

PROLINE-CE

WORKPACKAGE T2

PILOTS: IMPLEMENTATION AND FEEDBACK

O.T2.2 PA CLUSTER 'PLAINS: AGRICULTURE,
GRASS/WETLAND' - IMPLEMENTATION,
SHOWCASING BEST MANAGEMENT PRACTICES

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1. Introduction

Beside floods, conflicts between land use activities and drinking water protection in plains are inevitable and affect drinking water quality and quantity. The situation is worsened in every case by the lack of ecological awareness of the public and the lack of stimulations from the government.

Selected Pilot Actions (PA) face high pressure by land use due to agriculture. For all those PAs cost effective and environmentally friendly risk management is a prerequisite for ensuring safety of drinking water, therefore mitigation measures (best management practices) were developed in the frame of work package T2. Excessive educational programs would be also necessary even if the first approach of a problem is related to experts or the government.

Review of main land use conflicts and best management practices (BMPs) for drinking water protection and protection against floods on Pilot Action level is presented in *D.T2.1.2 Transnational case review of best management practices in pilot actions*, which was prepared on the basis of Pilot Actions report. Implementation and testing of BMPs in Pilot Action are described in *D.T2.2.2 Partner-specific Pilot Action documentation report*. Evaluation of actual implementation and thematic interpretation of tested management practices as well as their acceptance among stakeholders and experts is described in *D.T2.3.1 Evaluation reports for each pilot action*.

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 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 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.

The Slovenian pilot area (PA2.1) is 16.65 km². The largest percentage of surface is covered with forest and semi natural areas (45.3 %), following with artificial surfaces (30.6 %); the least of the surface belongs to agricultural areas (24.1%) (Fig. 1).

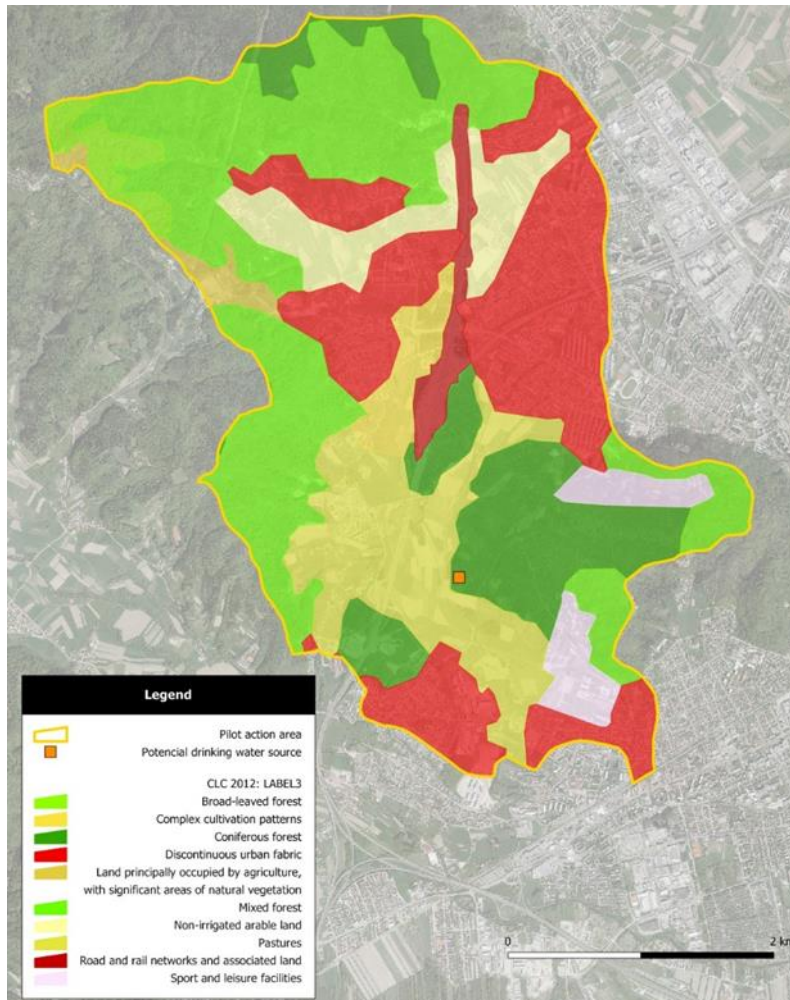


Figure 1: Land use in Dravlje valley pilot area, Slovenia (ARSO,2017).

