management service - units Tolmin and Ajdovščina)
f5	f12	when droughts occur in growing season there is less water available for ecosystems and their services and for water users (agriculture sector, urban users)	2-: medium negative relationship
f5	f15	increased frequency and intensity of droughts in growing season (mostly crop-growing periods) reduces the rainfed crop production (smaller or loss of income) - droughts can harm crops and reduce yields, water demand of crops is difficult to meet as water supplies are reduced	3-: strong negative relationship; SH in 1st WS indicated, that droughts pose a bigger problem for agriculture in the upper part of the RB. In the period from April to September major part of the Vipava valley is endangered or much endangered by drought.

			(http://geo.ff.uni-lj.si/pisnadela/pdfs/zaksem_201407_jus_znidarsic.pdf).
f5	f16	increased frequency and intensity of droughts in growing season (mostly crop-growing periods) reduces the irrigated crop production (smaller or loss of income) - droughts can harm crops and reduce yields, water demand of crops is difficult to meet as water supplies are reduced	1-: weak negative relationship; only a small part of the agricultural land is being irrigated from water reservoir Vogršček (lower part of the basin) and Vipava river (upper part of the basin) (irrigation needs in the Vipava Valley are greater than the available water quantities and other water sources beside water reservoir Vogršček would be needed)
f6	f12	floods cause damages to water supply systems (power failure – problems in water purifying plants, after heavy rainfall water in karst spring becomes turbid and it needs to be cleaned for further use) and so less water is available for its users	1-: weak negative relationship
f6	f13	floods cause damages to water supply systems (power failure – problems in water purifying plants, after heavy rainfall water in karst spring becomes turbid and it need to be cleaned for further use) and so quality of drinking water deteriorates, also surface water becomes turbid, carrying potential pollutants downstream – surface water quality also deteriorates	1-: weak negative relationship
f7	f6	more landslides trigger in periods of intense rainfall, more damages caused by floods occur; when landslides trigger they move large amounts of sediments, which not only stay on slopes, but also reach the fluvial network. Under catastrophic conditions, land sliding may lead to torrential outbursts, debris flows or dam-break waves after a dam-breach of natural dams. As a result, floods of larger scope occur.	2+: medium positive relationship; landslides occur on specific places of the basin, where the terrain is becoming more steep (hillslopes)
f8	f12	strong bora wind damages infrastructure and causes power failure - drinking water cannot be transported to some settlements, also purifying plant for drinking water cannot not work	1-: weak negative relationship, temporally and spatially limited impact
f8	f15	strong bora wind causes damages in agriculture mostly through wind erosion - removal of top soil, additionally drying soil and causing damages to the crops (damages to leaves); the result is lower crop production	1-: weak negative relationship, spatially limited impact meaning where planted wind barriers, this effects are not so strong, and where strong bora wind prevails, permanent grassland are present
f8	f16	strong bora wind causes damages in agriculture mostly through wind erosion - removal of top soil, additionally drying soil and causing damages to the crops (damages to leaves); the result is lower crop production	1-: weak negative relationship, spatially limited impact, where irrigation prevails, wind is not so strong and causes less damages; the expansion of irrigation crop production in greenhouses is also limited
f9	f6	if status of infrastructure is good, floods cause less damage	1-: weak negative relationship; spatially limited impact, e.g. water reservoir Vogršček also provides flood safety downstream, but due to leakage of the dam and not finished intervention works, lower water level is maintained by higher discharge of water into Vogršček

f9	f12	if status of water infrastructure, where present and intended for water use (e.g. irrigation system) is in good condition, working properly, more water is available for ecosystems and sectors (agriculture)	1+: weak positive relationship; spatially limited impact, some water infrastructure is present but not in good condition to fully provide water available in the basin
f10	f8	when forest is in good condition, there are less damages caused by strong bora wind	1-: weak negative relationship; weak relationship is due to low percent of forest in the form of wind barriers (wind breaks) in the valley
f10	f12	the main catchment area of the Vipava river and its tributaries are plateaus in the north, north-east side covered with forest, the status of forest ecosystem positively affects water availability in the flat part of the basin	1+: weak positive relationship
f10	f13	if the forest ecosystems is in better status, water is better quality - forests impact positively on quality of surface and ground water through minimizing soil erosion on site, thus reducing sediment in water bodies (wetlands, ponds and lakes, streams and rivers), and through trapping or filtering other water pollutants	1+: weak positive relationship; in the hinterland of the basin forests prevail, this area is also sparsely populated; good chemical status of groundwater and moderate status of surface waters
f11	f5	with better status of aquatic, riparian, wetland ecosystems more water is retained and not drained away (better retention function, infiltration of water in the ground) and so less hydrological drought occur	2-: medium negative relationship
f11	f6	with better status of aquatic, riparian, wetland ecosystems flood cause less damages, ecosystems services slow down the flow velocity – like for example menders and floodplains connected to the river	1-: weak negative relationship; some floodplains and meanders are present in the lower part of the basin, and are in a function of slowing down the flow velocity, but due to cannot alone reduce the extend of floods due to regulations of the watercourses in the upper part on the basin (more rapid water runoff from the basin, increased flow velocity, decreased retention function of the riverbed and soil)
f11	f13	with better status of aquatic, riparian, wetland ecosystems better self-cleansing capability of the aquatic environment (improvement in water quality through reduced nutrients)	1+: weak positive relationship; weak relationship due to moderate ecological status of surface water
f12	f10	water available in streams, soil and groundwater, satisfies basic environmental needs and if more water is available, forest ecosystem is in better state	2+: medium positive relationship
f12	f11	water available in streams, soil and groundwater, satisfies basic environmental needs and if more water is available, aquatic, riparian, wetland ecosystems are in better state	2+: medium positive relationship
f12	f13	when there is more water in watercourses and groundwater, water quality is of better quality mostly due to dilution of (potential) pollutants	2+: medium positive relationship; in the case of where net water quantities increase by moderate amounts, and surface water quality will generally improve as streams fill and dilute their pollutants
f12	f16	when more water is available for irrigation, agriculture production is higher	2+: medium positive relationship; spatially limited impact
f13	f12	if water is of better quality, more water is available for users (drinking water, water for irrigation and industry)	1+: weak positive relationship; one of the factor, but not the most important one - for domestic use raw water is being purified (due to

			nature of Hubelj (and Mrzlek) karst spring, used for drinking water, water is being purified with the help of water purification plant)
f14	f11	due to past regulations of watercourses and also due to improper intervention works on watercourses, aquatic, riparian and wetland ecosystems are not achieving e.g. good status according to Water framework Directive and natural habitats and habitats of species according to Habitats Directive	2-: medium negative relationship
f15	f8	if rainfed crop production is expanded or intensified, more wind damages occur due to expansion of arable land – in the past farmers alone have removed wind barriers that were introduced with Republic Green plan to expand the arable land – consequently more wind damages occur	1+: weak positive relationship
f15	f12	if rainfed crop production is expanded or intensified, the higher water uptake by plants and less water available for water-dependent ecosystems and sectors	2-: medium negative relationship
f15	f13	if rainfed crop production is expanded or intensified, water quality deteriorates due to the use of plant protection products and nutrients	1-: weak negative relationship; less pollution than from settlements (nutrients), but still present in Vipava RB, fungicides in fruit growing, Viticulture
f15	f17	if rainfed crop production is expanded or intensified, economic wealth gets higher – jobs guaranteed with higher income	1+: weak positive relationship
f16	f8	if irrigated crop production is expanded or intensified, more wind damages occur due to expansion of arable land – in the past farmers alone have removed wind barriers that were introduced with Republic Green plan to expand the arable land – consequently more wind damages occur	1+: weak positive relationship; limitations for vegetable crop production in closed areas (greenhouses) as wind tends to damage infrastructure
f16	f12	if irrigated crop production is expanded or intensified, less water is available for water-dependent ecosystems and sectors	2-: medium negative relationship; Water is used for irrigation that means irreversible water use. Irrigation crop production is present mostly in the lower part of the basin, near water reservoir Vogršček and where irrigation systems are present and functioning. In the upper part of the basin, irrigation of agricultural land is also present and the Vipava River is the only water source for irrigation
f16	f13	if irrigated crop production is expanded or intensified, water quality deteriorates due to the increased use of plant protection products and fertilizers	1-: weak negative relationship; less pollution than from settlements (nutrients), but still present in Vipava RB, fungicides in fruit growing, vegetable crop production
f16	f15	if irrigated crop production is expanded or intensified, area intended for rainfed crop production decreases – only if no expansion of arable land is planned	1-: weak negative relationship
f16	f17	if irrigated crop production is expanded or intensified, economic wealth increases – jobs guaranteed, self-sufficiency increases	1+: weak positive relationship; due to low purchase prices, agriculture crop productions is not so strong(e.g. peaches)

f17	f7	with increased economic wealth the expansion of settlement (individual houses) also occur and if the buildings extend into “problematic »terrain more landslides in periods of intense rainfall can occur due to inadequate regulation of storm water and hinterland water drainage	1+: weak positive relationship; spatially limited impact – on the slopes
f17	f12	if economic wealth gets higher and the population increases, domestic water use decreases water availability	1-: weak negative relationship; less water is used compared to the past, some SH say that due to the economic crisis people care more about the consumption
f17	f13	if economic wealth and the population increases, water quality deteriorates (more waste, waste waters) – in basin small and dispersed settlements have insufficient drainage and municipal wastewater treatment that are causing organic pollution of the surface water	2-: medium negative relationship
f17	f15	if economic wealth and population growth increases, rainfed crop production can be expanded or intensified due to increase in demand for food	1+: weak positive relationship
f17	f16	if economic wealth and population growth increases, irrigated crop production can be expanded or intensified due to increase in demand for food	1+: weak positive relationship
f18	f12	if the industrial production increases (heavy industry), water availability decreases – industry using a great amount of water (Fructal, Mlinotest, Tekstina) impacts water availability (where the same water source is being used - Vipava river, Hubelj spring)	1-: weak negative relationship; only if industry increases the consumption of water
f18	f16	if the industrial production increases (food processing industry, beverage production), irrigated crop production is expanded or intensified due to the increase in demand for crops	1+: weak positive relationship; industrial activities, food processing, beverage production purchase crops – right now as food processing industry is not so strong, low purchase prices for peaches allow only a small portion of irrigated crop production
f18	f17	if the industrial production increases, economic wealth together with population growth increases	1+: weak positive relationship; industrial activities (SME) are not so strong but still people work there and so the industry enables population development and economic wealth

Annex II

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

Water Management option 1

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

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

A Vipava river basin working group (WG) would be established to have an active role in water management with objectives of optimizing water use in sectors dependent on water availability through active involvement in planning sustainable techniques (water saving equipment) and water sources (alternative, more suitable techniques). The WG would be also involved in spatial planning of all involved Municipalities and so coordinating existing and planned interventions that have impact on flood safety and scope of droughts. The WG would have a role of active, promptly resolving conflicts of interest in spatial and water use (tourism, fisheries, agriculture) and would consist of experts of various fields (spatial planning, hydrology, nature conservation, economy, agronomy, agro meteorology, etc.) connected with competent state authorities (Ministrstvo za okolje in prostor (Ministry of the Environment and Spatial Planning) and its bodies Direkcija Republike Slovenije za vode (Slovenian Water Agency), Agencija Republike Slovenije za okolje in prostor (Slovenian Environmental Agency)).

