

PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.3

OUTLINING OF LESSONS LEARNT AND RESULTING RECOMMENDATIONS

D.T2.3.5 OUTCOMES OF PRACTICAL TESTING

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1. Introduction

In this report implementation of best management practices for drinking water protection and flood mitigation is described, as well as acceptance of BMPs among stakeholders and experts is defined. Associated recommendations and solutions for adapting the existing best management practices are described in transnational report *D.T2.3.2 Transnational conclusive report containing recommendations*. This report contains summarized implementation of BMPs and acceptance described in *O.T2.1 PA cluster ‘mountain forests and grasslands’ - implementation, showcasing best management practices*, *O.T2.2 PA cluster ‘plains: agriculture, grass/wetland’ - implementation, showcasing best management practices* and *O.T2.3 PA cluster ‘riparian strips’ - implementation, showcasing best management practices*. Results of the single PA are objectified in order to be able to translate them to the other areas and are classified towards their usability for entering the Action Plan O.T2.4.

Pilot actions and pilot sites respectively were classified into three clusters (Table 1) concerning the geographic specification and natural site characteristics (aquifer type) and main land use:

Pilot Action Cluster 1: Mountain forest and grassland sites,

Pilot Action Cluster 2: Plain agriculture/ grassland/ wetland sites and

Pilot Action Cluster 3: Special sites (riparian strips).

Table 1: Pilot Actions and Pilot Sites respectively, classified into three clusters according to land uses and geographic scope

PILOT ACTION CLUSTER 1 (PAC1) Mountain forest and grassland sites	PILOT ACTION CLUSTER 2 (PAC2) Plain agriculture/ grassland/ wetland sites	PILOT ACTION CLUSTER 3 (PAC3) Special sites (riparian strips)
PA1.1 Catchment area of the Vienna Water Supply, AT1 Drinking water source: Karst aquifer	PA2.1 Well field Dravlje valley in Ljubljana, SI Drinking water source: Porous aquifer	PA3.1 Po river basin, IT Drinking water source: Bank filtration
PA1.2 Catchment area of Waidhofen/Ybbs, AT2 Drinking water source: Fractured aquifer	PA2.2 Water reservoir Kozłowa Góra, PL Drinking water source: Surface water	PA3.2 Along Danube Bend, HU2 Drinking water source: Bank filtration
	PA2.3 Tisza catchment area, HU1 Drinking water source: Surface water	
	P2.4 Groundwater protection in karst area, HR 2.4.1 - South Dalmatia: Prud, Klokun and Mandina spring 2.4.2- Imotsko polje springs) Drinking water source: Karst aquifer	
	PA2.5 Neufahrn bei Freising, DE Drinking water source: Porous aquifer	



1.1. Pilot Action Cluster 1: Mountain forest and grassland sites

In mountain forests and grassland sites best management practices for land use and drinking water management differ from those in plain sites; therefore, this was selected as separate Pilot Action Cluster. In mountainous areas drinking water sources are mainly originated from groundwater (fractured and karst aquifers).

Into the Pilot Action Cluster 1 (PAC1) two Pilot Actions from Austria were assigned:

- **PA1.1: Catchment area of the Vienna Water Supply** , and
- **PA1.2: Catchment area of Waidhofen/Ybbs.**

Drinking water source in PA1.1 is karst aquifer, whereas drinking water source in PA1.2 is fractured aquifer (Table 1).

1.2. Pilot Action Cluster 2: Plain agriculture/ grassland/ wetland sites

In plain sites the main land uses are agriculture, grassland and urbanization. In plain sites drinking water sources can be surface water, bank filtered water or groundwater (mainly porous aquifer, but also karst aquifer (Croatian case)). Bank filtration has special characteristics; therefore, separate cluster (PAC3) was established for this case.

Into the Pilot Action Cluster 2 (PAC2) five Pilot Actions were assigned:

- **PA2.1: Well field Dravlje valley in Ljubljana, Slovenia,**
- **PA2.2: Water reservoir Kozłowa Góra, Poland,**
- **PA2.3: Tisza catchment area, Hungary,**
- **PA2.4: Groundwater protection in karst area, Croatia (PA2.4-1: South Dalmatia: Prud, Klokun and Mandina spring; and PA2.4-2: Imotsko polje springs),**
- **PA2.5: Neufahrn bei Freising, Germany.**

Drinking water source in PA2.1 and PA2.5 is porous aquifer, whereas drinking water source in PA2.4 is karst aquifer. Surface water is drinking water source in PA2.2 and PA2.3.

1.3. Pilot Action Cluster 3: Special sites (riparian strips)

In the Pilot Action Cluster 3 (PAC3) two Pilot Actions were assigned, one located in Italy and the other one in Hungary:

- **PA3.1: Po river basin (Figure 9);**
- **PA3.2: along Danube bend (Figure 10).**

Drinking water source in both PAs is bank filtration or/and porous aquifer.



2. Implementation of best management practices for drinking water protection

There are many best management practices for drinking water protection and flood protection, which already are existing but often actual implementation of these BMPs is slowed down or limited by economic, administrative, social acceptance or governance issues. Implementation possibilities were assessed for previous selected BMPs in all Pilot Actions of all three Pilot Action Clusters (PACs).

In the work-package T1, BMPs for drinking water protection and flood mitigation were identified at national level for each PP. The main goal of work package T2 was testing BMPs, which are considered relevant and most important for particular PA.

Testing of BMPs in PAs was done in three steps (Figure 1). In the first step the most important and relevant BMPs were selected. Various activities were performed for the implementation of BMPs (step 2) and the last step was to find out stakeholder’s opinion about selected BMPs (step 3) with Insights were driven from stakeholder interactions and integration of basic scientific studies.