The Polish pilot area (PA2.2) is 193.93 km². Its largest part is covered by forest areas - 47.8% of the land area, including forests - 46%. The remaining surface (1.8%) is covered by forest areas in the process of changes (forest nurseries, tree clearance). Agricultural lands cover the area of 82 km². This constitutes 42.3% of the total sub-basin area. They include arable lands, areas occupied by permanent crops (orchards and plantations), meadows and pastures as well as areas of mixed farming. Due to the dominant nature of the communes making up the sub-basin, anthropogenic regions constitute a small percentage of this area, with merely 7% (Fig. 2).

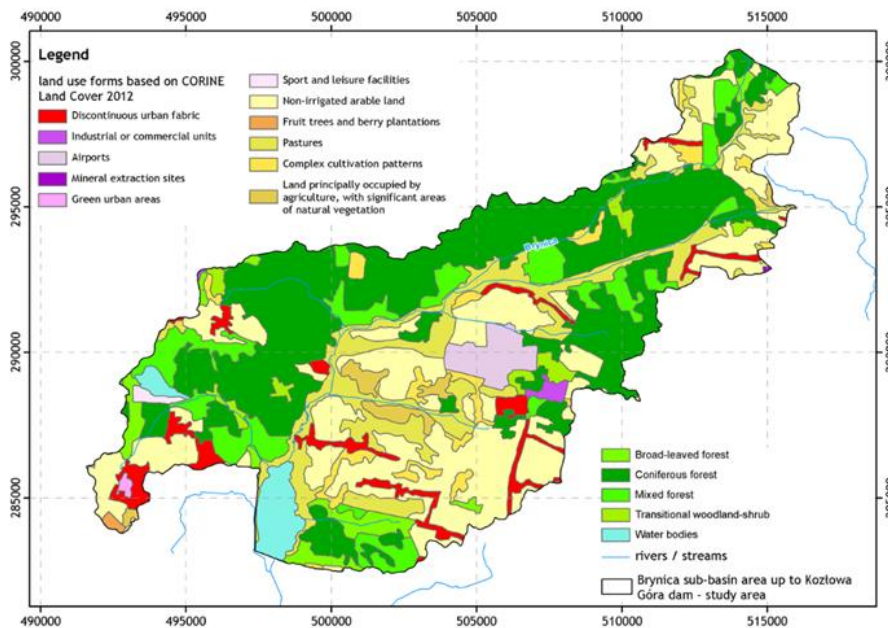


Figure 2: The land-use forms within the Brynica River sub-basin area, upstream the Kozłowa Góra dam, Poland.

The total surface of the Hungarian Pilot Action area is 7614 km². The largest part of the PA is covered by non-irrigated arable lands (35.42%), discontinuous urban fabric (14.06%) and broad-leaved forest (17.36%). Also significant land uses are discontinuous urban fabric, pastures, grasslands and shrubs (Fig. 3).