Objectives of working group (WG) are:

- determination of objectives and targets to guide the development plans of the planning authorities;
- active in processes of Municipal Spatial Plan development with the aim to ensure sustainable water management (providing expert assistance in determining land and water use);
- to promptly discuss about present issues on Vipava River (and tributaries) and solving potential disagreement (conflicts) between stakeholders (conducting confrontations and seeking solutions);
- to propose new ideas, initiatives, projects that would encourage sustainable development in Vipava river basin;
- to improve communication between Municipalities and experts (better flows of information) and so ensure needed support in finding the optimal solution at the river basin level;
- to improve communication and collaboration between local and state authorities.

Reference

1st WS; (Session: Desired state, annex image 12 (Group C)) (Session: Options, annex image 18 (Group B), 19 (Group C))

Implementation in the FCM

- Changing the relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (- 0.6) to 1+ (0.3).
- Changing the relationship from Water infrastructure and forest management to Status of water infrastructure from 1+ (0.3) to 2+ (0.6)
- Changing the relationship from Water infrastructure management to Landslides in periods of intense rainfall from 1- (-0.3) to 2- (-0.6).

Cost estimation

The cost estimation is based on the following assumptions:

- The group is established in the first year, requiring 12 person-months; the animation during the following years requires 3 person-months per year;
- 2 one-day meetings are organised every year with 7 to 12 people.

Year	organization and animation	Meeting
	Person month	*unit*
2018	12	2
2019	3	2
2020	3	2
2021	3	2
2022	3	2
2023	3	2
2024	3	2
2025	3	2
2026	3	2
2027	3	2
2028	3	2
2029	3	2
2030	3	2

Unit cost of different actions in the option

Infrastructure /action	Unit	Unit cost
Animator - organization and animation	Eur/Person-month	3,078 [1]
Meeting (7 to 12 participants, 1 whole day + travel)	Eur/meeting	2,000

The total discounted cost: 138,506 euros (EUR 2018, discount rate: 5%).

[1] Ajpes 2014: http://www.ajpes.si/Statistike/Place_javni_sektor/Porocila/Arhiv - bruto letna plača*2(vključen strošek režije)

Water Management option 2

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

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

An awareness campaign would be launched to increase awareness of experts, involved in water management (concessionaires for river management) to use more sustainable techniques when designing interventions on water bodies. The campaign would also increase awareness of experts on impacts of the effects of hydromorphological pressures (inadequate implementation of construction works). Awareness campaign would be carried out in cooperation with experts in the field of ecology. The objectives of the awareness campaign are:

- to promote sustainable techniques when planning interventions on watercourses;
- to initiate several activities to enhance and exchange knowledge of best water management practices and raise awareness among the experts regarding the effects of continued unsustainable water management;
- to disseminate existing practices on watercourse management, design and functioning of water infrastructures together with suggestions for improvements, technical guidelines to handle properly interventions on water infrastructures and aquatic and riparian areas, share information about events, contributions, scientific articles related to water management in Slovenia and around the world.

Reference

1st WS (Session: Challenges and issues, annex image 1 (water use)). Interviews: (Challenges, interviewee no. 14). RBMP (NUV I, 2011) - measure DUPPS3

Implementation in the FCM

- Changing the relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (-0.6) to +0.1.
- Changing the relationship from Water infrastructure management to Status of water infrastructure from 1+ (0.3) to 2+ (0.6).
- Changing the relationship from Water infrastructure management to Landslides in periods of intense rainfall from 1- (-0.3) to 2- (-0.6).

Cost estimation

The Institution leading the awareness campaign would need to:

- Prepare and manage a communication strategy: prepare and disseminate publications, organize events, maintain a website, social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year;
- Create the website and the database (first year);
- Collect information and produce material for the first period (2.5 person-months);
- Organize 1 workshop in the basin every year, stating from year 2;
- Review, analyse and synthesise best management practices every 5 year, publish them and prepare the content for the seminars (6 person-months and 1 publication, 100 copies)

Year	Communication	Scientific review and analysis	Workshop	Website	Publication
	Person-month	*Person-month*	*unit*	*unit*	*unit*
2018	12	2.5		1	
2019	3		1		
2020	3		1		
2021	3		1		
2022	3	6	1		1
2023	3		1		
2024	3		1		
2025	3		1		
2026	3		1		
2027	3	6	1		1
2028	3		1		
2029	3		1		
2030	3		1		

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Communication expert / Scientist	Eur/Person-month	3,795
Meetings, workshops (organisation, support, infrastructure)	Eur/unit	3,100
Website (design, conception and domain name)	Eur/unit	2,000
Publication (design and printing, 30 to 40 pages, 100 copies)	Eur/publication	5,080

The total discounted cost: 226,277 euros (EUR 2018, discount rate: 5%).

Water Management option 3

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

Challenge(s) targeted: Water availability during droughts, Appropriate water quality

Description

An awareness campaign would be launched to increase awareness among farmers to: 1) move towards a sustainable agricultural production, to optimize water use and reduce the use of fertilizers and plant protection products;2) irrigate agricultural land in more sustainable way with the help of decision support system (optimal, targeting the type of crop and soil type) that can result also in reducing pollution of surface and groundwater caused by washouts of nutrients, fertilizers and plant protection products; 3) use climate-smart agriculture practices and 4) to minimize the effects of hydromorphological pressures by avoiding or adjusting cultivating land near watercourses (in protected zones of watercourses). The objectives of awareness campaign are:

- to promote sustainable agricultural production and good agricultural practice to minimize the pollution of water from agriculture;
- to promote optimal and rational ways of using water for irrigation by teaching proper use of irrigation systems, in a way that does not result in unexpected negative impacts on the environment; to help farmers that irrigate to improve functioning of the existing irrigation systems
- to initiate several activities to enhance the water management practices of farmers and raise awareness among the farmers regarding the effects of continued unsustainable watering;
- to promote climate-smart agriculture practices to raise farmers and agriculture resilience and increase self-sufficiency;
- disseminate good practices with the aim of building the capacity of farmers and technical experts;
- to share information about events, contributions, scientific articles related to irrigation in Slovenia;
- etc.

Reference

1st WS (Session: Challenges and issues, annex image 1 (water use), 2 (sectoral challenge)) (Session: Desired state, annex image 15 (Group D)) (Session: Options, annex image 19 (Group C, food production)).

Implementation in the FCM

- Changing the relationship from Irrigated crop production to Water quality from 1- (-0.3) to - 0.1.
- Changing the relationship from Water availability to Irrigated crop production from 2+ (+0.6) to 1+ (+0.3).

Cost estimation

The Institution leading the awareness campaign would need to:

- Prepare and manage a communication strategy: prepare and disseminate publications, organize events, maintain social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year;
- Review and prepare a report on existing agricultural practices together with suggestions for improvements (first year, 4 person-months);
- Review, analyse and synthesise best management practices (technical guidelines for proper agricultural practices) every 3 years from year 1 on (3 person-months, 1 publication, 500 copies);
- Organize 1 workshop in the basin every year, stating from year 2;
- Collect and disseminate best management practices on existing agriculture events like AGRA (International Fair Of Agriculture and Food), seminars, workshops, conferences, symposiums, demonstrations (demo-sites), study tours and promote active participation of farmers in Vipava RB on existing events from year 2 (1.5 person-months, travel costs).

Year	Communication	Scientific review and analysis	Workshop	Travel	Publication
	Person-month	*Person-month*	*unit*	*unit*	*unit*
2018	12	7			1
2019	3	1.5	1	1	
2020	3	1.5	1	1	
2021	3	4.5	1	1	1
2022	3	1.5	1	1	
2023	3	1.5	1	1	
2024	3	4.5	1	1	1
2025	3	1.5	1	1	
2026	3	1.5	1	1	
2027	3	4.5	1	1	1
2028	3	1.5	1	1	
2029	3	1.5	1	1	
2030	3	4.5	1	1	1

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Communication expert / Scientist	Eur/Person-month	3,892
Meetings, workshops (organisation, support, infrastructure)	Eur/unit	3,100
Publication (design and printing, 30 to 40 pages, 500 copies)	Eur/publication	5,400
Travel costs (existing agriculture events like AGRA (International Fair Of Agriculture and Food), seminars, workshops, conferences, symposiums, demonstrations)	Eur/unit	200

The total discounted cost: 316,408 euros (EUR 2018, discount rate: 5%).