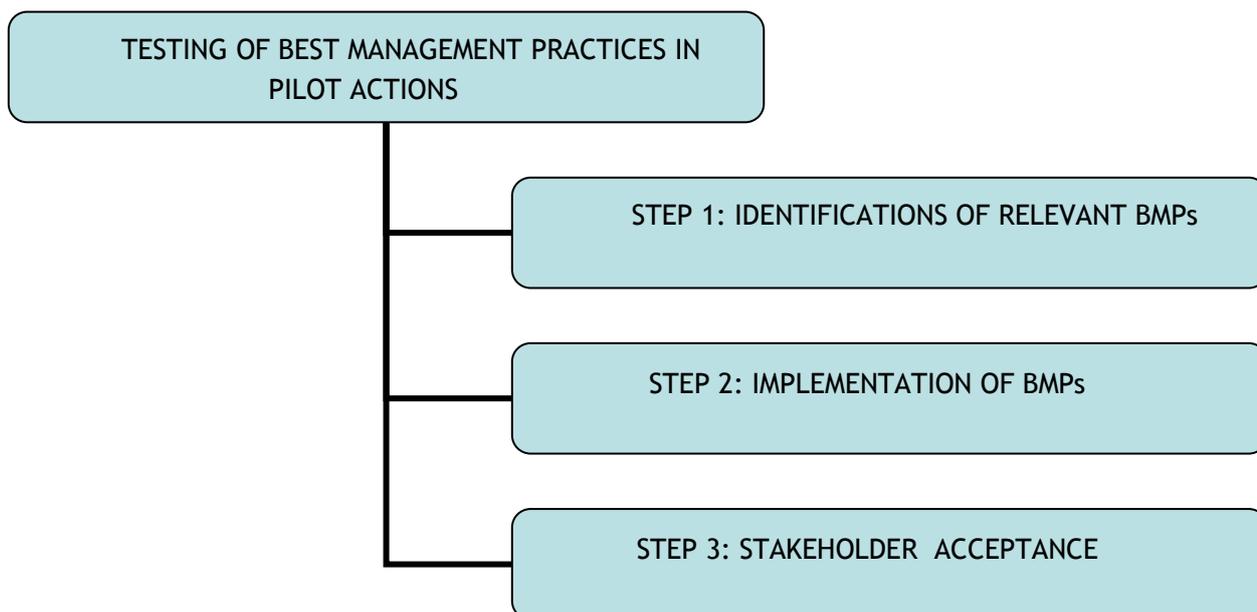


Figure 1: Testing of Best Management Practices (BMPs) in Pilot Actions.

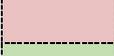
On the Pilot Action level some BMPs were already implemented in the frame of T2 activities. On the other hand, some BMPs are very complex and require system change or even policy change, which are long lasting procedures. Implementation of BMPs may require:

- adaptation of existing land use management practices with the purpose of drinking water protection,



- adaptation of existing flood/drought management practices with relation to drinking water protection,
- adaptation of policy guidelines.

For such BMPs possibilities of implementation were assessed and implementation strategies (procedures) were determined and are presented in Table 2. GAPS and corresponding BMPs were classified according to what kind of land use type/category each problem is related to: agricultural areas, urban areas, forest and alpine pasture. All GAPS/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses. BMPs were classified in the same way as in the T1 BMP catalogue into following categories:

	1) general water management,
	2) drinking water management,
	3) flood management,
	4) agricultural areas,
	5) urban areas,
	6) forest and
	7) Alpine pasture.

3. Acceptance of BMPs among stakeholders and experts

Implementation of best management practices at the local/regional level demands a transdisciplinary and participatory approach with dynamic interaction and feedbacks of stakeholders and experts. Therefore, an important part of implementation is acceptance of best management practices for drinking water protection and flood mitigation among stakeholders and experts, which was obtained through stakeholder workshops and individual discussion. The results of BMPs acceptance among stakeholders and experts are presented in Table 3.

Table 2: Implementation of best management practices for drinking water protection and flood mitigation

Category	Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation			Country	
			Possibility of implementation YES/NO; in case of NO explanation is added	Proposal of procedure for implementation YES/NO; in case of NO explanation is added	Other		
GENERAL WATER MANAGEMENT	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard		Implemented		PL	
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale		Implemented		PL	
	Land use activities causing changes in groundwater (GW) recharge and quality (e.g. quarries causing decrease of GW recharge; vulnerability of GW due to cattle grazing)	Continuous monitoring of relevant hydrological data and hydrological/hydrogeological modelling (surface run-off - spring dynamic modelling)	Implementation of Hydrological Modelling and Monitoring through the water works: Decision of the Municipality. Report about the modelling outcomes of the hydrological model KAMPUS.	Sustained implementation of Hydrological Monitoring, cooperation with experts. Presentation of the hydrological model KAMPUS applied within the pilot action "Zeller Staritzen" and its relevance for drinking water supply.	Analysis of modelling, application of management routines based on Modelling outcomes. Analysis of modelling, application of management routines based on Modelling outcomes.		AT
	No information about ecology of water reservoir	Establishment of an ecology model of water reservoir		Implemented		PL	
	Pressures on water resources management	The Drought Observatory/ Steering Committee and Drought Early Warning System (DEWS)	Yes, but partially implemented. For the complete implementation, it is necessary to: - empower modelling system; - increase accessibility and availability of information; - further develop stakeholder's awareness and engagement; - assure incentives and investments to prevent, mitigate and better manage water scarcity events; - improve dialogue and communication.	- Confirm and intensify already started activities and projects; - implement economic and environmental methodologies for water resource.	Extend the number of stakeholders and stimulate attention to drinking water.		IT
	Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources	Joined and integrated management of drinking water resources (horizontal and vertical co-operation)	Realistically there are low possibilities of this drastic change in work organisation.	Water sectors should be reunited into one organisation and clearly separate their duties about drinking water resources protection issues.	/		SI
	Lack of public engagement in development of action plans	Finding site-specific solutions by using a hydrologic model with a graphical user interface in a participative approach		Implemented			DE
	Low level of ecological awareness of society	Raising awareness and increasing knowledge		Implemented			PL