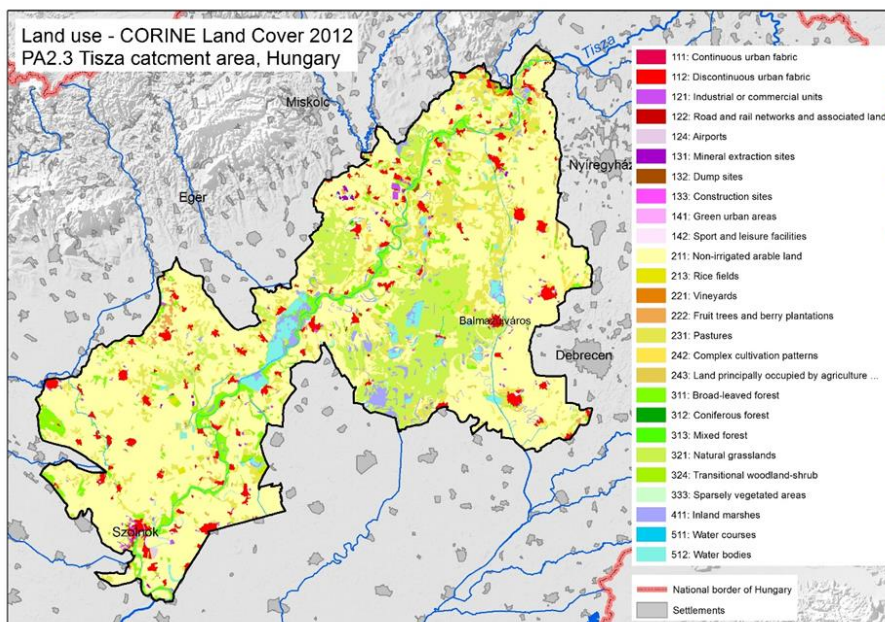


Figure 3: Land use in the Tisza catchment area, Hungary.



Croatia has two Pilot Action areas, PA2.4.1: South Dalmatia: Prud, Klokun and Mandina spring; and PA2.4.2: Imotsko polje springs. On PA2.4.1 broad-leaved forests (37919 ha) along with the transitional woodland-shrub areas (12125 ha) covers the majority of the area. Agricultural production composed of complex cultivation patterns, agricultural land with significant areas of natural vegetation, pastures, fruit trees and vineyards are concentrated in Rastok field, Vrgorac field and areas near Neretvariver. Water courses cover 256 ha, while 195 ha is covered with water bodies. Salt marshes (287 ha) and inland marshes (1693 ha) are present north of the Neretvariver (Fig. 4). Land use in Pilot Action Imotsko polje springs is Broad-leaved forests (6652 ha) along with land principally occupied by agriculture, with significant areas of natural vegetation (3715 ha) covers the majority of Pilot Action area. Agricultural production composed of complex cultivation patterns, agricultural land with significant areas of natural vegetation, permanently irrigated land, non-irrigated arable land, pastures and vineyards is concentrated in Imotsko field and along settlements. Water bodies cover 313 ha, while around 62 ha is covered with inland marshes (Fig. 5).

