PROLINE-CE

WORKPACKAGE T2

PILOTS: IMPLEMENTATION AND FEEDBACK

O.T2.4 ACTION PLAN FOR ADAPTATION OF EXISTING LAND USE AND FLOOD/DROUGHT MANAGEMENT PRACTICES

"EXECUTIVE SUMMARY"

Contributors, name and surname	Institution
Barbara Čenčur Curk	PP4 - University of Ljubljana, NTF
Anja Torkar	PP4 - University of Ljubljana, NTF
Urška Valenčič	PP4 - University of Ljubljana, NTF
Roland Koeck	PP3, LP/PP1 - University of Natural Resources and Life Sciences, Department of Forest- and Soil Sciences, Institute of Silviculture
Tamás Belovai	PP7 - General Directorate of Water Management OVF
Guido Rianna	PP13 - CMCC Foundation
Angela Rizzo	PP13 - CMCC Foundation

TABLE OF CONTENTS

Dictionary of abbreviations

BMP	Best Management Practice
DWPZ	Drinking Water Protection Zone
FEWS	Flood Early Warning System
GAP	Gap in Land use Management or Water Management practice
GWP	**G**uideline for securing the **W**ater **P**rotection functionality of the forest ecosystems within the DWPZ
PA	Pilot Action
PAC	Pilot Action Cluster

1. Introduction

Drinking water sources along rivers are vulnerable to floods, more distant areas to droughts. In the frame of work package T2 best practices for drinking water protection, flood and drought risk management were determined and tested concerning their contribution to improvement of drinking water safety and effectiveness including ecosystem services as well as economic efficiency, furthermore to achieve a function-oriented, land-use based spatial management for water protection at the operational level, which is task of subsequent work packages T3 and T4.

The main goal of work package T2 is testing of Best Management Practices (hereinafter BMPs), which were developed in the frame of the work package T1 and were selected as relevant BMPs for Pilot Actions (hereinafter 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. In PAs status of best management practices implementation was determined and in case of lacks identified, possibilities of improvement and implementation were assessed. In representative PAs, considering the different ecosystem services, implementation strategies of BMPs which are important for water protection were elaborated. PAs reflect the broad range of possible conflicts regarding drinking water protection, such as: forest ecosystem service function; land-use planning conflicts; flooding issues; impact of climate change and land-use changes; demonstration of effectiveness of measures including ecosystem services and economic efficiency.

The main goal of work package T2 is thus a joint conceptualization of all PAs and perform necessary steps towards elaboration of optimal measures and actions to achieve flood protection and a sustainable drinking water level as an input to the CE Transnational Guide towards an Optimal WAter REgime (GOWARE). This is a tool, which will be developed in the work package T3 and will be summarizing a common methodology and a vision for integrated water protection management in the participating regions, in order to provide a frame for the implementation of best practices regarding drinking water protection and flood mitigation.

2. Pilot Actions, Pilot Action Sites and Pilot Action Clusters

The key challenges of PROLINE-CE regarding land use and drinking water resources management are common to all EU countries and not only to the participating partners and are the following:

- protection of drinking water sources,
- balancing conflicts of land-use, environmental needs & drinking water protection,
- mitigation of flood and drought impacts on water resources used for water supply,
- adaptation to climate change issues despite uncertain prognoses by means of adapted and target-oriented land-use activities.

Land-use planning, and flood protection measures are often in conflict with drinking water protection activities. Hence different land uses, such as agriculture, forestry, grasslands - pastures, urbanization, etc., and flood protection measures have impacts to drinking water quality and quantity. Moreover, due to changing world, also climate change and land-use changes have to be considered. PAs were selected in order to cover the broad range of possible conflicts regarding land use (forest practices, agriculture, urbanization, etc.) and flood management versus drinking water protection and drinking water management in different natural conditions (mountainous areas, plain areas, riparian strips).

Pilot actions (PAs) and pilot sites were selected according to geographic and natural site characteristics (aquifer type) and main land use. Selection of PAs was performed according to following criteria:

- each country has one PA,
- PAs have to present different natural characteristics of drinking water sources and land uses in their recharge areas,
- PAs have to present broad range of possible conflicts regarding land use and flood management versus drinking water protection.

Each partner has one PA, where common project results from work package T1 are tested and implemented. Outcome is also experiences gained during testing and implementation process in PAs, above all, how to involve broad range of stakeholders and moreover how to communicate with policy makers.