DRINKING WATER MANAGEMENT	Climate change impacts on drinking water resources (e.g. pressure on water resources quantity)	Assessment of climate change impact on drinking water resources and determination of adaptation and resilience of public water supply (e.g. reducing pipeline leakage and water reuse)	Some structural measures are in implementation process, such as construction of new irrigation system for Imotsko polje.	Local authorities should incorporate CC Adaptation Strategy 2040-2070 and Action Plan 2019-2023 provide good guidelines for adaptation and resilience for CC it in local plans and strategies	/	HR
			<ul style="list-style-type: none"> - The topic about implementation should be differentiated considering the implementation on test case simply requiring the stages above described; - in general, to properly account for CC in drinking water protection management, Acts as National Strategy for Adaptation (published in 2014) and next National Adaptation Plan represent key activities; - it should be integrated with analogue experiences at regional and urban scale. - integration of CC mitigation and adaptation issues as a cross cutting theme into sectoral and territorial Plans (agriculture, energy, water protection, protected areas, urban planning). 	<ul style="list-style-type: none"> - Regional and Urban Adaptation Plans should be performed; - following EU Directive, the updates in Plans should explicitly account for CC issue (e.g. second implementation of actions required by flood Directive). 	More quantitative evaluations activities could permit better driving decisions of Administrators also if carried out only on limited domains.	IT
	Drinking water protection zones (DWPZs) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	Possible with cooperation of Municipality of Ljubljana city and Ministry of the environment and spatial planning for acceptance of drinking water protection decree.	Municipality of Ljubljana city finance hydrogeological study for determination of DWPZ and submit to the Ministry of the environment and spatial planning for acceptance of drinking water protection decree.	/	SI
			Implemented	Determination of drinking water protection zones (DWPZ), obligatory measures and limitations that are conducted in them as well as the deadlines for decisions on protection and the process of making these decisions are governed by The Ordinance on the conditions for the establishment of sanitary protection zones (Official Gazette No. 66/11 and 47/13).	Proposal is currently under legal procedures.	PL
Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	With Ministries (of the environment and planning) support and guaranteed budget the proposal would be feasible.	Ministry of the environment and spatial planning should assign supervisors to control locals and local farmers and their acts in DWPZs.	Workshops and informational system about DWPZ areas restrictions should be upgraded among locals.	SI	
FLOOD MANAGEMENT	Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	<p>Possibility for implementation are medium. Information on some pollution /sources could originate from:</p> <p>a) Formalized procedures relative to chimney sweepers identifying the location and status of devices (and tanks)</p> <p>b) Identification of stores and storage facilities with hazardous substances.</p>	To adopt and enforce legislation enabling access to data and reporting on the amount of stored hazardous substances on flood prone areas. Maintenance of the dataset. After the identification it is important to raise awareness and provide measures leading to improvements.	/	SI



Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulical model	The information on the type of the well (sealed) should be emended to the data specification according to INSPIRE directive and reported in the national database of public service providers.	Recommendations on the level of strategic guidelines resulting from the PROLINE-CE project, implementation on the level of national legislation requesting obligatory sealed well heads for the water supply wells on flood prone areas.	/	SI
Water balance status and effective mitigation measures are not known (identified)	Water balance status will be determined with Hydrological / Hydraulical modelling	The stakeholders generally fully accept the implementation of water balance model. The modelling to certain extent required by national legislation, but precise method is not defined.	Existing modelling approach - models developed by local communities and investors should be changed as they do not provide river basin scale models (they are usually limited by the municipal borders).	The scale and standardized approach to modelling is not defined different models are used (1D, 1D-2D, 2D for hydraulics), and different for hydrological modelling 1D, 2D, distributed, method for the integration of urban drainage is not defined.	SI
Increased contamination of surface drinking water resources during flood events	Reduction of flood effects at the surface drinking water resources	This measure is partially implemented as the Szolnok Waterworks already has an effective flood action plan, but we would suggest reviewing the action plan with the consideration of a CC model. The realization of a full implementation depends on how many complications would waterworks face during trying to have access to a CC model. In addition, cost of measure is high.	Waterworks and the Hungarian Meteorological Service should orient their cooperation to this direction.	The Szolnok Surface Waterworks operates well during flood events, purification technology is suitable for the treatment of changing water quality - the operating system and the purification technologies must be reviewed in the context of climate change.	HU
Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	Measure is complex, as it faces resistance of local population, lots of financial compensation for losses, and generally, structural measures are still favoured.	Expert community, service providers, decision makers and population must reach consensus in order to apply this measure.	/	HR
Flood impact not fully implemented and considered	The Flood Forecast Centre and Flood Early Warning System (FEWS)	Yes, but partially implemented. For the complete implementation, it is necessary to: <ul style="list-style-type: none"> - empower modelling system; - improve operational procedures and activities considering the whole disaster cycle; - further develop citizen information and operation tools for alert dissemination; - assure incentives and investments to prevent, mitigate and better manage floods. 	<ul style="list-style-type: none"> - Confirm and intensify already started activities and projects; - implement impact based economic evaluations of flood management. 	Extend the number of stakeholders and stimulate attention to drinking water supply systems protection in case of floods.	IT
Improper flood protection of bank-filtered wells during high water and flood events	Ensure the drinking water supply during high water or flood		Implemented		HU
River banks vegetation is not maintained	Reducing river banks vegetation		Implemented - but it is not maintained as regularly as it should be.		SI
Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas	Strict implementation of construction inhibition on floodplains considering flood hazard map is possible with Municipalities support.	After agreement with stakeholders (Ministry of the Environment and Spatial planning - Slovenian Environment & Slovenian water agency) this legislation proposal about flood risk evaluation of parcels included in municipal spatial planning will be discussed among departments how to implement this legislation and propose an approach of solving this problem.	Strict implementation of construction inhibition on floodplains considering flood hazard map.	SI