Water Management option 4

Awareness campaign for local public on impact of their activities on the river

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

An awareness campaign would be launched to increase awareness of the general public on the impacts of biological, chemical, hydrological and morphological pressures (due to legal and potential illegal water abstractions and impoundments of water, inadequate interventions in the riverbed), biological pressures (due to introduction of non-native (animal and plant) species into the environment), impacts of various pollution sources, etc. Objectives of awareness campaign are:

- to prepare programs for informing the public depending target audience (local society, high schools, elementary schools) - it is recommended to use strong visualization, audio-visual material;
- to accept and follow programs together with local schools and local communities;
- to prepare and share information on sustainable water management (including water use) – in form of audio-visual material of natural processes, including climate changes and climate-resilient water management practices;
- to organize campaign in form of panels, lectures in schools and local communities;
- to involve schools into implementation of smaller projects, related to Vipava RB (example of such a project – creation of learning paths (polygons) or by making a model of Vipava RB for better understanding of natural processes and effects of different land management practices on water flows, erosion, etc.);
- to organize on yearly basis at least one field trip that will include aquatic environment (where participants will have the possibility to use simple measuring devices to determine the basic parameters of the water (flow, T, pH, dissolved oxygen)), also by observation of riparian vegetation and small animals);
- to actively (ongoing process) collect examples of good practice and present them on webpage, seminars, workshops, conferences, symposiums, demonstrations, study tours;
- to share information about events, contributions, scientific articles related to sustainable water use in Slovenia and other countries;
- to promote optimal and rational ways of water management and urban land development for higher quality of life and healthy living environment by taking into account the latest state of the art in the field of science and technology;
- to teach of proper water use, in a way that does not result in unexpected negative impacts on the environment;
- to initiate several activities to enhance the water management practices of local public and raise awareness among the community regarding the effects of continued unsustainable water use;
- etc.

Topics that need to be considered are:

- water related challenges in Slovenia, focusing on Vipava RB, including climate changes,
    - needs (different water users), conflicts (between users), constrains that need to be considered (floods, Natura2000 sites, waterprotection zones) in Vipava RB.
- cause/effect relation (different pressures or modifications in relation to their impacts; mitigation measures planning);
    - impact of the hydromorphological pressures on aquatic, riparian ecosystems,
    - impacts of non-native species on aquatic, riparian ecosystems,
    - impacts of various pollution sources on water quality.

Reference
1st WS (Session: Challenges and issues, annex image 1 (regulation of water…, water use), 2 (sectoral challenge), 3 (communication)) (Session: Desired state, annex image 9, 10 and 11 (Group B)) (Session: Options, annex image 17 (Group A), 18 (Group B)). Interviews: (Challenges and other remarks, interviewee no. 11 and 12).

Implementation in the FCM

- New factor »Increased awareness of population« linked to Water availability with the strength of 1+ (+ 0.3).
- New factor »Increased awareness of population« linked to Water quality with the strength of 1+ (+ 0.3).
- New factor »Increased awareness of population« linked to Landslides in periods of intensive rainfall with the strength of 1- (- 0.3).
- New factor »Increased awareness of population« linked to Flood damages with the strength of 1- (- 0.3).

Cost estimation
Institution leading awareness campaign would need to:

- Prepare and manage a communication strategy: prepare and disseminate publications, organize events, maintain social networks and a database of stakeholders: 12 person-months in the first year, then 3 person-months per year;
- Prepare audio-visual material in form of documentary film with the objective to present water related challenges in Slovenia, focusing on Vipava RB, including climate changes (approx. 20 to 30 minutes long film can cost about 5,000.00 to 10,000.00 euros);
- Participate in existing events from year 2 on (2 events per year, travel cost for 2 persons, person months already included in communication strategy) and to be included in educational programs (3 schools, twice a year, travel cost for 2 persons, person months already included in communication strategy);
- Preparation of information panels on key points of Vipava RB (9 information panels, in year 1, maintenance: 5% of implementation costs).

Year	Communication	Documentary film	Travel (events, schools)	Information panels	Maintenance cost of information panels
	Person-month	*unit*	*unit*	*unit*	*unit*
2018	12	1		1	
2019	3		2		1
2020	3		2		1
2021	3		2		1
2022	3		2		1
2023	3		2		1
2024	3		2		1
2025	3		2		1
2026	3		2		1
2027	3		2		1
2028	3		2		1
2029	3		2		1
2030	3		2		1

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Communication expert / Scientist	Eur/Person-month	3,795
Documentary film (approx. 20 to 30 minutes long film can cost about 5,000.00 to 10,000.00 euros)	Eur/unit	7,500
Travel (events, schools)	Eur/unit	200
Information panels (9 information panels)	Eur/9 information panels	20,695
Maintenance cost of information panels	Eur/unit	1,000

The total discounted cost: 187,052 euros (EUR 2018, discount rate: 5%).

Water Management option 5

Improve the financing system for water infrastructure

Challenge(s) targeted: Water availability during droughts, Flood risk reduction

Description

Through changes in legislation, this option aims to improve and optimize the system of financing water infrastructure from the national Water fund; with the introduction of dedicated funding to finance measures to help achieve the objectives of water management and River Basin Management Plan. This option can result in the sustainability of water infrastructure, prevention instead of recovery, sustainable flood protection and higher life quality, reducing the damage caused by floods and droughts to different sectors (meaning also maintenance of Vogršček water reservoir to help prevent damages to the agriculture in growing season).

Reference

1st WS (Session: Challenges and issues, annex image 4 (funding), 5 (Questions and comments)) (Session: Desired state, annex image 6 (Group A)) (Session: Options, annex image 18 (Group B)). Interviews: (Challenges, interviewee no. 9). RBMP (NUV I, 2011) - measures 1ET, DDU19

Implementation in the FCM

- Changing the relationship from Water infrastructure and forest management to Status of water infrastructure from 1+ (+ 0.3) to 2+ (+ 0.6).
- Changing the relationship from Water infrastructure management to Landslides in periods of intense rainfall from 1- (-0.3) to 2- (-0.6).

Cost estimation

There are different ways to improve system of financing water infrastructure (all of the bellow proposed actions need to be explored further on):

- If other uses, different from the one that water infrastructure was designed and build for, are present, they must contribute financially to maintain[2] the water infrastructure.
    - Explaination - Reservoir Vogršček is financed from two sources according to its specified primary (irrigation) and secondary use (flood protection). Other uses of water reservoir – e.g. tourism and fishery do not contribute to the financing scheme.
    - Preparation of expert bases for the purpose of determination of contribution key. Good basis for information is measure DDU19 (RBMP – NUVI - http://www.izvrs.si/pregledovalnik_vtpv/maske/DDU/DDU19.pdf) – 6 person months in year 1;
    - Preparation of contracts with users of the water infrastructure (in accordance with article 48. of waters Act – ZV-1). Pre-action is to identify this users! This information can be gained from measure DDU19 (RBMP – NUVI) – 6 person months in year 1;
    - Performance of the obligations determined in contracts – 1 person months from year 2 on.
- Municipalities get annualy on average 60% of the funds contributed by the concession (water rights). The purpose of the use of these funds in municipal budget is not prescribed. The proposal is to prepare legal basis for eligible use of funds and that is for achieving the objectives of water management.
    - Amendment of Financing of Municipalities Act (http://www.pisrs.si/Pis.web/pregledPredpisa?id=ZAKO385) on the basis of expert analysis (Report for measure 4ED, 2013). The initiative must come from Ministry responsible for the environment but it is the Ministry responsible for finances that must amend the Act – 7 person months, year 1;

[2] Not just costs for maintanence but also operating, capital (new investments) and administrative cost (source: WFD CIS Guidance Document No. 1 Economics and the Environment – The Implementation Challenge of the Water Framework Directive, page 118, http://ec.europa.eu/environment/water/water-framework/economics/pdf/Guidance%201%20-%20Economics%20-%20WATECO.pdf)

- Performance of amended Act – Municipalities contribute funds for all the objectives of article 2. of Waters Act; collaboration with Water Fund of the Ministry responsible for environment to set priorities for measures needed for achieving the objectives of water management. No additional costs are expected for this action.

- Improving the system of financing water infrastructure from the national Water fund; with the introduction of dedicated funding to finance measures to help achieve the objectives of water management and RBMP, optimize use of resources, increase the realization the use of funds with respect to the eligible use of funds and an increase in personnel capacities.
  - Expert basis/analysis have been already prepared (Report for measure 4ED, 2013) to help analyse all relevant policy instruments that affect financing of Water Fund and propose proper changes to help achieve the objectives of water management and RBMP, optimize use of resources, increase the realization the use of funds with respect to the eligible use of funds and an increase in personnel capacities. No additional costs are expected for this action.
  - Amendments of policy instruments mentioned in Report 4ED. The initiative must come from Ministry responsible for the environment. Depending on proposition for amendments of different policy instruments, other ministries start the process on changing the legislation – 7 person months, year 1.
  - Performance of amended policy instruments in Annual Programme of the Water Fund. No additional costs are expected for this action as the programme is existing task of Water Fund.
- Assessment of the possibility of co-financing of water infrastructure from the EU funds, Operational Programme Cohesion Policy (2014 - 2020) and the transnational and cross-border programs.Co-financing of water infrastructure:
  - To make an analysis of possible EU Funds, Operational Programme Cohesion Policy (2014 - 2020) and the transnational and cross-border programs. The analysis to be performed on regional level due to better knowledge on what issues need to ne addressed – 4 person months, year 1, year 4.

Year	Expert basis/analysis	Contracts with users/ Performance of the obligations	Eligible use of municipal funds	Financing Water Fund	Co-financing of Water Infrastructure
	Person-month	*Person-month*	*Person-month*	*Person-month*	*Person-month*
2018	6	6	7	7	4
2019		1			
2020		1			
2021		1			4
2022		1			
2023		1			
2024		1			
2025		1			
2026		1			
2027		1			
2028		1			
2029		1			
2030		1			

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Expert basis / analysis and Co-financing of Water Infrastructure	Eur/Person-month	3,892
Contracts with users/ Performance of the obligations / Eligible use of municipal funds / Eligible use of municipal funds	Eur/Person-month	4,374

The total discounted cost: 178,610 euros (EUR 2018, discount rate: 5%).