2.1. Pilot Action and Pilot Site

For the work within work package T2 definition of Pilot Action and Pilot Site is needed.

Pilot Action presents activities performed at Pilot Site, such as study of gaps and best management practices of land use and flood protection within sight of drinking water protection. In T2, Pilot Actions were verified regarding implementation status of best management practices. In case of lacks identified, possibilities of improvement and

implementation were assessed. In representative pilot actions, considering the different ecosystem services, project partners prepared implementation strategies of best practices which are important for drinking water protection. Thus, water supply management systems and best practices should be 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 management.

Pilot site is a physical environment – a recharge area of drinking water source, where Pilot Action is performed. A recharge area can be river basin in case of surface water sources; porous, fractured or karst aquifer in case of groundwater sources; and riparian strip in case of bank filtration.

2.2. Clustering of Pilot Actions

The single PA is clustered concerning the geographic specification and natural site characteristics (type of drinking water source: surface water, groundwater, bank filtration) and main land use (Table 1) in three pilot action clusters (PAC):

- Pilot Action Cluster 1 (PAC1): Mountain forest and grassland sites,
- Pilot Action Cluster 2 (PAC2): Plain agriculture/ grassland/ wetland sites and
- Pilot Action Cluster 3 (PAC3): Special sites (riparian strips).

General classification was made already in the Application Form, but the final classification was done after discussions at the kick-off meeting in Munich in September 2016 and at the second project meeting in Parma in January 2017. In the Application Form dry areas were selected to be part of Pilot Action Cluster 3. According to WHO, UNEP and deMartonne aridity index there are no dry areas in PROLINE-CE selected Pilot sites. On the other hand, during the discussion at the Parma meeting it was found out that several Pilot sites are facing water shortage in dry periods (each year or only in years with low precipitation); therefore it was decided that in all Pilot Actions impact of dry periods on drinking water resources will be studied, because in these periods there might be a problem regarding water quantity and quality and the competition for water. For that reason, the term “dry areas” was excluded from the PAC3 title. Nevertheless, both Pilot Actions in the Pilot Action Cluster 3 have the least precipitation in comparison to other Pilot Actions.

Table 1: Pilot Actions and Pilot Sites respectively, classified into three pilot action 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, GER Drinking water source: Porous aquifer	

2.3. Main land uses in Pilot Action Clusters (PAC)

PAC1 - Mountain forest and grassland sites: In mountainous areas, drinking water sources are mainly originated from groundwater (fractured and karst aquifers). In PROLINE-CE project, two PAs in karstic mountainous areas could be allocated to this cluster, the major land use is forest,

grassland and pastures. The main conflicts regarding drinking water protection are timber production, gaming and cattle grazing.

PAC2 - Plain agriculture/ grassland/ wetland sites: In plain sites, the main land uses are agriculture, grassland and urbanization. Drinking water sources can be surface water, bank filtered water or groundwater [mainly porous aquifer, but also karst aquifer (Croatian case)]. All PAs are in plain areas and the major land use is agriculture (with grasslands), but also urbanization.

PAC3 - Special sites (riparian strips): The main land uses are represented by agriculture and settlements. Both PAs face issues related to both water availability and water quality damage. Agricultural activities represent the main causes of contamination of water bodies and of the increase in water demand, associated to irrigation practices. Furthermore, both PAs struggle with direct and direct impacts of flood and drought events.