AGRICULTURAL AREAS	Improper manure storage	Frequently monitoring livestock farms (authorities), providing information to the farmers about the environmental disadvantages of improper manure storage and about climate change	Possible. It depends on the relevant authorities who could inspect the operation of livestock farms (do authorities have enough capacity for the regular inspection?).	Authorities should be informed about GAP, as well as the imminence of climate change, so they can make the first step towards a regular monitoring/ inspection.	/	HU
	Agricultural surface water and groundwater pollution (e.g. improper or excessive use of pesticides and manure on plant production fields)	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.	Possible. If farmers could be convinced that the Agrarian Environmental Program is beneficial for them, the implementation has a good possibility to be realized. To convince the farmers brochures have to be prepared or local events have to be organized to inform them about the consequences of improper use of pesticides and the benefit of participating in Agrarian Environmental Program.	Informative meetings for farmers about the Agrarian Environmental Program and climate change.	/	HU
	Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application	With sufficient political will and farmers support implementation would be possible.	Increasing of environmental awareness of local farmers and to upgrade legislations with political consultant's advice.	/	
	Increased water demand	Establishment of groundwater level monitoring network (e.g. Imotsko polje and South Dalmatia) for monitoring of irrigation water demand in order to assure efficient use of water in agriculture	The measure is simple, but requires funding sources, which is unclear at the moment.	Water suppliers, municipality or county can seize the initiative or even finance it, but they can also file an official request to Croatian Waters.	/	HR
	Continuous conversion of (permanent) grasslands crop fields/lands	Continuous quantity and quality monitoring of agriculture pollution and water level in both, surface water and groundwater		Implemented		DE
URBAN AREAS	Insufficiently effective wastewater treatment system that needs to be reconstructed and expanded	Natural wastewater treatment system	Hard to predict. Challenges include high costs (which is also case with other purification methods) and extensive land surface is needed for the method (up to 5 m ² per PE).	Local authorities or county starts the initiative and tries to find financial models.	/	HR
	Torrential water flooding - excessive surface runoff, lack of water for animals and watering the plants	Collecting torrential water in wider channels, small retention pond (e.g. transient marsh Mali Rožnik) managed according to Hydrological / Hydraulical model	Currently low possibilities for implementation. There is no national discussion on sustainable drainage systems. Development of regulation and indicator system for the identification of objectives of water retention and reuse municipalities should achieve.	Development of regulation on water wise cities on national level as a part of climate change adaptation procedures. Integration of water wise concept on the level of city planning with overall water balance management as one of the components of spatial planning process.	/	SI
	Waste disposal which do not meet technical and environmental standards and illegal waste disposal	Educative brochure and awareness raising activities Encourage and promote innovative solutions of sustainable waste management	Main obstacle is unwillingness of the local community to adopt new environmentally friendly habits as a consequence of insufficient education on environmental issues and lack of government stimulations.	Implemented Small scale application must start in order to provide a positive example for the rest of community.	/	HR



	Lack of sewage system and wastewater treatment	Appropriate collection and treatment of municipal wastewater	Mostly Implemented, while sewage disinfection is not a general problem in the pilot area, there are specific locations that are still lacking.			HU
	Unarranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas	Hopefully our political consultants will have good advice on its implementation to change construction legislations.	Separate drainage system should already be included into road planning.	/	SI
	No limitation of road runoff water salinity	Define limitation of salinity of road water run-off	Possible with strong stakeholder involvement.	Stakeholder involvement for adopting guidelines regarding roads salting or even updating existing Decree on the emission of substances in the discharge of meteoric water from public roads.	/	SI
FOREST	Continued application of the clear-cut technique	Avoidance of the clear-cut technique	Application of the GWP, hence facilitation of BMP implementation.	Setting up of the contract with the forest owners according to GWP, facilitated BMP application.	/	AT
	Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages	Forest Ecologically Sustainable Wild Ungulate Densities	Application of the Hunting Law (Provincial Hunting Act of Lower Austria).	Information campaigns in local media (newspapers, radio or TV), persuasive efforts with regard to the implementation of ecological hunting practices.	In severe cases persecution of a trial in the specific court.	AT
	Abandonment of private forests, resulting aging of the forests and through it elevated vulnerability of the forests towards natural disasters	Forestry subsidies and encouraging foresters to facilitate regeneration dynamics within their forests	Concessionaires (Snaga d.o.o.) are taking over management of the TRŠ park and therefore policies of the Park will be upgraded, and many actions will take place since the Parks budget will increase according to the Municipalities promises.	Snaga d.o.o. already started to inform and increase awareness of relevant stakeholders like local farmers and residents through meetings.	/	SI
	Extensive construction of forest roads	Limitation of forest roads	Application of the GWP, hence facilitation of BMP implementation.	Setting up of the contract with the forest owners according to GWP, facilitated BMP application.	/	AT
	Creation of conifer plantations, even within deciduous forest communities	Tree Species Diversity According to the Natural Forest Community	Application of the GWP, hence facilitation of BMP implementation.	Setting up of the contract with the forest owners according to GWP, facilitated BMP application.	/	AT
	Cutting of old, huge and vital tree individuals	Foster old, huge and vital tree individuals	Application of the GWP, hence facilitation of BMP implementation.	Setting up of the contract with the forest owners according to GWP, facilitated BMP application.	/	AT
ALPINE PASTURE	Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces	Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings	Persuasive efforts with regard to the alpine pasture staff. Contracts with the alpine pasture staff.	After information campaigns for the own staff and the alpine pasture staff, the set-up of specific contracts can be carried out.	/	AT
	Grazing of cattle in or close to dolines and sinkholes	Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features	Persuasive efforts with regard to the alpine pasture staff. Contracts with the alpine pasture staff.	After information campaigns for the own staff and the alpine pasture staff, the set-up of specific contracts can be carried out.	/	AT
	Unwanted cattle grazing (cattle density and grazing patterns)	Grazing management for cattle on alpine pastures (temporally limited grazing on different locations)	Persuasive efforts with regard to the alpine pasture staff. Contracts with the alpine pasture staff.	After information campaigns for the own staff and the alpine pasture staff, the set-up of specific contracts can be carried out.	/	AT

Table 3: Acceptance of BMPs for drinking water protection among stakeholders and experts