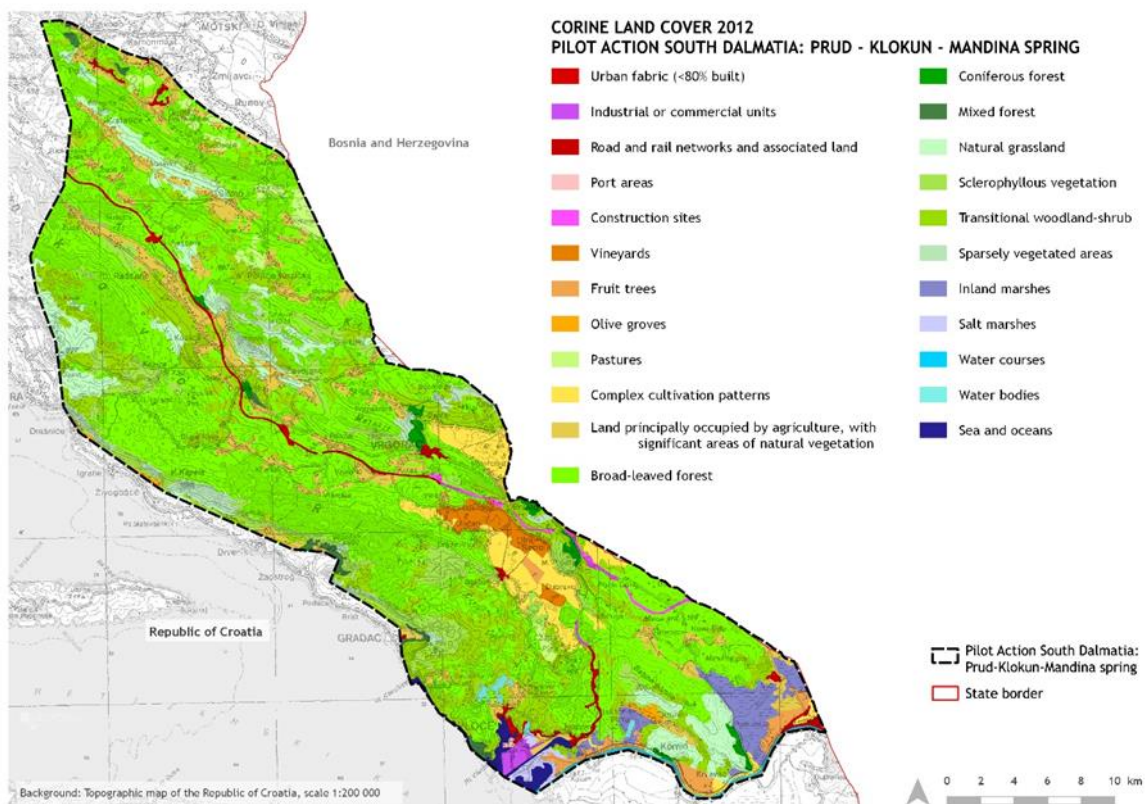


Figure 4: Land use in South Dalmatia, Croatia.

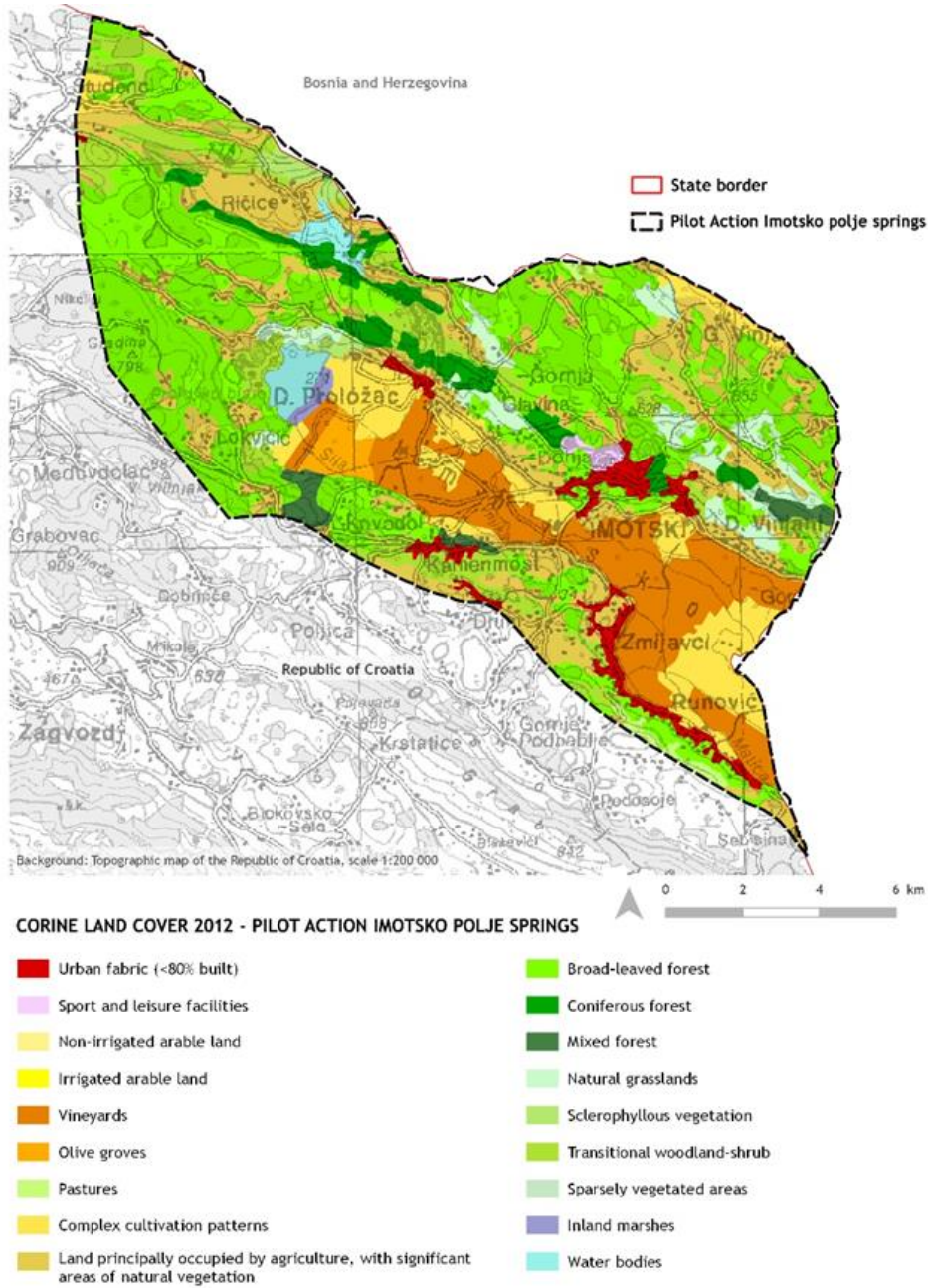


Figure 5: Land use in Imotsko polje springs, Croatia.