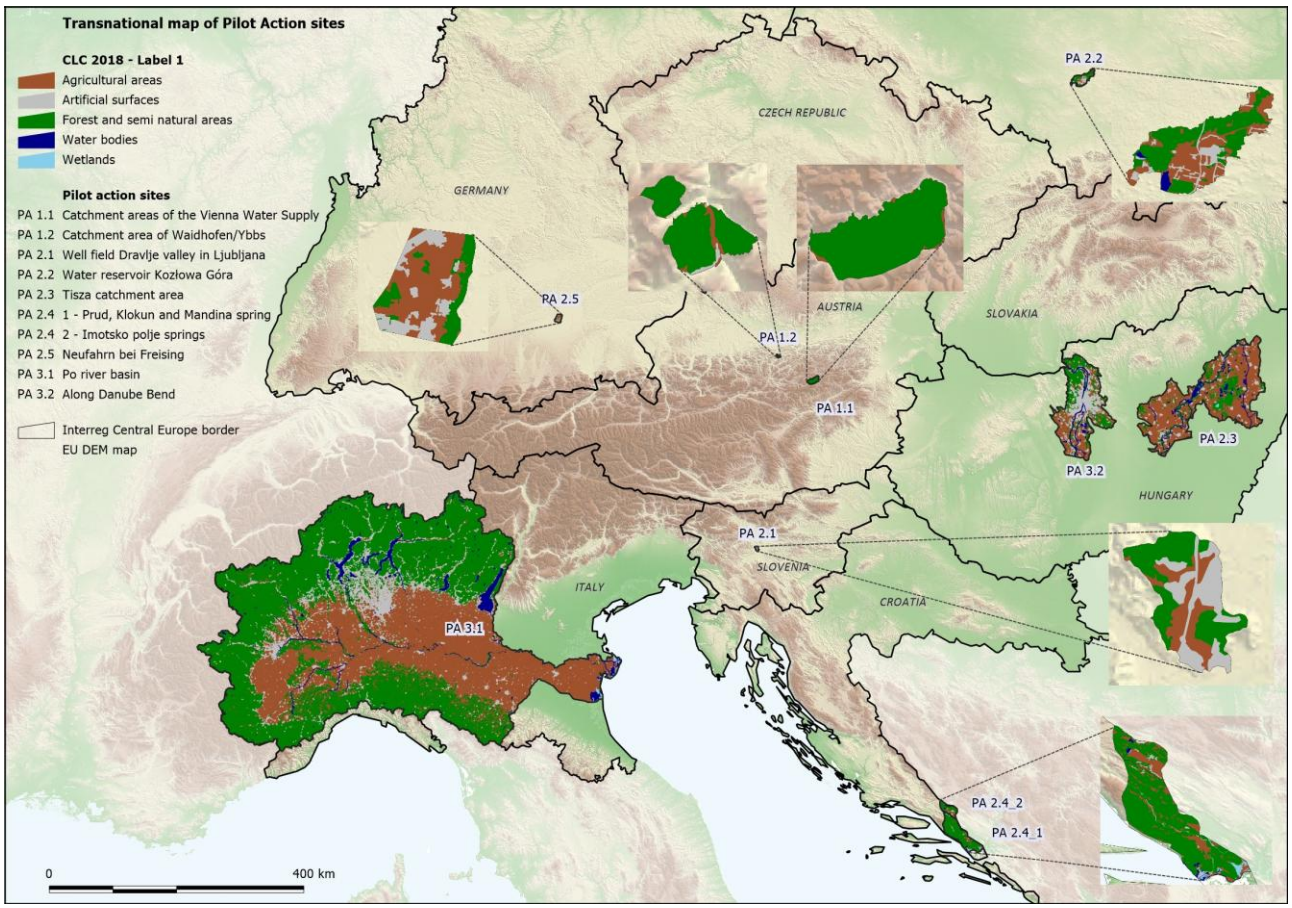

Figure 1: Transnational map of Pilot Action sites.

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

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

Drinking water source in PA1.1 is a karst aquifer, whereas drinking water source in PA1.2 is a fractured karst aquifer (Table 1). Both PA are situated in the Austrian Calcareous Alps and karstic springs are used as source water.

Into the Pilot Action Cluster 2 (PAC2) five Pilot Actions were assigned (Table 1):

- 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.

Into the Pilot Action Cluster 3 (PAC3) two Pilot Actions were assigned (Table 1):

- PA3.1: Po river basin, Italy and
- PA3.2: Along Danube Bend, Hungary.

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

3. Best management practices for drinking water protection and mitigating floods

In Pilot Actions demonstration of effectiveness of measures was performed, including ecosystem services and economic efficiency. The relevant Best Management practices (BMPs) selected for particular pilot action represent the management actions which were considered to solve the problems given through the existing GAPs. Their identification is the result of desk reviews, expert judgments and a deep stakeholder involvement.

BMPs selected within each Pilot Action were categorized in previous T1 and T2 reports according to Pilot Action Clusters (PAC1, PAC2 and PAC3). Each BMP was elaborated in detail addressing the following titles: Identified GAP provoking action, GAP short name, GAP short description, Best Management Practice / Management Action, Name of BMP, Type of land use regarded, Location, BMP description, Advantages of this BMP in PA, Challenges of this BMP in PA, Relevance, Limitations, Implementation of the BMP in PA, Comments and References / sources.