Category	Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts			Country
			Possibility of implementation	Proposal of procedure for implementation	Other	
GENERAL WATER MANAGEMENT	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard	Stakeholders and experts recommend implementation of catchment modelling in water management as one of the tools to simulate water environment and impact of possible hazard on water.	Catchment modelling should be included in policy guidelines as important tool for water management.	/	PL
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale	Conducting a multi-aspect monitoring is an easy and sufficient solution for gathering information about water ecosystem	Implementation needs first carrying out screening monitoring to gather general spatial and seasonal information about water environmental components and water hazards. Next step is selecting representative monitoring points, which provide reliable information. Within selected monitoring point it is recommended to provide long-term multi-aspect monitoring to gather full knowledge of water environment and possible hazards.	/	PL
	Land use activities causing changes in groundwater (GW) recharge and quality (e.g. quarries causing decrease of GW recharge; vulnerability of GW due to cattle grazing)	Continuous monitoring of relevant hydrological data and hydrological/hydrogeological modelling (surface run-off - spring dynamic modelling)	<p>The main stakeholder, the water works of Waidhofen/Ybbs, are convinced from the necessity of this BMP and hence ensure its application.</p> <p>The main stakeholder, Vienna Water, is convinced from the necessity of this BMP and hence ensures its application in the course of the project.</p>	<p>The main tasks were already fulfilled during project life-time. The monitoring task will have to be sustained in future.</p> <p>The surface flow - spring dynamic modelling will be finalized during the project duration period.</p>	/	AT
	No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	Stakeholders and experts recommend implementation of the ecological modelling, integrated with catchment models, in water management as one of the tools to simulate water environment and impact of possible hazard on water.	Ecological modelling, integrated with catchment models, should be included in policy guidelines as important tool for water management	/	PL
	Pressures on water resources management	The Drought Observatory/ Steering Committee and Drought Early Warning System (DEWS)	<p>Stakeholders are a bit doubtful about the success of this measure because their involvement is more recent with respect to flood issues. Although positive trends can be observed, the process is slow and requires persistence of efforts.</p> <p>Experts put in evidence the main implementation opportunities underlining the role of funding, multi-sectoral partnership, interdisciplinary qualitative-quantitative approaches, and innovation (ICT, humanities, applied research etc.), social awareness, training, and</p>	<ul style="list-style-type: none"> - Insert easier and more accessible water information, especially drinking water, according to stakeholders needs; - increase the involvement of experts from different fields (communication, economy, environment, and social sciences) to test operational tools and share knowledge; - funding and implementation of interactive systems for hydrological simulation and application. 	<ul style="list-style-type: none"> - Increase the knowledge of existing and potential problems and vulnerabilities linked to pressure on water resources; - increase the awareness on benefits of information and scenario (evidence-based) based decisions; - share with stakeholders and citizens the main steps and results. 	IT

		stakeholder involvement.				
	Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources	Joined and integrated management of drinking water resources (horizontal and vertical co-operation)	Possible with strong stakeholder involvement and cooperation.	Persons (NGO or civil initiatives)/institution (national level) needed for coordination of different sectors.	/	SI
	Lack of public engagement in development of action plans	Finding site-specific solutions by using a hydrologic model with a graphical user interface in a participative approach	The proposed BMP is of difficult implementation. The support of an expert is fundamental for the stakeholder in setting up the model, running it and interpreting the results.	<ol style="list-style-type: none"> 1. Perform a field survey to verify the accuracy of the available information 2. Analyse the quality of available data 3. Develop a conceptual model 4. Develop a mathematical model 5. Calibrate and validate the model 6. Use the model to test scenarios proposed by stakeholders 7. Support decision makers providing the model results in a comprehensible form 	<p>Bottlenecks that we identified in the implementation of the procedure are:</p> <ul style="list-style-type: none"> - correct communication of the concept of model uncertainty, - correct communication of model results which may not be expected by the stakeholders. 	DE
	Low level of ecological awareness of society	Raising awareness and increasing knowledge	High need to raise awareness and increase knowledge in society.	Organisation of meeting at local scale.	/	PL
DRINKING WATER MANAGEMENT	Climate change impacts on drinking water resources (e.g. pressure on water resources quantity)	Assessment of climate change impact on drinking water resources and determination of adaptation and resilience of public water supply (e.g. reducing pipeline leakage and water reuse)	Stakeholders gave positive feedback, but realistic possibility is questionable (consensus of all involved groups is hard to reach).	This essential topic must be promoted to stakeholders and decision makers on all levels (from local to government). Results of CC modelling for Croatian pilot area was presented during 2 nd national stakeholder workshop in Metković and discussion was held regarding potential loss of water resources in near future as well as adaptation of ecosystems to changes in temperature and precipitation trends. Higher level decision makers are harder to address, therefore, there is need for expert and scientific papers and publications.	/	HR
			<p>Due to high complexity of investigated issue, several expertises are required to effectively address the topic; the starting point could be represented by Observatories proposed in other BMPs involving also expert in atmospheric sciences or adaptation processes.</p> <p>Moreover, awareness about the future potential issues for drinking water should be increased also in general public, making the results of research and institutional activities easier for all potential stakeholders (for example, stressing pros and cons or uncertainties in current estimations).</p>	<ul style="list-style-type: none"> - Promote the development of participative processes and stakeholder engagement to promote bottom-up approaches; - integrate the activities about adaptation in Observatories, Technical panels and other decision-making bodies in which experts and communities are already involved; - replicate the experiences carried out on different contexts favouring the dissemination of the results. 	/	IT