The German PA covers an area of about 48.8 km². The land use in the pilot area is dominated by (non-irrigated) arable land (44.86 %). Settlement structures (CORINE codes 112 and 121) take over 20.56 % of the pilot area. These include discontinuous urban fabrics as well as industrial and commercial units. With a considerably lower areal extent as compared to the arable land, forested areas and pastures take over 17.66 % and 13.05 % of the pilot area, respectively (Fig. 6).

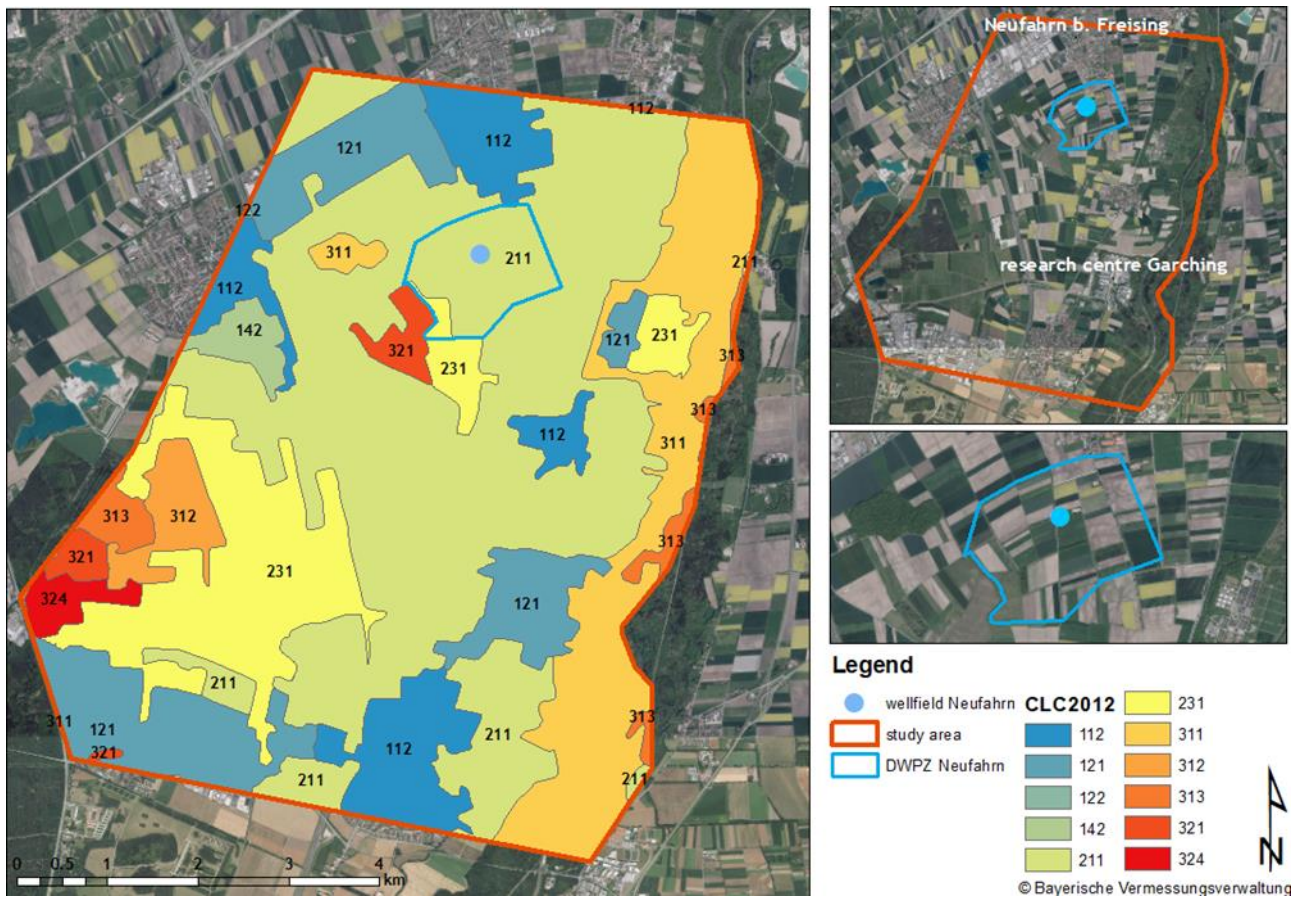


Figure 6: Land use in the Neufahrn pilot area, Germany.