Here, however we classified GAPs/BMPs according to what kind of land use type/category each problem is related to: agricultural areas, urban areas, forest and alpine pasture (Table 2). All GAPs/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses. BMPs were therefore classified into following categories:

1) general water management (all land uses),
2) drinking water management (all land uses),
3) flood management (all land uses),
4) agricultural areas,
5) urban areas,
6) forest and
7) alpine pasture.

In Table 2 are listed all selected GAPs and BMPs within Pilot Actions. 40 GAPs were identified, followed by 41 BMPs.

Table 2. Overview table which summarizes all the GAPs and related BMPs identified in Pilot Actions, classified according to land use type /category.

CATEGORY	GAP	BMP	COUNTRY	PAC	LEVEL
GENERAL WATER MANAGEMENT (all land uses)	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard	PL	2	OL
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale	PL	2	OL
	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)	AT	1	OL
	No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	PL	2	OL
	Pressures on water resources management	The Drought Observatory/ Steering Committee and Drought Early Warning System (DEWS)	IT	3	PL/OL
	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)	SI	2	PL
	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	DE	2	PL
	Low level of ecological awareness of society	Raising awareness and increasing knowledge	PL	2	OL
DRINKING WATER MANAGEMENT (all land uses)	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)	HR	2	PL
			IT	3	PL
	Drinking water protection zones (DWPZs) for the drinking water source (in case of Slovenia potential drinking water source) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	SI	2	PL
			PL	2	PL
			HR	2	PL
	Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	SI	2	OL/PL

FLOOD MANAGEMENT (all land uses)	Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	SI	2	OL
	Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulic model	SI	2	OL
	Hydrological characteristics of the watershed and effective mitigation measures are not known (identified)	Hydrological characteristics will be determined with Hydrological / Hydraulic modelling	SI	2	OL
	Increased contamination of surface drinking water resources during flood events	Reduction of flood effects at the surface drinking water resources	HU	2	OL
	Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	HR	2	OL
	Flood impact not fully implemented and considered	The Flood Forecast Centre and Flood Early Warning System (FEWS)	IT	3	PL/OL
	Improper flood protection of bank-filtered wells during high water and flood events	Ensure the drinking water supply during high water or flood	HU	3	OL
	River banks vegetation is not maintained	Management of river banks vegetation	SI	2	PL/OL
	Legalization of illegal constructions (without construction permit) on flood prone areas	Preventing legalization of construction on flood prone areas, removal of illegal constructions	SI	2	PL/OL
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	HU	2	OL
	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.	HU	2	OL, PL
	Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application	SI	2	PL
	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	HR	2	OL
	Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	DE	2	OL

URBAN AREAS	Insufficiently effective wastewater treatment system that needs to be reconstructed and expanded	Natural wastewater treatment system	HR	2	OL
	Flash floods - excessive surface runoff, lack of water for animals and watering the plants	Retaining water in retention reservoirs, small retention ponds (e.g. transient marsh Mali Rožnik) managed according to Hydrological / Hydraulic model	SI	2	OL
	Waste disposal which do not meet technical and environmental standards and illegal waste disposal	Educative brochure and awareness raising activities	HR	2	OL
		Encourage and promote innovative solutions of sustainable waste management			OL
	Lack of sewage system and wastewater treatment	Appropriate collection and treatment of municipal waste water	HU	3	OL
	Discharge of meteoric water from public roads without treatment and retention	Collection, treatment, retention of meteoric water from public roads, particularly within drinking water protection areas	SI	2	OL
	No limitation of road runoff regarding the water salinity	Collection and gradual dilution of road runoff with increased salinity, particularly within drinking water protection areas	SI	2	PL
FOREST	Continued application of the clear-cut technique	Avoidance of the clear-cut technique	AT	1	OL
	Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages	Forest Ecologically Sustainable Wild Ungulate Densities	AT	1	OL/PL
	Lack of forest management	Forestry subsidies and encouraging foresters to facilitate regeneration dynamics within their forests	SI	2	OL/PL
	Extensive construction of forest roads	Limitation of forest roads	AT	1	OL/PL
	Creation of conifer plantations, even within deciduous forest communities	Tree Species Diversity According to the Natural Forest Community	AT	1	OL
	Cutting of old, huge and vital tree individuals	Foster old, huge and vital tree individuals	AT	1	OL
ALPINE PASTURE	Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out of faeces	Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings	AT	1	OL

	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	AT	1	OL
	Unwanted cattle grazing (cattle density and grazing patterns)	Grazing management for cattle on alpine pastures (temporally limited grazing on different locations)	AT	1	OL

4. Action plan for achieving best functional patterns of land use

The main goal of the work package T2 activities is to set up an Action plan for adaptation of existing land use and flood/drought management practices for the purpose of drinking water protection. This Action Plan presents a road map towards integrated and sustainable drinking water protection.