FLOOD MANAGEMENT	Drinking water protection zones (DWPZs) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	Implementation is feasible.	Municipality of Ljubljana city finance hydrogeological study for determination of DWPZ and submit to the Ministry of the environment and spatial planning for acceptance of drinking water protection decree.	/	SI
			High need of establishing DWPZ at Kozłowa Góra reservoir.	Procedure complies with legal acts.	/	PL
			The administration of these measures is expected to be more efficient in near future.	Further education activities and awareness raising are needed to fully implement DWPZs	/	HR
	Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	Stakeholders identify lack of not effective inspection. Implementation itself is very complex and hard to realize.	Good effects on activities in the DWPZs are Agricultural Advisory Services encourage farmers to organic farming without pesticides and fertilizers. Because of smaller harvest, farmers get money compensations.	/	SI
	Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	Data collection, data validation and maintenance, legal framework for the data collection present a challenge.	Communication with the Slovenian Water Agency regarding the added information on potential storage of hazardous substances (as activity) in Water Management Information System.	Aggregated list of all potential point pollution sources (industry, heating oil tanks in households, etc.) is needed for efficient incident management in case of flood event.	SI
	Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulical model	Implementation is easily feasible with consideration of guidelines.	Guidelines have to be prepared and promoted by Ministry of environment and spatial planning.	Awareness rising and education process on this risk and potential measure as the number of stakeholders (only Water Utilities) is relatively limited.	SI
Water balance status and effective mitigation measures are not known (identified)	Water balance status will be determined with Hydrological / Hydraulical modelling	Stakeholders agree on the importance of the harmonized river basin scale hydrological and hydraulic modelling providing good information on water balance. Nevertheless, existing legislation, but also specific bottlenecks (human resources, financial resources) do not provide easy solutions.	Change in legislation should define better the institution in charge of river basin scale models instead of municipality base models.	/	SI	
Increased contamination of surface drinking water resources during flood events	Reduction of flood effects at the surface drinking water resources	During the discussions with stakeholders, they gave positive feedback on the idea, however they seemed to find the predicted issues related to climate change less drastic.	Rising general awareness on CC.	The Szolnok Surface Waterworks operates well during flood events, purification technology is suitable for the treatment of changing water quality - the operating system and the purification technologies must be reviewed in the context of climate change.	HU	
Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	Stakeholders gave positive feedback, but realistic possibility is questionable (consensus of all involved groups is hard to reach)	Specific needs must be defined by local communities and service providers, while financing (for big infrastructural works) usually has to be supported by regional, national or EU funds.	/	HR	
Flood impact not fully implemented and considered	The Flood Forecast Centre and Flood Early Warning System (FEWS)	Stakeholders gave positive feedback, putting in evidence some difficulties and proposing ideas and solutions to complete the implementation. Experts put in evidence the main implementation strategies whose added value rely on funding opportunities, innovation (ICT, humanities, applied research etc.), social awareness, interdisciplinary applications, and stakeholder	<ul style="list-style-type: none"> - Insert easier and more accessible water information, especially drinking water, according to stakeholders needs; - increase the involvement of experts from different fields (communication, economy, environment, and social sciences) to test operational tools and share knowledge; - funding and implementation of interactive 	<ul style="list-style-type: none"> - Increase the knowledge of existing and potential problems and vulnerabilities linked to floods; - increase the awareness on benefits deriving from decisions based on full information and specific scenarios; - share with stakeholders and citizens the main steps and results. 	IT	

			involvement.	systems for hydrological simulation and application.		
	Improper flood protection of bank-filtered wells during high water and flood events	Ensure the drinking water supply during high water or flood	Location of individual wells is a critical factor, some are easier to protect than others.	Implementation can only be done at a local level.	/	HU
	River banks vegetation is not maintained	Reducing river banks vegetation		Implemented - but it is not maintained as regularly as it should be.		SI
	Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas	Despite strict legislations usually corruption at municipalities or at planning companies make such acts possible, therefore implementation and realisation present a challenge.	Stakeholders (Ministry of the Environment and Spatial planning - Slovenian Environment & Slovenian water agency) support us and will suggest how to approach solving this problem.	Flooding of constructions in floodplains due to noncompliance of the legislation and large material damage are now Municipalities problem.	SI
AGRICULTURAL AREAS	Improper manure storage	Frequently monitoring livestock farms (authorities), providing information to the farmers about the environmental disadvantages of improper manure storage and about climate change	Experts from water sector agreed that the raised problems are very complex, and that although the situation might seem to be under control at the moment, the climate change could be a serious threat. It is also a common opinion that monitoring the water quality of River Tisza is enough, there is no need to monitor its tributaries.	<ul style="list-style-type: none"> - Educating farmers about proper manure storage; - Educating farmers about the disadvantages of improper manure storage. 	/	HU
	Agricultural surface water and groundwater pollution (e.g. improper or excessive use of pesticides and manure on plant production fields)	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.	Experts from water sector agreed that the raised problems are very complex, and that although the situation might seem to be under control at the moment, the climate change could be a serious threat. It is also a common opinion that monitoring the water quality of River Tisza is enough, there is no need to monitor its tributaries.	<ul style="list-style-type: none"> - Raising awareness; - Improving available subsidies and grants; - Educating farmers about the available methods. 	/	HU
	Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application	The Slovenian Environment Agency agronomic prediction according to the weather forecast but is more as a recommendation Expected limitations are lack of political will and resistance of local farmers.	Workshops and seminars for local farmers would improve awareness and perhaps reduce polluting their local groundwater source.	/	SI
	Increased water demand	Establishment of groundwater level monitoring network (e.g. Imotsko polje and South Dalmatia) for monitoring of irrigation water demand in order to assure efficient use of water in agriculture	Stakeholders gave positive feedback, but realistic possibility is questionable (mainly due to financing).	Monitoring of surface and groundwaters are responsibility of Croatian Waters. Research institution (such as Croatian Geological Survey) can propose locations for new monitoring sites on the basis of desk studies and field investigations	/	HR
	Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	The proposed BMP is of relatively simple implementation. The support of an expert view can help the stakeholder in optimizing the monitoring network finding a good configuration in terms of cost/benefit ratio.	<ol style="list-style-type: none"> 1. Perform a field survey to verify the accuracy of the available information. 2. Analysis of the institutional path to ask for the permission of the installation of additional monitoring point. 3. Design a monitoring network according to the necessity of the study site. 	<p>Bottlenecks that we identified in the implementation of the procedure are:</p> <ul style="list-style-type: none"> - complex organizational structure to obtain the permit for the installation of new monitoring points, - resistance of some individuals in processing the requests for the installation of new monitoring points, - lack of knowledge about the current situation (e.g., it 	DE