Water Management option 6

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

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

Option aims to upgrade the monitoring network for the state of the water environment as there is a need for a good and representative monitoring of hydrological, biological and water quality-based parameters, possible meteorological and agro-meteorological parameters. This option aims to upgrade also the existing monitoring stations together with establishment of additional ones for water quality and hydrological, meteorological measurements. More representative data can help to better understand the current situation in the Vipava river basin and so improve planning measures to improve the river basin management.

Reference

Interviews: (Desired state, interviewee no. 11), (Challenges, interviewee no. 16). RBMP (NUV I, 2011) - measures ON16

Implementation in the FCM

- Changing the relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (-0.6) to +0.1

Cost estimation

Investor must follow next step when implementing new monitoring stations:

- Planning of monitoring stations (Review of all existing monitoring stations and their status, review of BOBER outcomes and what still needs to be covered. Determination of priority areas and existing monitoring stations that need to be implemented/upgraded. Also need to check if implementation of monitoring stations is allowed in Municipal spatial plans) – 1 person month/station.
  - (Investor) plans monitoring stations in following steps ("plan"):
    - searching of plots,
    - searching for servitudes and consents (a consent of the owner in the form of easement agreements (slo: "služnostna pogodba")) with surveying snapshot,
    - Designing (dimensioning) and determine fixed boundary conditions (designing engineering base) with the help of hydraulic calculations (for monitoring stations on watercourses).
- Preparation of project documentation – 0.5 person months/station.

According to expert knowledge:

- Average cost of building up (including project engineering, construction and craft works, engineering and control, connection to electricity) of one hydrological monitoring station for surface waters (watercourses) is approx. 35,000.00 EUR[3].
- A meteorological station has a bigger price than hydrological monitoring station for surface waters, approx. 40,000.00 to 50,000.00[4] EUR. When talking to Mr. Štucin, he indicated that additional meteorological stations in Vipava Valley are not needed. Hence, we will not include them in the WMO.
- Monitoring station for water quality (not fixed, no construction needed, but laboratory analysis included):
  - Ecological status:
    - Invertebrates: 1,000.00 EUR/location,
    - algae: 1,000.00 EUR/location,

[3] ARSO, Roman Trček, telephone call, 8.9.2015
[4] ARSO, Filip Štucin, telephone call, 9.9.2015

- fish; 2,000.00 EUR/location,
- macrophites: 1,000.00 EUR/location
- chemical parameters: 1,000.00 EUR/location.

- Chemical status (priority substances and certain other pollutants)[5]:
  - 1 sample of water: 1,580 EUR (without VAT) = 1,927.6 EUR/location
  - 1 sample of sediment: 1,565 EUR (without VAT) = 1,909.3 EUR/location
  - 1 sample of biota: 1,085 EUR (without VAT) = 1,323.7 EUR/location

Year	Expert basis/analysis	Preparation of project documentation	Hvdrological station	Ecological state	Chemical state	Maintenance
	Person-month	*Person-month*	*Eur/station*	*Eur/station*	*Eur/station*	*Eur*
2018	1	1	1			
2019				4	4	3,117
2020						6,465
2021						6,465
2022						6,465
2023						6,465
2024						6,465
2025						6,465
2026						6,465
2027						6,465
2028						6,465
2029						6,465
2030						6,465

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Planning of monitoring stations (expert basis/analysis)	Eur/Person-month	4,374
Preparation of project documentation	Eur/Person-month	4,374
Implementation of Hydrological station (1 station)	Eur/station	35,000
Implementation of Monitoring station for water quality (4 stations) - Ecological state	Eur/station	6,000
Implementation of Monitoring station for water quality (4 stations) - Chemical state	Eur/station	5,160
Maintenance cost as a share of investment costs (starting from the year following the implementation)	% of implementation cost	7.5

The total discounted cost: 491,330 euros (EUR 2018, discount rate: 5%).

[5] ARSO, Mojca Dobnikar Tehovnik, e-mail on 29. September 2015. Reference on DIRECTIVE 2008/105/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on environmental quality standards in the field of water policy, amending and subsequently repealing Council Directives 82/176/EEC, 83/513/EEC, 84/156/EEC, 84/491/EEC, 86/280/EEC and amending Directive 2000/60/EC of the European Parliament and of the Council.

Water Management option 7

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

Challenge(s) targeted: Water availability during droughts, Appropriate water quality

Description

This option aims to set up monitoring of hydromorphological pressures on aquatic ecosystems to ensure appropriate water management. With this option, more comprehensive data supporting water management regarding pressures will be obtained, meaning legal and potential illegal water abstractions and impoundments of surface water. Verifying actual water consumption at holders of water rights during a period of low natural flows. Verifying of possible illegal abstractions and impoundments.

Reference

RBMP (NUV I, 2011) - measures R1, BI3

Implementation in the FCM

- Changing the relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (-0.6) to 1- (-0.1)
- Changing the relationship from Drought occurrences in growing season to Rainfed crop production from 3- (-0.9) to -1.

Cost estimation

Actions that need to be followed:

- Verifying existing water rights in Vipava RB – 0.25 person month;
- Verifying actual water consumption at holders of water rights during a period of low natural flows. Verifying of possible illegal abstractions, impoundments during a period of low natural flows – 1 person month (woth field trip);
- Measurements on selected locations, analysis of the results and the written report – 4 person month;
- If needed, proposal of measures to the Government: for example - adjustment of already acquired water rights in order to reduce negative impacts on the aquatic ecosystems / penalties for possible illegal water abstractions – 0.5 person month.

These actions (1 to 4) are repeated every 5 years, starting year 1.

Year	Existing water rights	Actual water consumption	Measurements, report	Proposal of measurements
	Person-month	*Person-month*	*Person-month*	*Person-month*
2018	0.25	1	4	0.5
2019				
2020				
2021				
2022				
2023	0.25	1	4	0.5
2024				
2025				
2026				
2027				
2028	0.25	1	4	0.5
2029				
2030				

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Existing water rights/ Actual water consumption/ Measurements, report/ Proposal of measurements	Eur/Person-month	5,107

The total discounted cost: 65,507 euros (EUR 2018, discount rate: 5%).

Water Management option 8

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

Challenge(s) targeted: Water availability during droughts, Flood risk reduction

Description

With construction of water reservoirs, high waters can be retained and accumulated in the colder part of the year (e.g. autumn peak of precipitations) in the upper part of the Vipava river basin. When high waters occur due to short but heavy rainfall, water retention in the upper part of river basin can minimize floods downstream. In the warmer part of the year (spring, summer) accumulated water can represent a water resource for two main purposes: 1) for irrigation of agricultural land and so avoiding agricultural drought and 2) water source in the function of enriching low waters by maintaining environmentally acceptable flow downstream and so avoiding hydrological drought. If not in conflict they can be planned as multifunctional reservoirs with possibility of e.g. developing tourism activities.

Reference

1st WS; (Session: Challenges and issues, annex image 1, 4) (Session: Desired state, annex image 6 (Group A), 7 (Group A), 12 (Group C), 15 (Group D)) (Session: Options, annex image 17 (Group A), 20 (Group D)). OPN Ajdovščina (planned accumulation Košivec) - Supplemented draft of Ordinance of the Municipal Spatial Plan of the Municipality of Ajdovščina (June 2014, article 66.)

Implementation in the FCM

- New factor "Water reservoirs on watercourses" linked to Water availability with the strength of 3+ (+ 0.9).
- New factor "Water reservoirs on watercourses" linked to Flood damages with the strength of 2+ (– 0.6).
- New factor "Water reservoirs on watercourses" linked to Status of aquatic, riparian, wetland ecosystems with the strength of 1- (-0.3).

Cost estimation

In "Development Plan for irrigation till 2020" (http://www.mkgp.gov.si/si/medijsko_sredisce/novica/article/12981/8134/7772a9c158dadc251c895e148c3b1241/) following water reservoirs are planned in Vipava RB (priorities till year 2020):

- Košivec – in municipality Ajdovščina, volume 1.176 million m^3 (is also object of land use changes in municipal spatial plan),
- Vrnivec – in municipality Ajdovščina, volume 1 million m^3,
- Svinjšček – in municipality Ajdovščina, volume 1 million m^3,
- Pasji rep – in municipality Vipava, volume 2.5 million m^3.

Main costs have been determined with the help of last known implementation costs of water reservoir Košivec. The costs consist of:

- Purchase of land (separately for each location);
- Preparation of project documentation (separately for each location) (8 % of investment costs)[6];
- Implementation of water reservoirs (all 4 reservoirs separately implemented, year 2, year 4, year 6, year 8);
- Maintenance (2 % of investment costs)[7].

[6] Merila za vrednotenje inženirskih storitev, marec 2012: http://www.izs.si/fileadmin/dokumenti/pravilniki/MVIS-marec-2012-potrjen-29-skupscina-objava-www.pdf

[7] http://www.sos112.si/slo/tdocs/naloga_97.pdf, page 39

Year	Project documentation	Implementation costs (with land purchase)	Maintenance costs
	Eur	*Eur*	*Eur*
2018	405,346		
2019		5,066,821	
2020	167,200		101,336
2021		2,090,000	101,336
2022	167,200		143,136
2023		2,090,000	143,136
2024	780,664		184,936
2025		9,758,300	175,408
2026			370,574
2027			370,574
2028			370,574
2029			370,574
2030			370,574

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Maintenance cost as a share of investment costs (starting from the year following the implementation)	% of implementation cost	2 %

The total discounted cost: 18,292,910 euros (EUR 2018, discount rate: 5%).

Water Management option 9

Construction of dry reservoirs

Challenge(s) targeted: Flood risk reduction

Description

With construction of dry reservoirs, high waters in the colder part of the year (e.g. autumn peak of precipitations) can be retained till the water flow normalises. Water retention in the upper and lower part of the river basin would solve problems with floods downstream. If dry reservoirs would be built along watercourses, this option would represent a more sustainable solution then building dry reservoirs on watercourses.

Reference

1st WS; (Session: Options, Map Group C). Interviews: (Desired state, interviewee no. 1)

Implementation in the FCM

- New factor “Dry reservoirs” linked to Flood damages with the strength of 2- (– 0.6).