Testing of BMPs in PAs was done in three steps (Figure 2). In the first step the most relevant BMPs for particular PA from the work package T1 were selected. In PAs status of best management practices implementation was assessed and in case of lacks identified, possibilities of improvement (solutions and recommendations) and implementation were assessed. Various activities were performed for the implementation of BMPs (Step 2 in Figure 2) and to find out stakeholder's opinion about selected BMPs (Step 3 in Figure 2). In representative PAs, considering the different ecosystem services, implementation strategies of BMPs which are important for water protection were elaborated.

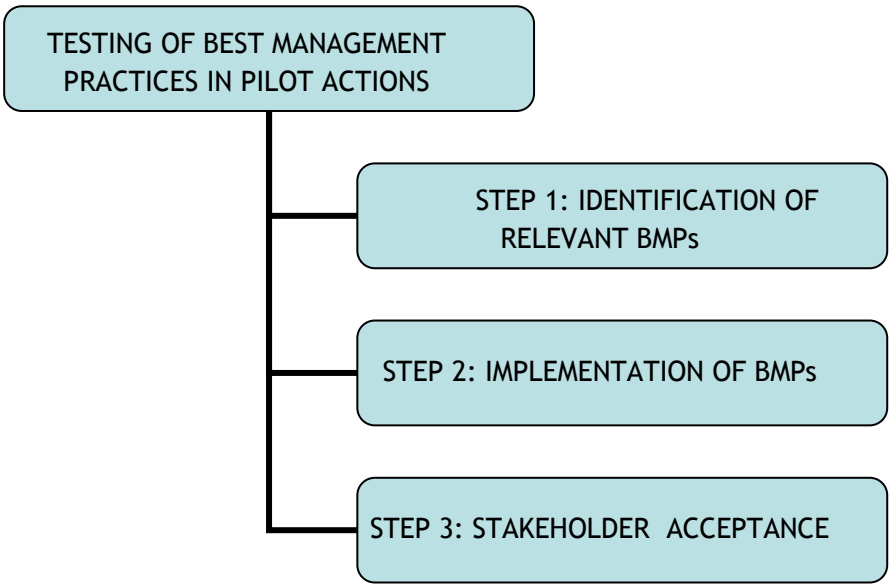

Figure 2: Testing of Best Management Practices (BMPs) in Pilot Actions.

4.1. Solutions and recommendations

In this chapter an analysis of examined/tested best management practices and related suitable solutions and recommendations for adaptation of existing land use and flood/drought management practices and improved policy guidelines in the particular PA is summarized. The overall purpose of all mentioned management adaptations is the sustainable protection of the drinking water resources.

37 proposed recommendations and solutions were laid out within the section ***Adaptation of existing land use management***, 35 within ***Adaptation of existing flood/drought management*** and 36 within ***Adaptation of policy guidelines***. Classifying GAPs and BMPs according to what kind of land use type/category each problem is related to, showed that most of the issues found on the Pilot Action sites are related to flood events and general water management issues which refer to all land uses.

General and drinking water management: proposed solutions and recommendations show lack of measures, tools, or information. The most common are the following recommendations: results of catchment modelling and ecological modelling should be integrated in preparation of spatial plan, using hydrological modelling, applying a rainfall/run-off model, increase the use and sharing of drought early warning system among stakeholders, increasing the number of spatial/temporal detail and type of data about land use and environment representation, more cooperation and interactions between ministries, experts and public is needed - combining their knowledge and experiences instead of independently approaching to common problematics. In DWPZs, land use management practices must change accordingly. This is mostly related to agricultural practices, construction, spatial planning and waste management.

Flood management: update of registry of pollution sources, use of hydrological/hydraulical models – elaboration of flood risk maps as an adaptation of evaluation of parcels included in municipal spatial planning, prevention of land use change that could deteriorate conditions regarding sustainable protection of the drinking water resources, establishment of protective forests and promotion of cultures resistant to floods are mostly proposed.