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

On PAs within PAC2 in the *D.T2.2.2 Partner-specific pilot action documentations* a total of 19 GAPs were identified and 22 BMPs were proposed. In *D.T2.2.3 Pilot action cluster report*, we classified GAPs/BMPs according to what kind of land use type each problem is related to, or, if a problem is not related to any specific land use types, we grouped them according to water management subcategories. The groups are:

- *general water management,*
- *drinking water management,*
- *flood management,*
- *all land uses,*
- *agricultural areas,*
- *urban areas.*

2.1. Implementation possibilities of selected best management practices

There are many best management practices for drinking water protection and flood protection, which already exists, but often there are problems with actual implementation of these BMPs. Implementation possibilities for selected BMPs were assessed in the particular Pilot Action of Pilot Action Cluster 2.

In work package T1 BMPs for drinking water protection and flood mitigation were identified. The main goal of work package T2 is testing of BMPs, which are relevant for Pilot Actions. In the first step relevant BMPs were selected (Figure 7). Various activities were performed for the implementation of BMPs (Step 2) and to find out stakeholder's opinion about selected BMPs (Figure 7).

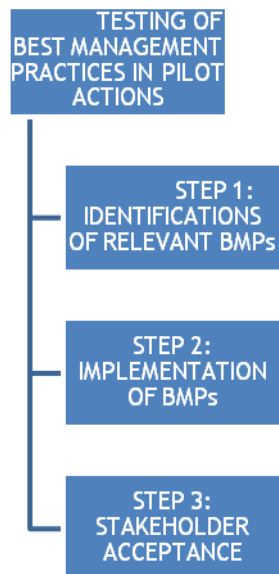


Figure 7: Testing of Best Management Practices (BMPs) in Pilot Actions.

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.

Solutions and recommendations for adaptation of best management practices are presented in Table 3.

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. For such BMPs possibilities of implementation were assessed and implementation strategies (procedures) were determined (Table 4).

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. Acceptance of best management practices for drinking water protection and flood mitigation among stakeholders and experts is presented in Table 5.



Table 2. Overview table of identified GAPs and related BMPs on Pilot Actions sites in Cluster 2.

CATEGORY	GAP	BMP	COUNTRY
GENERAL WATER MANAGEMENT (all land uses)	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard	PL
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale	PL
	No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	PL
	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
	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
	Low level of ecological awareness of society	Raising awareness and increasing knowledge	PL
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
	Drinking water protection zones (DWPZs) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	SI
			PL
			HR
Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	SI	
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
	Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulical model	SI
	Water balance status and effective mitigation measures are not known (identified)	Water balance status will be determined with Hydrological / Hydraulical modelling	SI
	Increased contamination of surface drinking water resources during flood events	Reduction of flood effects at the surface drinking water resources	HU
	Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	HR
	River banks vegetation is not maintained	Reducing river banks vegetation	SI
	Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas	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	HU
	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
	Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application	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	HR
	Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	DE
URBAN AREAS	Insufficiently effective waste water treatment system that needs to be reconstructed and expanded	Natural waste water treatment system	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	SI
	Waste disposal which do not meet technical and environmental standards and illegal waste disposal	Educative brochure and awareness raising activities	HR
		Encourage and promote innovative solutions of sustainable waste management	
	Unarranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas	SI
No limitation of road runoff water salinity	Define limitation of salinity of road water runoff	SI	
FOREST	Abandoning private forests, aging of forests and with it exposing vulnerable forests to natural disasters	Forestry subsidies and encouraging foresters to younger their forests	SI



Table 3: Solutions and recommendations for adaptation of best management practices (STEP 1: Identification of BMPs).