Cost estimation

No data on the potential locations of dry reservoirs for Vipava RB exist. A very crucial part for this option would be performing analysis of existing data on floods (significant flood areas plus all areas, where floods are present) and analysis of interventions for reducing flood risk that is already in place (through concessions) together with review of planned activities (Ministry responsible for environment – slo: “Načrt zmanjševanja poplavne ogroženosti pred poplavami (NZPO)”). Afterwards priority areas of constructions of dry reservoirs that will retain high waters and prevent floods downstream need to be determined, taking into account the objectives of the Water and Floods directive.

- Indicated by one of our stakeholders indicates the duration of an analysis: 6 months, cost around 100,000.00 Eur (depends on defining requirements in the "project idea", where (area of influence), "what" problem with what purpose, etc. “Without this informaton it is almost impossible to estimate the time and duration, as this may vary from .. 20,000.00 to ... 250,000.00 Eur.” For the purpose of cost assessment we estimated the cost of analysis 140,000.00 Eur.

As no projects on potential dry reservoirs exist for Vipava RB, we looked 1) at locations of dry reservoirs that were proposed in 1st workshop by stakeholders and 2) checked if any study of similar dry reservoir was made with costs assessed in Slovenia and prepared a rough estimation of implementation costs. It has to be pointed out that costs of implementation of dry reservoirs are not simple and should be carried out for each of the proposed reservoir separately. Each placement is specific. The cost depends on the measures to be taken for the reservoir, so it can also serve its purpose (type of barrier, the need for sealing the bottom, the quantity of material for the barrier, mitigation measures, etc. ...).

The main costs consist of:

- Integrated analysis for potential location for dry reservoirs (year 1);
- Purchase of land (separately for each location, land must be purchased where the barrier will stand);
- Preparation of project documentation (separately for each location) (8 % of investment costs)[8];
- Implementation of dry reservoirs/barriers (4 dry reservoirs, year 2, year 4, year 6, year 8);
- Maintenance (2 % of investment costs)[9].

[8] Merila za vrednotenje inženirskih storitev, marec 2012: http://www.izs.si/fileadmin/dokumenti/pravilniki/MVIS-marec-2012-potrjen-29-skupscina-objava-www.pdf

[9] Different sources indicated different % of maintainance costs. They vary from 0,25 % and all up to 3,6 %.

Year	Expert analysis	Project documentation	Implementation costs (with land purchase)	Maintenance costs
	unit	*Eur*	*Eur*	*Eur*
2018	1			
2019		102,400		
2020			1,280,000	
2021		37,920		25,600
2022			474,000	25,600
2023		41,600		35,080
2024			520,000	35,080
2025		320,000		45,480
2026			4,000,000	45,480
2027				125,480
2028				125.480
2029				125,480
2030				125,480

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Expert analysis	Eur/unit	140,000
Maintenance cost as a share of investment costs (starting from the year following the implementation)	% of implementation cost (Eur)	2 %

The total discounted cost: 5,637,741 euros (EUR 2018, discount rate: 5%).

Water Management option 10

Reconstruction of existing water reservoir Vogršček

Challenge(s) targeted: Water availability during droughts

Description

With reconstruction of exsisting water reservoir Vogršček in the lower part of Vipava river basin, this options aims to improve the operation of reservoir Vogršček and its associated facilities. Good status of water reservoir Vogršček is the precondition for a well-functioning and optimal utilization of the irrigation system. The impact of this option will be more efficient irrigation of agricultural land in lower part of the river basin that can prevent agricultural drought, enable cleaner water for irrigation and healthier local food production.

Reference

1st WS; (Session: Challenges and issues, annex image 4, reduction of droughts) (Session: Desired state, annex image 9 (Group B), 12 (Group C)). (Session: Options, annex image 18 (Group B - remediation of a.Vogršček). Interviews: (Challenges, interviewee no. 11)

Implementation in the FCM

- Changing relationship from Water infrastructure and forest management to Status of water infrastructure from 1+ (+0.3) to 2+ (+0.6).

Cost estimation

Ministry responsible for environment is with “Conceptual plan” (slo: “projektna naloga” of terms of reference) already in process of public procurement[10] for Reconstruction of barrier Vogršček and its accompanying facilities. In conceptual plan, project and investment documentation for obtaining a building permit must be prepared (construction works carried by a contractor). We used last known estimated cost of restoration works of the reservoir[11] from year 2013. The costs consist of:

- Preparation of project documentation (8 % of investment costs)[12];
- Implementation of reconstruction works;
- Maintenance (2 % of investment costs)[13] – here we also took into account existing costs of maintaining the reservoir Vogršček (100,000 Eur/year).

Year	Project documentation	Implementation costs	Maintenance costs
	unit	*unit*	*unit*
2018	1		
2019		1	
2020			1
2021			1
2022			1
2023			1
2024			1
2025			1
2026			1
2027			1
2028			1
2029			1
2030			1

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Project documentation - 8 % of implementation cost	Eur/unit	344,000

[10] MOP, september 2015: http://www.mop.gov.si/si/javne_objave/javna_narocila/?tx_t3javnirazpis_pi1%5Bshow_single%5D=1011

[11] MKO, 2013. Uvrstitev projektov: »Protipoplavni ukrepi ob Voglajni s pritoki v Šentjurju – faza B« in »Sanacija pregrade Vogršček s pripadajočimi objekti« v načrt razvojnih programov za obdobje 2013-2016 – predlog za obravnavo. Št. Zadeve: 355-51/2013 z dne 24.9.2013: http://vrs-3.vlada.si/MANDAT13/vladnagradiva.nsf/aa3872cadf1c8356c1256efb00603606/a27506e48f0ade61c1257bf6002534fd/$FILE/vogrscek2.DOC (september, 2015)

[12] Merila za vrednotenje inženirskih storitev, marec 2012: http://www.izs.si/fileadmin/dokumenti/pravilniki/MVIS-marec-2012-potrjen-29-skupscina-objava-www.pdf

[13] http://www.sos112.si/slo/tdocs/naloga_97.pdf, page 39

Implementation costs (land purchase included)	Eur/unit	4,300,000
Maintenance cost as a share of investment costs (starting from the year following the implementation) - 2 % of implementation cost	Eur/unit	- 14,000

The total discounted cost: 4,428,486 euros (EUR 2018, discount rate: 5%).

Water Management option 11

Development of new irrigation systems

Challenge(s) targeted: Water availability during droughts

Description

This option develops/implements new irrigation systems, derived from the existing water reservoir Vogršček or from other planned water reservoirs (e.g. Košivec, Vrnivec, Svinjšček, Pasji rep). This measure can prevent agricultural drought and consequently reduce the damage caused in the agriculture and consequently, also increase self-sufficiency in food. Also cleaner and more appropriate water for irrigation means reducing the risk of contamination and consequently healthier local food production. The establishment of proper irrigation systems, new technologically more efficient and equipped with proper agrometeorological support with sensors for optimal irrigation, targeting the type of crop and soil, and also reducing water consumption caused by inappropriate irrigation techniques.

Reference

1st WS; (Session: Challenges and issues, annex image 3 (Water use), 4 (drought prevention)), (Session: Desired state, annex image 6 (Group A), 12 (Group C), 15 (Group D)), (Session: Options, annex image 19 (Group C)). Interviews: (Desired state, interviewee no. 4). Interviews: (Challenges, interviewee no. 4). Also measure in PRP 2007 - 2013: Measure 121 (http://www.program-podezelja.si/images/phocadownload/Arhiv_PRP_2007-2013/prp_2007_2013_6_sprememba.pdf). PRP 2014 - 2020: not yet adopted, submeasure 4.1 and 4.3 (http://www.program-podezelja.si/images/PRP14-20.pdf)

Implementation in the FCM

- New factor “Irrigation systems” linked to factor “Irrigated crop production” with strength of 2+ (+0.6) (smaller strength due to spatial limitations, wind, soil type, crop type)

Cost estimation

Steps that need to be considered:

- Preparation of project documentation (8 % of investment costs);
- Implementation of new irrigation systems (For cost assessment we decided to take into account data from “Action plan for the development of irrigation in the RS until 2020”[14] on planned new irrigation systems for 2,700.00 ha of net agricultural land. Action plan also financially evaluated the measure based on information on funds of rural development program (2007 - 2013) intended for the construction of new irrigation systems. It has been estimated that 6,046.00 €/ha is the cost of new irrigation system.);
- Maintenance (2 % of investment costs) starting from the year following the implementation.

Plan for implementation of new irrigation systems (according to Action plan and information based on one of our stakeholders in the field of agricultural consultancy):

- Irrigation system from water reservoir Vogršček with area 1,080 ha:
  - project documentation in year 1,
  - implementation in year 2.
- Irrigation system from water reservoir Košivec with area 600 ha:
  - project documentation in year 3,
  - implementation in year 4.
- Irrigation system from water reservoir Vrnivec with area 1,107 ha:
  - project documentation in year 5,
  - implementation in year 6.
- Irrigation system from water reservoir Svinjšček with area 188 ha:
  - project documentation in year 7,

[14] Načrt ukrepov za razvoj namakanja v RS do leta 2020: http://www.mkgp.gov.si/fileadmin/mkgp.gov.si/pageuploads/osnutki/2015/Nacrtnamakanjajuni2015.pdf

- implementation in year 8.

- Irrigation system from water reservoir Pasji rep with area 822 ha:
  - project documentation in year 9,
  - implementation in year 10.

Year	Project documentation	Implementation costs	Maintenance costs
	ha	*ha*	*ha*
2018	1,080		
2019		1,080	
2020	600		1,080
2021		600	1,080
2022	1,107		1,680
2023		1,107	1,680
2024	188		2,787
2025		188	2,787
2026	822		2,975
2027		822	2,975
2028			3,797
2029			3,797
2030			3,797

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Project documentation 8 % of implementation cost	Eur/ha	484
Implementation costs (unit is in ha)*	Eur/ha	6,046
Maintenance cost as a share of investment costs (starting from the year following the implementation) - 2 % of implementation cost	Eur/ha	121

The total discounted cost: 22,500,811 euros (EUR 2018, discount rate: 5%).