Agricultural areas: ensure closed manure storage facilities and provide guidelines for farmers about manure storage, the availability of subsidies for the implementation of such practices, the period of restrictions of fertilizers and manure application should be redefined according to the weather condition instead of calendar date, establishment of groundwater level monitoring network.

Urban areas: plans for the extension of sewage and purification network must shift towards green and innovative methods, raising awareness on interaction of pollutants, groundwater and fast infiltration (in karst terrains), remediation of illegal and improper landfills (especially in such vulnerable environment as karst), controlled and regularly maintained road rainwater discharge is necessary for all roads and motorways.

Forests: prohibition of clear-cut applications within DWPZs, regulation of the wild ungulate densities to a forest ecologically sustainable level, construction of forest roads only exceptionally if necessary for forest stabilisation, man-made plantations with non-natural tree species should be transformed gradually to stands dominated by native species.

Alpine pastures: more troughs should be provided and distributed strategically over the whole alpine pasture in order to avoid the creation of erosion dynamics, at active pastures the karstic features dolines and sinkholes have to be fenced out in order to minimize the risk of source water contamination with faeces, strategical placing of fences and the punctual change of the grazing cattle from one to the next fenced part of the alpine pasture helps to avoid erosion processes.

Regarding remaining issues to be solved for best management practices, which were selected as relevant BMPs for Pilot Actions the importance of awareness raising among relevant stakeholders and community is mostly emphasised. Awareness and preparedness about water resources issues is crucial to be able to cope with drought and flood events, which could be also enhanced by climate change. Another relevant point is timely reaction and development of CC adaptation plans and simulation tools which benefit all ESS and people. Furthermore, these and similar strategies could save money in the long term due to prevention, instead of intervention. Integration of water policies with land use policies (strategic planning process) and with this connected availability of good quality input data is also vital for achieving optimal results.

4.2. Implementation possibilities of selected best management practices

There are many best management practices for drinking water protection and flood protection, which are already 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).

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.

We can conclude that sustainability of these measures will depend mostly on 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 ***agricultural areas***: 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 ***forests***: habitual management practices, strong interest and lobby for trophy-hunting, purpose of timber-yield maximisation, insisting on bad management practices in terms of water;
- in ***alpine pastures***: habitual management practices, lacking will to implement new management routines, purpose of intensification of alpine pasture land-use, purpose of extension of active alpine pasture areas.

4.3. Acceptance of BMPs among stakeholders and experts

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.

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.

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.

5. 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 regarding drinking water protection, such as: forest ecosystem service functionality; land-use planning conflicts; flooding issues; impact of climate change and land-use changes.

The main goal of the work package T2 activities is to set up an Action Plan for adaptation of existing land use and flood/drought management practices for the purpose of drinking water protection. This Action Plan presents a road map towards integrated and sustainable drinking water protection:

- Step 1: selection of the most relevant BMPs for particular PA from the work package T1
- Step 2: assessment of status of BMPs in PAs; in case of lacks identified, possibilities of improvement (solutions and recommendations) and implementation were assessed.
- Step 3: various activities were performed for the implementation of BMPs and to find out stakeholder's opinion about selected BMPs.

In representative PAs implementation strategies of BMPs which are important for water protection were elaborated. The relevant Best Management Practices (BMPs) selected for particular pilot actions represent the management actions which were considered to solve the problems given through the existing GAPs. Their identification is the result of desk reviews, expert judgments and a deep stakeholder involvement.

GAPs are basically the result/consequence of interactions or contradictions in the space, as the space is a product of its intrinsic characteristics and inputs of human activities/land use. Therefore, all selected GAPs and corresponding BMPs within the PAs of PROLINE-CE project were classified according to which land use type/category the identified problems/challenges are related to: agricultural areas, urban areas, forests and alpine pastures. All GAPs/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses.