				<p>4. Find an optimal cost/benefit configuration of the monitoring network.</p> <p>5. Collect the permission to install new monitoring points.</p> <p>6. Share the data, maintain the database and proof the quality of collected data.</p>	was not possible to identify the owner of some existing monitoring points).	
URBAN AREAS	Insufficiently effective wastewater treatment system that needs to be reconstructed and expanded	Natural wastewater treatment system	Unknown, mostly due to high costs.	A first step towards the implementation of this BMP, will be the stakeholder involvement actions (authorities, local community, economic subjects etc.). Natural UWWTP possibilities will be included in educative brochure (see previous BMP).	/	HR
	Torrential water flooding - excessive surface runoff, lack of water for animals and watering the plants	Collecting torrential water in wider channels, small retention pond (e.g. transient marsh Mali Rožnik) managed according to Hydrological / Hydraulical model	<p>An initiative was launched and Ljubljana as Green Capital of Europe 2016 is considering it as one of the development potentials.</p> <p>No communication on higher (regulatory) level yet, due to the election procedure and re-organization of the ministries.</p>	Communication with the stakeholders: state level - Ministry of Environment and Spatial Planning (general regulatory framework) and the City Municipality of Ljubljana (implementation framework).	Overall awareness rising as retention measures have significant spill-over effect, in order to motivate the communities towards its implementation. Retention measures should address the issue of IAS and mosquito control as well.	SI
	Waste disposal which do not meet technical and environmental standards and illegal waste disposal	Educative brochure and awareness raising activities	Stakeholders gave positive feedback and claim that foreseen activities will have positive impact on behaviour.	Details of optimal brochure dissemination and awareness raising activities will be discussed with local stakeholders.	/	HR
		Encourage and promote innovative solutions of sustainable waste management	Stakeholders are a bit doubtful about the success of this measure. Although positive trends can be observed, the process is slow and requires persistence.	Education of the local community to adopt new environmentally friendly habits.	/	
	Lack of sewage system and wastewater treatment	Appropriate collection and treatment of municipal wastewater	Sewage systems are continuously being improved in the region.	Increasing funding in critical regions in order to improve results.	/	HU
	Unarranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas	Legislation for rain water discharge is very good but for many roads not implemented, moreover it should be stricter on DWPZ.	Inspection of all existing roads.	On motorways and main roads rainwater drainage and retention ponds with treatment are arranged but the infrastructure is not maintained.	SI
No limitation of road runoff water salinity	Define limitation of salinity of road water run-off	Guidelines for road salting have to be determined (The dosing quantities of solvent should take into account the amount of solvent that it is already on the road).	Guidelines have to be prepared and promoted by Ministry of environment and spatial planning and Ministry of infrastructure.	/	SI	
FOREST	Continued application of the clear-cut technique	Avoidance of the clear-cut technique	The acceptance of this BMP among stakeholders and experts is already given, what is due to information campaigns and persuasive efforts during the project pilot activities.	Application and execution of the GWP (Guideline for securing the Water Protection functionality of the forest ecosystems within the DWPZ)	If forest owners do not comply with GWP, persuasive efforts have to be carried out in order to convince them from contracting.	AT
	Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages	Forest Ecologically Sustainable Wild Ungulate Densities	The acceptance of this BMP is still rather low among most of the stakeholders. The provincial Hunting Act will have to be stressed in some cases.	Some forest owners like the Austrian Federal Forests could act as example for all other stakeholders, as they have already the implementation of this BMP on their agenda.	Utilisation of interdependencies between forest owners, like the example of single forest enterprises. Stressing of the Hunting Act. Information campaigns for the general public in order to create a sphere of awareness for this relevant issue. Forcing of the regional and local forest authorities through public awareness to conform with law.	AT

	Abandonment of private forests, resulting aging of the forests and through it elevated vulnerability of the forests towards natural disasters	Forestry subsidies and encouraging foresters to facilitate regeneration dynamics within their forests	Implementation depends on the budget of the Park. The main problem is given through numerous private owners with relatively small parcels, hence constant conflicts among them.	The upgrade of the Park's policies in the direction of providing forest regeneration dynamics in sufficient quality and quantity and regularly maintaining the forest.	/	SI
	Extensive construction of forest roads	Limitation of forest roads	The acceptance of this BMP is still rather low among most of the stakeholders and experts.	Application and execution of the GWP. The specific situation for this BMP will have to be stressed specifically during the contracting process.	Further information of forest owners, that the application of technical alternatives will result in higher PES.	AT
	Creation of conifer plantations, even within deciduous forest communities	Tree Species Diversity According to the Natural Forest Community	Forest owners have a higher understanding regarding this BMP, facilitated through the latest weather conditions.	Application and execution of the GWP. The fitting tree species were spatially explicitly defined through the Forest Hydrotope Model.	The implementation of tree species diversity based on native tree species still will need persuasive efforts, as Austrian foresters cling to the primacy of Norway spruce and recently also of Douglas fir.	AT
	Cutting of old, huge and vital tree individuals	Foster old, huge and vital tree individuals	Some stakeholders (forest owners) actually tend to cut all huge trees of forest stands. The understanding regarding this BMP will still need the application of persuasive efforts.	Application and execution of the GWP.	Persuasive efforts with regard to all forest owners and stakeholders who still did not sign the GWP contract.	AT
ALPINE PASTURE	Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces	Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings	This BMP is accepted among stakeholders and experts. An adequate water supply for livestock together with fixed trough sites is seen as relevant from all stakeholders.	The implementation of this BMP could be hindered through lacking water resources in karstic terrain or lacking monetary resources for construction works. The latter obstacle could be overcome through contracts with alpine pasture staff.	/	AT
	Grazing of cattle in or close to dolines and sinkholes	Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features	Fences around dolines and sinkholes are potentially accepted through stakeholders, if those are informed accordingly. Hence persuasive efforts will have to be stressed.	Accurate maps with doline and sinkholes on the pasture areas improve the decision process where fencing is necessary. Knowledge transfer and discussion process with the stakeholders (alpine pasture staff).	/	AT
	Unwanted cattle grazing (cattle density and grazing patterns)	Grazing management for cattle on alpine pastures (temporally limited grazing on different locations)	Grazing management is the BMP which actually will face the lowest degree of acceptance among stakeholders, as they will show resistance against changing their management habits. This BMP requires a high level of expertise and willingness to change.	Persuasive efforts in the course of information meetings with alpine pasture staff. The alpine pasture staff has to be convinced that both overgrazing and under-grazing is bad for the economic output of the alpine pasture and that grazing management is the adequate solution for this situation. Also, the positive side-effects on water protection and flood prevention should become aware.	/	AT