PA2.1 Well field Dravljje valley in Ljubljana, Slovenia					
Actual management practice (GAP)	Proposed BMP	Proposed solutions and recommendations			Remaining issues to be solved
		Adaptation of existing land use management practices towards the purpose of drinking water protection	Adaptation of existing flood/drought management practices with regard to drinking water protection	Adaptation of policy guidelines	
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)	Ministries, experts and public independently approach to common problematics, such as drinking water resources protection, instead of combining their knowledge and experiences to find unified and optimal solutions. Therefore, more communication and cooperation is needed horizontally (inside ministries, among ministries, among experts, etc.) and vertically (panel discussions/round tables with experts and governmental bodies). More interactions (discussions, negotiations, finding solutions for sectors on which drinking water protection measures affect (trying to find win-win situations)) are needed for achieving the main goal - drinking water protection.	/	/	/



<p>Pollution sources in flood prone areas are not known / identified</p>	<p>Register of potential point pollution sources on flood areas identified in PA</p>	<p>Some of the potential pollution sources are known (especially industrial establishments under Seveso Directive), but there is among others no registry of some other pollution sources (i.e. heating oil tanks in households), which are still quite common in Slovenia. Also, storage of large quantities of hazardous materials on flood prone zones is not regulated.</p>	<p>Some non-SEVESO and non - IED facilities are handling nevertheless significant amounts of polluting substances on flood prone areas. This includes also households storing small amount of chemicals, and especially heating oil tanks, that might leak during the flood event.</p>	<p>Potential pollution sources are exceeding current requirements of national legislation (Slovenia: Environmental protection act O.G. 39/2006) and EU requirements SEVESO Directive, IED Directive 2010, E-PRTR Register.</p> <p>Proposed amendment to existing Decree on conditions and limitations for constructions and activities on flood risk areas 89/08 - activities of storage activity on flood prone zones.</p>	<p>/</p>
<p>Drinking water protection zones (DWPZs) do not exist</p>	<p>Determination (e.g. hydrogeological modelling) and establishment of DWPZs</p>	<p>DWPZ areas were determined with modelling and will be proposed to include in the Spatial plan of the Municipality of Ljubljana. In current Spatial plan there is only reserved are for planned Water field without surrounding protected areas with restrictions. The restrictions should already be applied, such as: construction of buildings is prohibited, no waste disposal, no storages of dangerous substances, prohibition of use of pesticides and fertilizers, salting undrained surfaces like yards and gravel roads, etc.</p>	<p>Glinščica stream is already regulated practically in its entire length. The riverbed is made from concrete and there are concrete panels on some parts of the bank. The planned water field is not endangered with flooding, but the surrounding area is.</p>	<p>Adaptation of Spatial plan of the Municipality of Ljubljana with DWPZ determination and adoption of Decree on the water protection area for this aquifer.</p>	<p>/</p>
<p>Lack and not</p>	<p>Strict</p>	<p>It is prohibited to carry out</p>	<p>In case of floods in the area of</p>	<p>Implementation should be</p>	<p>/</p>



effective control over implementation restrictions for existing DWPZ	implementation and inspection of DWPZ restrictions	activities in the catchment area that could endanger the ground water quality, such as: the disposal of waste, the storage of dangerous substances, the use of pesticides and fertilizers, salting undrained surfaces like yards and gravel roads, vehicle maintenance and parking of construction machinery, except in the case of activities for the public supply of drinking water. Hence well directed restrictions for DWPZ area there is no inspection and no control over its implementation.	DWPZ surface waters and groundwater could cause pollution by transportation of pollutants.	supervised by inspectors of the Ministry of Agriculture, Forestry and Food.	
Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	Some of the potential pollution sources are known (especially industrial establishments under Seveso Directive), but there is among others no registry of some other pollution sources (i.e. heating oil tanks in households), which are still quite common in Slovenia. Also, storage of large quantities of hazardous materials on flood prone zones is not regulated.	Some non-SEVESO and non - IED facilities are handling nevertheless significant amounts of polluting substances on flood prone areas. This includes also households storing small amount of chemicals, and especially heating oil tanks, that might leak during the flood event.	Potential pollution sources are exceeding current requirements of national legislation (Slovenia: Environmental protection act O.G. 39/2006) and EU requirements SEVESO Directive, IED Directive 2010, E-PRTR Register. Proposed amendment to existing Decree on conditions and limitations for constructions and activities on flood risk areas 89/08 - activities of storage activity on flood prone zones.	/
Surface water intrusion in the well	Sealed wells heads on flood areas	Wells heads should be constructed as sealed in a way to prevent the	Many water supply wells are on flood-prone plains, so the wells	Amendment to the data specification relative to standards	