Water Management option 12

Reconstruction of existing irrigation system

Challenge(s) targeted: Water availability during droughts

Description

This option aims to replace the current irrigation network from water reservoir Vogršček to arable land. The existing irrigation systems are outdated, inappropriately managed and this results in unsustainable use of water for irrigation (pipes are leaking - loss of water, the lack of pressure in the system, etc.). This measure can prevent agricultural drought and consequently reduce the damage caused in the agriculture and consequently, also increase self-sufficiency in food. Also cleaner and more appropriate water for irrigation means healthier local food production. The establishment of proper irrigation systems, new technologically more efficient and equipped with proper agrometeorological support or modernization of existing irrigation systems with sensors for optimal irrigation, targeting the type of crop and soil, and also reducing water consumption caused by inappropriate irrigation techniques (sprinklers vs drip irrigation).

Reference

1st WS; (Session: Desired state, annex image 9 (Group B), 12 (Group C)). (Session: Options, annex image 18 (Group B - remediation of a.Vogršček). Interviewees: (Challenges, interviewee no. 4). Also measure in PRP 2007 - 2013: Measure 121 (http://www.program-podezelja.si/images/phocadownload/Arhiv_PRP_2007-2013/prp_2007_2013_6_sprememba.pdf). PRP 2014 - 2020: not yet adopted, submeasure 4.1 and 4.3 (http://www.program-podezelja.si/images/PRP14-20.pdf)

Implementation in the FCM

- Changing relationship from Irrigated crop production to Water quality from 1- (-0.3) to -0.1.
- Changing relationship from Water availability to Irrigated crop production from 2+ (+0.6) to 1+ (+0.3) (as you are making agriculture less dependent on water)

Cost estimation

Steps that need to be considered:

- to review status of existing irrigation systems, needs and scope of the needed reconstruction works – 3 person month, year 1;
- Preparation of project documentation (8 % of investment costs), year 1;
- Reconstruction works in year 2 - for cost estimation we decided to take into account cost assessment of planned reconstruction of existing irrigation systems in Action plan for the development of irrigation in the RS until 2020[15]. Action plan financially evaluated the measure with help of data based on information on funds of rural development program (2007 - 2013) intended for the reconstruction of existing irrigation systems. It has been estimated that 2,395.00 €/ha is the cost of reconstruction of existing irrigation system.). As no data is available on the status of existing irrigation systems we assumed that all 1,000 ha of existing irrigation systems need to be reconstructed due to the fact that most systems are 20 to 30-years old;
- Maintenance (2 % of investment costs) starting from the year following the implementation.

[15] Načrt ukrepov za razvoj namakanja v RS do leta 2020: http://www.mkgp.gov.si/fileadmin/mkgp.gov.si/pageuploads/osnutki/2015/Nacrtnamakanjajuni2015.pdf

Year	Analysis of the status	Project documentation	Implementation costs	Maintenance costs
	Person month	*unit*	*unit*	*unit*
2018	3	1	1	
2019				1
2020				1
2021				1
2022				1
2023				1
2024				1
2025				1
2026				1
2027				1
2028				1
2029				1
2030				1

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Analysis	Eur/Person-month	4,374
Project documentation - 8 % of implementation cost	Eur/unit	192
Implementation costs (unit is in ha) for 1,000 ha	Eur/unit	2,395
Maintenance cost as a share of investment costs (starting from the year following the implementation) - 2 % of implementation cost	Eur/unit	48

The total discounted cost: 2,864,605 euros (EUR 2018, discount rate: 5%).

Water Management option 13

Restoration of Vipava river and its tributaries

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

This option aims to restore the functionality of natural aquatic and also riparian ecosystems on Vipava river and its tributaries. Aim of this option is also to start implementation procedures for improvement of ecological status of Vipava River and all the other benefits that comes together with this option such as improvement of hydromorphological elements of river body quality.

With restoration of regulated watercourses, the stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems.
With retaining flood waves and prolonging the runoff, flood magnitudes can be reduced downstream. With natural self-cleansing capability, based essentially on the action of microorganisms and plants that can survive in polluted water or soil, and either absorb, break down or neutralize harmful waste substances, water quality is improved or preserved. With capacity of retaining water, this results in natural enrichment of groundwater (raising the level of ground water) and also results in natural humidification of the soil. Providing a suitable habitat for animal and plant species that are tied to occasional flooding and so maintain a favourable status of protected and endangered plant and animal species (Natura 2000 management) and creating conditions for preserving biodiversity of aquatic, riparian and wetland ecosystems. If buffer zones or water margins along watercourses are established they can also slow down the wind and locally prevent wind erosion. Giving the Vipava River and its tributaries more needed space, natural river processes and link between water and terrestrial ecosystems can be restored. In the areas where agriculture prevails, improving habitat and biodiversity, and thus connectivity of ecosystems is important. Increased self-cleaning capacity of the watercourse eases the effects of chemicals (pesticides, insecticides) on aquatic and riparian ecosystems and the quality of water is preserved. Increased retention function of aquatic and riparian ecosystems results in natural humidification of the soil and raised groundwater level.).

Reference

1st WS (Session: Challenges and issues, Regulations of water surpluses..., annex image 1) (Session: Desired state; annex image 6 (Group A), 12 (Group C)) (Session: Options; annex image 19 (Group C)). Interviews: (Options, interviewee no. 8)

Implementation in the FCM

- Changing relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (- 0.6) to 1+ (+0.3).
- Changing relationship from Wind damages to Irrigated crop production from 1- (-0.3) to -0.1.
- Changing relationship from Wind damages to Rainfed crop production from1- (-0.3) to -0.1.
- Changing relationship from Status of aquatic, riparian, wetland ecosystem to Drought occurrences from 1- (-0.3) to 2- (-0.6).

Cost estimation

For the purpose of cost estimation, few options for restoration are prepared by IzVRS expert. On Vipava river and its tributaries all together 23 locations potentially suitable for restoration have been determined. On Vipava river, 16 potential locations have been determined with a total of 11 km (11,016 metres) and 74 ha (40 m protected zone on each side). On tributaries, 7 potential locations have been determined with a total of 11 km (10,910 metres) and 11 ha (5 m protected zone on each side). For calculations of the area of restoration, one- or two-sides of riverbank was taken into account.
Main costs have been determined with the help of IzVRS expert. The costs consist of:

- Preparation works to examine potential locations for restoration, preparation of “restoration plan” by expert 0.25 person month/location, 23 locations would mean 6 person months in year 1;

- Purchase of land (separately for each location);
- Preparation of project documentation (separately for each location) (8 % of investment costs);
- Implementation of measures (Removal of lateral walls / hard lateral structures (allowing for morphologic development) and planting riparian reed vegetation) (separately for each location, not for all locations planting riparian reed vegetation is planned);
- Maintenance (2 % of investment costs).

Year	Preparation works	Length restored	Implementation costs (land purchase and project documentation)	Length maintained	Maintenance costs
	Person month	*m*	*Eur*	*m*	*Eur*
2018	6				
2019		1,250	473,093	1,250	
2020		1,022	407,433	2,272	9,462
2021		1,892	896,420	4,164	17,611
2022		1,488	853,287	5,652	35,539
2023		1,430	730,570	7,082	52,605
2024		2,236	1,176,702	9,318	67,216
2025		1,698	934,806	11,016	90,750
2026		3,969	484,940	14,985	109,446
2027		3,187	318,857	18,172	119,145
2028		3,754	490,810	21,926	125,522
2029				21,926	135,338
2030				21,926	135,338

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Analysis	Eur/Person-month	5,107
Maintenance cost as a share of investment costs (starting from the year following the implementation)	% of implementation cost	2 %

The total discounted cost: 5,868,377 euros (EUR 2018, discount rate: 5%).

Water Management option 14

Restoration of old meanders and oxbows of Vipava river and its tributaries

Challenge(s) targeted: Water availability during droughts, Flood risk reduction, Appropriate water quality

Description

This option aims to restore functionality of abandoned (non-functional) natural aquatic ecosystems called meanders and oxbows on Vipava river and its tributaries. The stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems.

The stability and functionality of the natural aquatic ecosystems is established, which enables dynamic stability and biodiversity and so increases the self-cleaning capability of the aquatic ecosystems.
With retaining flood waves and prolonging the runoffs, floods can be reduced downstream. With natural self-cleansing capability, based essentially on the action of microorganisms and plants that can survive in polluted water or soil, and either absorb, break down or neutralize harmful waste substances, water quality is improved. With capacity of retaining water, this results in natural enrichment of groundwater (raising the level of ground water) and also results in natural humidification of the soil. Providing a suitable habitat for animal and plant species that are tied to occasional flooding and so maintain a favorable status of protected and endangered plant and animal species (Natura 2000 management) and creating conditions for preserving biodiversity of aquatic, riparian and wetland ecosystems.

Reference

1st WS (Session: Challenges and issues, Regulations of water surpluses..., annex image 1) (Session: Desired state; annex image 6 (Group A), 12 (Group C)) (Session: Options; annex image 19 (Group C)). Interviews: (Options, interviewee no. 8)

Implementation in the FCM

- Changing relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (-0.6) to + 0.1.

Cost estimation

For the purpose of cost estimation, few options for restoration are prepared by IzVRS expert. On Vipava river and its tributaries all together 9 locations potentially suitable for restoration have been determined with a total of 2 km (2,721 metres).
Main costs have been determined with the help of IzVRS expert. The costs consist of:

- Preparation works to examine potential locations for restoration, preparation of “restoration plan” by expert 0.25 person month/location, 9 locations * 0.25 month = 2.5 person months;
- Implementation of measures (restoration of meander or oxbow) together with preparation of project documentation;
- Maintenance (2 % of investment cost).