Eight GAPs were assigned to ***general water management***, which is related to ***all land uses***. These GAPs draw up shortage in measures, tools, or information, which would be necessary for ensuring a more efficient water management in the given PAs. The Italian partners have developed and currently maintain the Water scarcity and Drought Early Warning System (DEWS), supporting the Drought Observatory/Steering Committee of the Po River Basin and planning processes managed by the Po River Basin District Authority as well. Four GAPs in this group were identified in the Polish PA, where the inadequate monitoring system, lack of information about water hazards, lacking information about ecology of the water reservoir and low level of

ecological awareness are presenting main issues. The Austrian and German partners stressed importance of continuous hydrological monitoring and hydrological/hydrogeological modelling in order to assess groundwater recharge and possible impacts of land use on spring water quantity and quality. The German PA describes the need of collaboration of public, the government as well as experts in development in action plans. This cannot be approached with water management tools, but it regards general water management. Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources was set out in Slovenia as connecting different stakeholders (governmental institutions) and experts from different fields is of vital importance to achieve optimal results.

Three GAPs were classified in the group of ***drinking water management***, which is related to ***all land uses*** and present the pressure on water resources quantity caused by anthropogenic pressure, pipeline leakage, and climate change in the Italian and Croatian PAs. Because of these factors there is a significant freshwater loss which could be mitigated by reconstruction of public water supply network improving the understanding about the potential direct and indirect (e.g. for LUC) impacts of climate change permitting adequate adaptation strategies. In the Slovenian, Polish and Croatian PAs a need to establish drinking water protection zones (DWPZs) arises, therefore those GAPs were merged into one; however, in future steps each country proposed its own approach to solve the problem. Another GAP was identified in the Slovenian PA, which is insufficient inspection of limited/prohibited activities in existing DWPZs.

Issues related to ***flood management***, which is related to ***all land uses***, are the most common in Slovenia, then in Hungary but also noted in Italy and Croatia. The GAPs are describing deterioration in both water quality and quantity and the most important measure proposed is hydrological/ hydraulical modelling. For this flood forecast is very important and the Flood Early Warning System (FEWS), developed and currently maintained by the Italian partner, supporting the Flood Forecast Centre and planning processes managed by the Po River Basin District Authority, is a sample case. In both Hungarian PAs and in Slovenian PA the main problems are (1) potential rinsing of pollutants in flooded areas causing pollution of surface waters and with this linked drinking water sources and (2) interruption of drinking water supply due to flooding of drinking water supply infrastructure, for which registration of potential pollution sources in flood prone areas is needed and flood prevention measures (considering climate change) have to be implemented for ensuring drinking water supply during high waters/flood. The maintenance of river banks vegetation and legalization of illegal construction on flood areas are recognised as problem in Slovenia. In Croatian PAs the flood events pose problems mainly because of lack of maintenance of flood controlling infrastructure, but along with this the Croatian partner proposed non-structural mitigation methods as well.

Six GAPs/BMPs are recognised in ***agricultural areas***. Three of those were identified in Slovenia and Hungary, where the main problem is improper use of pesticides and/or fertilizers and improper manure storage. These anthropogenic factors cause quality deterioration in surface and groundwater, while climate change could worsen the problem. Solution is involving farmers to the Agrarian Environmental Program, frequent monitoring and education of farmers and

emphasizing the importance of green products. In Croatian PA increased water demand for irrigation is becoming a serious problem and it will be worsened by the expansion of agricultural production areas in the future and by climate change. The proposed solution is continuous monitoring of groundwater level and of irrigation water demand. In the German PA continuous changes in agricultural land use pose a great issue for surface- and groundwater quality and quantity.

Six GAPs/BMPs are identified in ***urban areas*** in the Croatian, Slovenian and Hungarian PAs. The main issue is water quality deterioration due to insufficiency or lack of sewage system and wastewater treatment, illegal waste disposal and waste disposal which do not meet environmental standards and unarranged road rainwater discharge. In case of wastewater management one solution is the establishment of wastewater systems (collection and treatment). For wastewater treatment a natural system was proposed, which costs three times less than common purification methods, it does not need any machinery or energy, and it is eco-friendly. The other issue is related to the public or illegal waste disposal, and the improper waste management. The proposed BMPs were raising awareness and educate the public about sustainable waste management. Concerning road rainwater, a collection and treatment of road rainwater discharge, particularly within drinking water protection areas are proposed. Moreover, limitation of salinity of road water run-off has to be determined. In the Slovenian PA also, urban runoff management was proposed as collection of torrential water in wider channels and/or small retention ponds which should be determined by hydrological/hydraulical model.