4. Conclusions

The main goal of work package T2 is testing of Best management practices (BMPs), which were developed in the frame of the work package T1 and were selected as relevant BMPs for Pilot Actions (PAs). PAs were selected in each partner country in order to reflect conflicts (GAPs) of management & operation of water supply companies and land-use management in recharge/water protection areas. PAs reflect the broad range of possible conflicts connected with drinking water protection, such as: forest ecosystem service function; land-use planning conflicts; flooding issues; impact of climate change and land-use changes.

The most important measures and practices for drinking water protection considering land use and flood management have been identified and implemented in the PAs. Furthermore acceptance through relevant stakeholders and experts was obtained.

Drinking water protection and management and best practices are strategically implemented in the pilot actions, in order to achieve a function-oriented land-use based spatial management for water protection at the operational level. Measures and actions were analysed and proposed concerning mitigation of extremes and achieving a sustainable drinking water level. The stakeholder involvement provided in PROLINE-CE was crucial for achieving steps towards the implementation of the BMPs within the Pilot Actions.

On the project level **40 GAPs** were identified, following the **41 BMPs**, with respective possibilities of implementation and acceptance among stakeholders and experts. Classifying the GAPs/BMPs showed that most of the issue found out in the pilot sites are related to flood events, the lack of measures, tools, or information in water management and general water management issues which apply to all land uses. All of these factors cause deterioration in both drinking water quality and quantity. In many cases the lack of public awareness worsens the situation; therefore excessive educational programs would be necessary even if the first approach of the problem is related to experts or the government. Sustainability of the measures will depend on mostly the interaction between authorities and land users. The implementations of proposed BMPs are limited by:

- **in general, and drinking water management:** lack of political will, long lasting administrations, little public interest, low quality data;
- **in flood management:** not available or low quality data, high cost of measures (lack of funds), lack of trans-border cooperation;
- **in agriculture:** financing, lack of willingness of farmers to cooperate (a change to green production is expensive);
- **in urban areas:** unwillingness of the local community to adopt new environmentally friendly habits as a consequence of insufficient education on environmental issues and lack of government stimulations
- **in forest:** lack of financing and knowledge among stakeholders,
- **in alpine pasture:** lack of knowledge among alpine pasture staff and accurate maps.

The evaluation of the BMPs implementation, current activities and ongoing projects concerning the current and potential effectiveness of the selected BMPs in all PAs has been undertaken with a strong engagement of stakeholders and experts. From the thematic interpretation of tested management practices emerged that work is still needed in order to:

- empower, maintain and integrate modelling system;
- increase accessibility and availability of information;
- improve the understanding of the impacts of climate change and land uses changes;
- increase the awareness of all the stakeholders (actors or users: administrators, decision-makers but also communities) about the future challenges for effectively preserving drinking water resources.

Both local/regional/national authorities need further training and stakeholder involvement activities in order to overcome habitual management practices which are in contradiction to the requirements of a consequent BMP implementation. This crucial task has to be accomplished in order to establish a sustainable protection of drinking water resources in mountainous regions and will require additional efforts in this thematic field. Hence further stakeholder trainings can be seen as necessary task to be fulfilled in future. Also, improvements in the field of policy could contribute to a better drinking water supply security. An improved interaction between authorities and land-users with the purpose of improved drinking water protection strategies should be intended.

The results achieved during the PROLINE-CE project highlight that an integrate and effective management of the drinking water resources, carried out taking into account both the direct and indirect impacts of the analysed processes, could provide benefits to all the involved stakeholders. Administrators and decision-makers could benefit from the availability of more detailed data on events occurrence and on the area more vulnerable, as well as from the availability of high-resolution climate scenarios. On the other hand, farmers could benefit from a better land use planning and from the implementation of sustainable agricultural practices, which could also provide possible resolution to the potential use conflicts among different stakeholders groups. At the same time, an adequate territorial planning coupled with a more effective modelling and prevision of flood and drought events will ensure the drinking water supply to the local population even during crisis.

Environmental challenges related to sustainable land use, flood and drinking water management have a transnational relevance. PROLINE-CE outputs, which include the proposal of efficient management methods and strategies for the sustainable use of water resources, the correct land use planning, and the protection of drinking water, could contribute to the implementation of EU policies purposes on such topics (Water Framework Directive, Drinking Water Directive, Groundwater Directive, Flood Directive) providing cutting-edge tools and frameworks.

In this regard, PROLINE-CE permitted clearly identifying gaps, needs and the most effective ways to address them. The implementation process was undertaken driven by innovative and agreed technical, scientific and governance solutions. Nevertheless, as well known, such processes require long times for implementation often affected by administrative or unforeseeable delays

for external causes. Then, further investigations should include a proper assessment of the climate change issue for all the related aspects promoting, also in this case, a proper mainstreaming of adaptation actions in policies and regulations.

5. References

PROLINE-CE WORKPACKAGE T2, ACTIVITY T2.3 REPORTS:

- D.T.2.3.2 Transnational conclusive report containing recommendations
- D.T.2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 1 - Mountain Forest and Grassland Sites
- D.T.2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 2 - Plain agriculture/ grassland/ wetland sites
- D.T.2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 3 - Special sites (riparian strips)

PROLINE-CE WORKPACKAGE T2, OUTPUT REPORTS:

- O.T2.1 PA cluster ‘mountain forests and grasslands’ - implementation, showcasing best management practices.
- O.T2.2 PA cluster ‘plains: agriculture, grass/wetland’ - implementation, showcasing best management practices.
- O.T2.3 PA cluster ‘riparian strips’ - implementation, showcasing best management practices.