Year	Preparation works	Length restored	Implementation costs (land purchase and project documentation)	Length maintained	Maintenance costs
	Person month	m	Eur	m	Eur
2018	2.5				
2019		230	132,358	230	
2020		311	178,972	541	2,647
2021		243	139,840	784	6.227
2022				784	9,023
2023		317	182,424	1,101	9,023
2024				1,101	12,672
2025		468	269,321	1,569	12,672
2026		197	113,368	1,766	18,058

2027		194	111,641	1,960	20,326
2028		199	114,519	2,159	22,558
2029		562	323,415	2,721	24,849
2030				2,721	31,317

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Analysis	Eur/Person-month	5,107
Maintenance cost as a share of investment costs (starting from the year following the implementation)	% of implementation cost	2 %

The total discounted cost: 1,276,262 euros (EUR 2018, discount rate: 5%).

Water Management option 17

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

Challenge(s) targeted: (B) Flood risk reduction

Description

This option aims to reconstruct stabilizing and transverse constructions from natural stone in the smaller tributaries of the Vipava River. These barriers would be in function of slowing down the flow and retention of sediment and woody debris.

Reference

Individual conversations with SH (Bratož, Harej), 2nd WS

Implementation in the FCM

- Changing relationship of Status of water infrastructure to Flood damages from 1- (-0.3) to 2- (-0.6)

Cost estimation

No data on the state of stabilizing and transverse constructions for Vipava RB exist. There are some data on web portal "e-Vode"[16] on where water infrastructure in located, but the state and needed reconstruction works are not known. For this option steps are proposed:

- Analysis of all stabilizing and transverse constructions (weirs) on the smaller tributaries on steep slopes needs and review of activities that are already carried out (through concessions) intended mainly to reduce flood risk. Afterwards priority areas of reconstruction need to be determined, taking into account the objectives of the Water and Floods directive and also existing iniciatives from involved Municipalities – 6 person month
- Preparation of the reconstruction project (8 % of investment costs).
- Implementation of the measure – cost estimation of reconstruction/implementation of one transverse construction for stabilizing river bed was prepared by IzVRS expert – for 5 meter wide watercourse (5 meters into the bottom level of 0.5 meters, 0.5 meters deep): 11,500.00 €/location;
- Maintenance (2 % of investment costs) starting from the year following the implementation.

Year	Analysis and review	Project documentation	Implementation costs (with land purchase)	Maintenance costs
	Person-month	*unit*	*unit*	*unit*
2018	6	3		
2019		3	3	
2020		3	3	3
2021		3	3	6
2022			3	9
2023				12
2024				12
2025				12
2026				12
2027				12
2028				12
2029				12
2030				12

[16] Web portal e-Vode, Atlas voda: http://gis.arso.gov.si/evode/profile.aspx?id=atlas_voda@Arso

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Analysis and review	Eur/Person-month	5,107
Project documentation - 8 % of implementation cost	Eur/unit	920
Implementation costs	Eur/unit	11,500
Maintenance cost as a share of investment costs (starting from the year following the implementation) - 2 % of implementation cost	Eur/unit	230

The total discounted cost: 173,934 euros (EUR 2018, discount rate: 5%).

Water Management option 19

Improving the system of payment for water used for irrigation

Challenge(s) targeted: Water availability during droughts, Appropriate water quality

Description

This option aims to improve the system of payment for water used for irrigation. Water availability would be reflected in the payments that need to be made to allow water being used for irrigation purposes.

Reference

Interviews: (Challenges, interviewee no. 14). See also link (summary): http://ksh.fgg.uni-lj.si/kongresvoda/03_prispevki/01_vabljeniZnanstStrok/14_Meljo.pdf and Decree on the water fee (http://www.pisrs.si/Pis.web/pregledPredpisa?id=URED2657, article 7)

Implementation in the FCM

- Changing the relationship from »Water availability« to »Irrigated crop production« from 2+ (+0.6) to 3+ (+0.9).

Cost estimation

There are two possible ways to improve system of payment for water used for irrigation. Both options need to be further analysed if feasible:

- Overall analysis of both proposed options, their effectiveness, and on farmers willigness to pay more for irrigation – 6 person month in year 1;
- To lower the limit of yearly consumption (from 5.000 m^3 to 2.500 m^3) when farmers do not need to pay for actual water use.
- Amendments of Decree on the water fee (http://www.pisrs.si/Pis.web/pregledPredpisa?id=URED2657). Here it is important to know, if any analysis is needed to determine boundaries of yearly consumption showing also result of such an action! – 7 person month in year 2;
- To increase the level of water reimbursement fee for the use of water for irrigation of agricultural land to the value specified for the irrigation of non-agricultural land (in year 2013 that was 0.0015 €/m^3 for agricultural land compared to non-agricultural land 0.0919 €/m^3).
- Amendments of Decision determining the amount of water charge basis for the use of water, alluvial deposits and water areas (2014: http://www.pisrs.si/Pis.web/pregledPredpisa?id=SKLE9903) – 4 person month in year 2:

Year	Overall analysis	Amendments of Decree	Amendments of Decision
	Person-month	*Person-month*	*Person-month*
2018	6		
2019		7	4
2020			
2021			
2022			
2023			
2024			
2025			
2026			
2027			
2028			
2029			
2030			

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Overall analysis	Eur/Person-month	6,345
Amendment of Decree / Decision	Eur/Person-month	4,374

The total discounted cost: 83,895 euros (EUR 2018, discount rate: 5%).

Water Management option 20

Preservation of existing and introduction of new shelterbelts

Challenge(s) targeted: Water availability during droughts, Appropriate water quality

Description

This option aims to protect the land against the effects of wind. Shelterbelts would reduce velocity of the strong winds (Bora), and would reduce damage in agriculture caused by this strong bora wind and also would be in function of reducing evaporation and the impact of summer winds on soils (drying, loss of water in soil). Also this vegetation belts represent a habitat for animal species that feed on insects (biodiversity, pest management) - lower consumption of plant protection products and related water pollution (sustainable agriculture). It is important to use native trees species - probably deciduous trees.

Reference

1st WS; (Session: Challenges and issues, annex image 1 (Wind)) (Session: Options, annex image 17 (Group A), 20 (Group D)). Interviewees; (Challenges, interviewee no. 11). The restoration and implementation of new wind barriers were proposed on the Consultation about erosion in agriculture (organization of Anton Melik Geographical Institute together with Chamber of Agriculture and Forestry of Slovenia, Nova Gorica, date 22 May 2012) - http://giam2.zrc-sazu.si/sl/dogodki/posvet-erozija-v-kmetijstvu#v

Implementation in the FCM

- New factor »Shelterbelts« linked to »Wind damages« with a 1- (-0.3).

Cost estimation

Potential locations and length of shelterbelts in upper part of Vipava RB (last information from March 2015):

- Ajdovsko polje: 6,500 meters,
- Lokavec: 8,850 meters,
- Log-Zemono: 14,506 meters,
- Vipavski Križ: 10,370 meters.

Steps for successful implementation of shelterbelts:

- Preparation of implementing regulation or amending existing Forest Act of its implementing regulations, with the objective to regulate the system of financing for the implementation and maintenance of shelterbelts – 4 person month in year 1;
- Already mentioned new implementation regulation or amendments of the existing ones, proper control of shelterbelts must be ensured – 12 person month from year 2 on;
- Implementation of shelterbelts (all together 40,226 meters) - 11.70 Eur/m;
- Maintenance - 3.70 Eur/m (cost in 4 years).

Year	Preparation of regulation	Control of shelterbelts	Implementation	Maintenance
	Person-month	*Person-month*	*m*	
2018	4			
2019		12	6,500	
2020		12	8,850	6,500
2021		12	14,506	15,350
2022		12	10,370	29,856
2023		12		40,226
2024		12		33,726
2025		12		24,876
2026		12		10,370
2027		12		
2028		12		
2029		12		
2030		12		

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Preparation of regulation / control of shelterbelts	Eur/Person-month	4,374
Implementation costs	Eur/m	11.70
Maintenance costs (3.70 Eur/m in 4 years = 0.925 EUR/meter/year for one location)	Eur/m	0.925

The total discounted cost: 1,018,971 euros (EUR 2018, discount rate: 5%).

Water Management option 21

Removal of invasive non-native species

Challenge(s) targeted: Appropriate water quality

Description

Non-native plant and animal species have a direct impact on the biodiversity of aquatic environment, changing and threating the natural balance of aquatic ecosystems (their functional and structural features). With changing the composition of riparian and aquatic habitats, they degrade ecosystems and so have indirect impact on water quality. Introduction of fish in aquatic systems can affect trophic relationships and set off “trophic cascades” with resulting declines in native species and degradation of water quality [114] (e.g. Common Carp (Cyprinus carpio) feeds by searching through underwater vegetation. This feeding habit uproots plants which muddies the water. This makes it hard for other fish to see and destroys the food and cover for other fish. Also they compete with native species or are their predators, can be vectors of disease to native species). This can be also the case of plant species (e.g. Japanese knotweed threatens native plants and animals by forming dense thickets, blocking routes used by wildlife to disperse).

More exactly there are problems with non-native fish species that were introduced by fishermen (fish farming) - for Vipava river it means a biological pressure - 9 non-native fish species were recorded in the project Analysis of biological pressures With measure identification, data collection and removal of invasive non-native species is planned. This measure would be addition to measure of restoration of watercourses in river basin to maintain a favorable status of protected and endangered plant and animal species.

Reference

1st WS; (Session: Desired state, annex image 12 (Group C)) (Session: Options, annex image 19 (Group C)). Interviews: (Desired state, interviewee no. 11). RBMP (NUV I, 2011) - measure BI1, BI2

Implementation in the FCM

- Changing relationship from River basin management to Status of aquatic, riparian, wetland ecosystem from 2- (-0.6) to 1- (-0.1).

Cost estimation

Not enough data on the species, number and prevalence is available (available only for fish species in Vipava river). Hence next steps are needed to implement this WMO:

- Identification and data collection of invasive non-native species in Vipava RB – 2 person month, year 1. 4. 7. 10, 13;
- Determination for which species, the area and the method of removal and disposal is possible – 1 person month, year 1. 4. 7. 10, 13;
- Preparing work program of removal of invasive non-native species – 0.5 person month, year 1. 4. 7. 10, 13;
- Choosing the location of the disposal of invasive non-native species – 0.5 person month, year 1. 4. 7. 10, 13;
- Preparing and execution of monitoring programme – 1 person month, year 1. 4. 7. 10, 13;
- Execution of removal of non-native species (priority: Vipava river; duration of the removal approx. 5 years) – 2 person month, year 1. 4. 7. 10, 13.