Six GAPs are assigned to land use ***forest***. The majority were recognized in Austrian PAs, one in Slovenian PA. They mostly derive from (excessive) anthropogenic activities like clear-cutting, forest road construction, hunting, and conifer tree plantations and have as a consequence e.g. increased surface runoff and decrease of groundwater quality and quantity. Proposed BMPs are the avoidance of clear-cuts, limitation of forest road constructions, sustainable wild ungulate density, and plantation or natural regeneration of diverse site-adapted autochthonous tree species. The overall purpose of BMPs in the field of forestry is the improvement of forest ecosystem stability and resilience in order to achieve high drinking water protection functionality.

Finally, three GAPs are classified in the group of ***alpine pastures*** and were identified in Austrian PA. The related BMPs address grazing management for cattle on karstic alpine pastures to prevent erosion processes and groundwater pollution.

In T2 many conflicts (GAPs) of management & operation of water supply companies and land-use management in recharge/water protection areas were identified. For most of them BMPs were proposed. For BMPs possibilities of implementation were assessed and implementation strategies (procedures) were determined. Implementation of BMPs for drinking water protection and flood mitigation 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.

Additionally, stakeholder's opinion about selected BMPs was acquired. In most cases stakeholders are supporting the proposed BMPs, but mostly they are not in the position to achieve changes in the system.

Identified BMPs within PROLINE-CE project are on different levels, some of them are legislation and governmental oriented and the others are very operational and are based on practitioners (farmers, individuals…).

On the Pilot Action level 14 out of 41 BMPs were already implemented in the frame of T2 activities, most of them (9) in general water management category and forest land use. One example is the implementation of BMPs in PA1.2 Waidhofen/Ybbs where BMPs were strategically planned through the elaboration of the "Guideline for securing the Water Protection functionality of the forest ecosystems within the DWPZ" (GWP) which defines all relevant BMPs for the watershed. GWP was resolved through the city council of Waidhofen/Ybbs and has now normative character. The second example is set up of the multiscale monitoring of the water resources to investigate and assess water resources, sources of pollution and possible hazards in PA2.2 Kozłowa Góra. Based on the results mathematical models of hydrology and ecology of the Kozłowa Góra reservoir was established. Simulations run allowed to assess an impact of land use and water management to water quality and quantity and its ecology. A proposal for DWPZ was prepared and is being implemented. The proposal includes limitation in land use, wastewater management and fishery.

On the other hand, some BMPs are very complex and require system change or even a change of policy guidelines, which are long lasting procedures and cannot be done during the project lifetime. Moreover, implementation of BMPs is limited by economic, administrative, social acceptance or governance issues. Therefore, it is crucial to continue the stakeholder dialogues to foster the implementation of BMPs into daily practice and/or policy guidelines. Further activities should have the focus on the implementation of the proposed BMPs on the national (guidelines issued by state agencies) and local levels (e.g. BMP implemented by a public water supplier or municipality). It is therefore crucial that BMPs for drinking water protection and flood mitigation are as much as possible in concordance with all stakeholders (linked to all land use activities) in the recharge area of the drinking water source.

6. References

PROLINE-CE WORKPACKAGE T2, ACTIVITY T2.1 REPORTS:

- D.T2.1.2 Transnational case review of best management practices in pilot actions. Transnational report

PROLINE-CE WORKPACKAGE T2, ACTIVITY T2.2 REPORTS:

- D.T2.2.3 Pilot action cluster report: PILOT ACTION CLUSTER 1 – Mountain Forest and Grassland Sites
- D.T2.2.3 Pilot action cluster report: PILOT ACTION CLUSTER 2 - Plain Agriculture/ Grassland/ Wetland Sites
- D.T2.2.3 Pilot action cluster report: PILOT ACTION CLUSTER 3 - Special Sites (riparian strips)

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

- D.T2.3.3 PA reports about climate change issues in pilots. Transnational report

PROLINE-CE WORKPACKAGE T2, OUTPUT REPORTS:

- O.T2.1 PA cluster 'mountain forests and grasslands' – implementation, showcasing best management practices. Output of Cluster 1.
- O.T2.2 PA cluster 'plains: agriculture, grass/wetland' – implementation, showcasing best management practices. Output of Cluster 2.
- O.T2.3 PA cluster 'riparian strips' – implementation, showcasing best management practices. Output of Cluster 3.

COLOPHON

PROLINE-CE web shared platform:

http://proline-ce.fgg.uni-lj.si/

Interreg Central Europe Programme - PROLINE-CE web page:

https://www.interreg-central.eu/Content.Node/PROLINE-CE.html

March 2019