Year	Identification	Determination	Working program	Location of disposal	Execution of the program	Removal
	Person-month	*Person-month*	*Person-month*	*Person-month*	*Person-month*	*Person-month*
2018	2	1	0.5	0.5	1	2
2019						
2020						
2021	2	1	0.5	0.5	1	2
2022						
2023						
2024	2	1	0.5	0.5	1	2
2025						
2026						
2027	2	1	0.5	0.5	1	2
2028						
2029						
2030	2	1	0.5	0.5	1	2

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Identification/Determination/Working program/Location of disposal/Execution	Eur/Person-month	5,107
Removal	Eur/Person-month	3,984

The total discounted cost: 175,921 euros (EUR 2018, discount rate: 5%).

Water Management option 22

Construction of municipal wastewater treatment plants and sewage systems

Challenge(s) targeted: Appropriate water quality

Description

Problem of small and dispersed settlements and insufficient sewage systems and municipal wastewater treatment causing pollution (organic, pollution with nutrients and pathogens) of surface and ground water. All municipal wastewater treatment plants (WWTP), also can be implemented as biological WWTP, constructed wetlands for wastewater treatment, etc., depending on the analysis of most suitable treatment technology. Construction of small wastewater treatment plants Lozice, Črnice and other small WWTP in dispersed settlements. Also additional treatment of municipal wastewaters in the areas of bathing waters (in the case of the establishment of eco-bathing).

Reference

1st WS; (Session: Challenges, annex image 1 (water pollution), 2 (sectoral challenges), 3 (water quality), 4 (water quality)) (Session: Desired state, annex image 6 (Group A), 9 (Group B), 12 (Group C), 15 (Group D)) (Session: Options, annex image 17 (Group A), 19 (Group C), 20 (Group D)). Interviews: (Challenges and Desired state, interviewee no.1). Operational program (OP) of discharge and municipal wastewater treatment (period from 2005 to 2017) - for the implementation and monitoring of the OP are responsible and accountable municipalities and the ministry responsible for the environment. RBMP (NUV I, 2011) - measures ON1, ON1.1, ON1.2. WWTP Vipava - Project "Clean Up Vipava River" - Collection and treatment of waste waters in the RB Vipava - Lot 1 - http://www.ocistimo-vipavo.si/predstavitev. WWTP Nova Gorica - Project "Collection and treatment of waste water in the basin of the Soca (WWTP Nova Gorica)".

Implementation in the FCM

- New factor Municipal wastewater treatment plants and sewage systems linked to Water quality with a 1+ (+0.3).

Cost estimation

IzVRS has within the framework of the preparation of the operational program for drainage and wastewater treatment made analysis of existing WWTP and sewage systems[17]. For some of already constructed WWTP and sewage systems new data have not been taken into account and are seen as still missing[18] (test operation of new WWTP Vipava, the construction of WWTP Vrtojba (and sewage systems that will connect WWTP with agglomerations) that will treat wastewaters from municipalities Nova Gorica, Šempeter-Vrtojba and Miren-Kostanjevica (or some of their agglomerations))[19]. Hence we decided that this agglomerations will not be considered in cost assessment.

The overall results have been prepared on the basis of the number of PE in each agglomeration:

- Agglomerations under 2,000 PE (no. of person equivalent):
  - 21,225.44 PE is without existing public sewage system – cost of implementation of sewage system for agglomerations under 2,000 PE is 1,500 €/PE;
  - 21,137.05 PE is without existing (municipal) WWTP - cost of implementation of WWTP for agglomerations under 2,000 PE is 800.00 €/PE;
  - Project documentation (8% of implementation costs);
  - Maintenance (2 % of implementation costs).
- Agglomerations above 2,000 PE (no. of person equivalent):

[17] Data valid on 31st December 2014: http://www.ijsvo.si/
[18] Data valid on 31st December 2014: http://www.ijsvo.si/
[19] https://www.google.si/url?sa=t&rct=j&q=&esrc=s&source=web&cd=3&cad=rja&uact=8&ved=0CCsQFjACahUKEwipgrXina7IAhWm_HIKHSIxCjA&url=http%3A%2F%2Fwww.miren-kostanjevica.si%2Fmedia%2Fgradiva_seje%2F34_redna_seja%2Fpovzetek_IP.pdf&usg=AFQjCNGhozWI7brttNJOTQqMLAMXt1e4CA AND http://www.cisto-porecje-soce.si/o-projektu/cistilna-naprava.html , viewed on 6th October 2015

- 4,767.36 PE is without existing public sewage system – cost of implementation of sewage system for agglomerations above 2,000 PE is 1,000 €/PE;
- 5,207.80 PE is without existing (municipal) WWTP - cost of implementation of WWTP for agglomerations above 2,000 PE is 500 €/PE;
- Project documentation (8% of implementation costs)
- Maintenance (2 % of implementation costs)

Year	Project documentation	Implementation costs (above 2,000 PE, sewage system)	Implementation costs (above 2,000 PE, WWTP)	Implementation costs (under 2,000 PE, sewage system)	Implementation costs (under 2,000 PE, WWTP)	Maintenance
	Eur	*PE*	*PE*	*PE*	*PE*	*Eur*
2018	589,701					
2019	1,256,245	4,768	5,208			
2020	301,870			6,702	7,062	147,425
2021	430,321			1,641	1,641	461,486
2022	450,174			2,339	2,339	536,954
2023	343,970			2,447	2,447	644,534
2024	373,870			1,869	1,869	757,078
2025	355,451			2,032	2,032	843,070
2026	351,624			1,932	1,932	936,538
2027				1,911	1,911	1,025,400
2028						1,113,306
2029						1,113,306
2030						1,113,306

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Project documentation - 8 % of implementation cost	%	8 %
Implementation costs (above 2,000 PE, sewage system)	Eur/PE	1,000
Implementation costs (above 2,000 PE, WWTP)	Eur/PE	500
Implementation costs (under 2,000 PE, sewage system)	Eur/PE	1,500
Implementation costs (under 2,000 PE, WWTP)	Eur/PE	800
Implementation costs (land purchase included)	%	2 %

The total discounted cost: 55,461,147 euros (EUR 2018, discount rate: 5%).

Water Management option 23

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

Challenge(s) targeted: Water availability during droughts, Appropriate water quality

Description

To cultivate crops resistant to droughts, pests and diseases. Problem of agriculture is that it is not adapted to climate changes. This measure can reduce water use (irrigation), water pollution (reducing the use of plant protection products) and increase self-sufficiency in food.

Reference

1st WS; (Session: Challenges, annex image 3 (water use))

Implementation in the FCM

- Changing the relationship from Drought occurrences in growing season to Rainfed crop production from 3- (-0.9) to 2- (-0.6).

Cost estimation

- Review and analysis of existing data, studies, projects on the best selection of crop type regarding water requirements, growth phases (when and how long) and soil type - 6 person months;
- Formation of an experimental center (test area - can be an active or abandoned agricultural land, part of a farm, where the municipality, agricultural cooperative or an individual farmer is owner and is willing to sell/rent the farm for experimental cultivation of these crops and to put theory into practice.
  - Purchase of the farm, and purchase of agricultural land of about 20 ha (some of existing equipment and basic infrastructure – e.g. tractor within the farm, warehouse);
    - Some expert assume 200,000 to 300,000 € cost for buying a farm; we used 250,000 €;
    - For buying an agricultural land we used data where 1 ha is estimated at 24,000 €[20]
  - Preparation of project documentation (8%) – new equipment – one greenhouse (10x63 meter)[21], cold storage (cost is part of the warehouse) and warehouse (around 1,000 m2)
  - Implementation[22]
  - Maintenance (2%) of implementation works plus running costs:
    - 24 person month from year 3 on,
    - 6 person month from year 3 on.
- Replacement of maize with sorghum crops from year 8 on (80 ha/year). In year 12 area of 400 ha will be replaced with sorghum.

[20] http://prostor3.gov.si/zvn/zvn/ZVN.html (zbirka vrednotenja nepremičnin, 7.9.2015, CONA 7 = 24000 eur/ha, CONA 10 = 41500 eur/ha)
[21] Company Rastlinjaki RAR NOVI d.o.o., mr. Boris Valenčič, phone call on 6th October 2015.
[22] DIIP, 2008: Šifra: Naziv investicijskega projekta: 351-9/2008 REGIJSKO SKLADIŠČE CIVILNE ZAŠČITE V AJDOVŠČINI

Year	Expert basis/analysis	Preparation of project documentation	Implementation of experimental center	Maintenance	Operational cost (technician, engineer)	Operational cost (agricultural expert)	Replacement of crops
	Person-month	*Eur*	*Eur*	*Eur*	*Person-month*	*Person-month*	*unit*
2018	6	59,600					
2019			1,425,711				
2020				15,972	24	6	
2021				15,972	24	6	
2022				15,972	24	6	
2023				15,972	24	6	
2024				15,972	24	6	
2025				15,972	24	6	1
2026				15,972	24	6	2
2027				15,972	24	6	3
2028				15,972	24	6	4
2029				15,972	24	6	5
2030				15,972	24	6	5

Unit cost of different actions in the option

Infrastructure /action	unit	Unit cost
Expert basis/analysis	Eur/Person-month	6,345
Preparation of project documentation	% of implementation cost (Eur)	8 %
Maintenance costs (warehouse and greenhouse)	% of implementation cost (Eur)	2 %
Operational cost (technician, engineer)	Eur/Person-month	3,357
Operational cost (agricultural expert)	Eur/Person-month	5,107
Replacement of crops on 80 ha (from year 8 to year 12, each year crops on additional 80 ha are replaced, all together 400 ha)	Eur/unit	47,524

The total discounted cost: 452,957 euros (EUR 2018, discount rate: 5%).

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