	evaluated according to Hydrological / Hydraulical model	surface water intrusion in the well during the flood event.	heads should be constructed as sealed.	of construction on flood prone zones (proposed amendment to existing Decree on conditions and limitations for constructions and activities on flood risk areas 89/08).	
Water balance status and effective mitigation measures are not known (identified)	Water balance status will be determined with Hydrological / Hydraulical modelling	/	A Hydrologic model is a simplification of a real-world system (e.g., surface water, groundwater) that aids in understanding, predicting, and managing water resources. Hydrological/hydraulical models are developed to analyse, understand, and explore solutions for sustainable water management, in order to support decision makers and operational water managers. Hydrological models also allow us to do scenario analysis.	Flood risk map as an adaptation of evaluation of parcels included in Municipal spatial planning.	
River banks vegetation is not maintained	Reducing river banks vegetation	Spreading of invasive plants cannot be limited. The most problematic plants are Ambrosia and Japanese Knotweed (<i>Fallopia japonica</i>). Ambrosia is declared to remove with a Decree while Japanese Knotweed is only advised to remove, both in the periods until blooming (August/September) to reduce the	River banks vegetation prevents accessibility of rivers / streams and with it cleaning the stream bed. Fluidity of the streams is reduced with the residues after the logging, which presents a great issue in time of high water and floods.	Similar Decree as on Ambrosia (Ambrosia should be Decree on measures to suppress harmful plants of genus Ambrosia (Official Gazette No. 63/10) should be accepted also on Japanese Knotweed. The fees for not cutting river bank vegetation should increase.	



		spreading. Ambrosia is prescribed to spray with applications to slower the spreading but with only cutting, it is still not sufficiently removed. Some of the stakeholders will try to remove Ambrosia with steam devices which is a new technic and more sufficient. Japanese knotweed is removed by cutting but the only sufficient way to permanently remove the plant is to dig it out with its roots.			
Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas	Parcels evaluation of flood risk should not be taken only as a recommendation but for a regulation, never the less it is a mandatory requirement for buildings permit. Therefore, construction on such areas is illegal and should be penalized.	Illegal construction on areas evaluated with flood risk should not be legalized and should bear the consequences of floods or financial consequences of flood protection constructions.	Improvement of ineffective control or higher penalties from state authority on illegal construction (legislation implementation problem).	
Redefinition of time ban of fertilizers and manure application	Since vegetation activity depends on current weather conditions, the period of restrictions should be redefined according to the weather condition instead of calendar	Inappropriate fertilization management affecting groundwater and surface waters could cause pollution by transportation of pollutants during floods.	The Slovenian Environment Agency yearly produces the agronomic prediction according to the weather forecast but is more as a recommendation and not as an obligation with determined exact date of fertilizing period.	Redefinition of time ban of fertilizers and manure application	



	date. If vegetation is not active, the N-compounds pass through soil directly into the groundwater.				
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	Development of small retention measures, with water retention for different users. Potential users: watering of green infrastructure, climate impact on the city level, water for biodiversity, water for animals in the city. Improved fire protection for more resilient city.	Development of small retention measures, with water retention for different users. Potential users: watering of green infrastructure, climate impact on the city level, water for biodiversity, water for animals in the city. Improved fire protection for more resilient city.	Existing policy and regulation measures do not address necessity for gradual multi-use improvements of existing drainage systems. Strategic development of new policy framework addressing complex climate change adaptation process is necessary.	
Unarranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas	Road rainwater discharge (and main roads rainwater drainage and retention ponds with treatment) must be controlled and regularly maintained for all roads and motorways. Furthermore, road rainwater should not run through public sewage system.	Undesirable liquids such as mineral oils or other chemicals can be rinsed from the road into the groundwater and can consequently result in pollution of the drinking water source. Therefore, controlled and regularly maintained road rainwater discharge is necessary for all roads and motorways.	Adaptation of road management policy for road rainwater to run through separate system and not through public sewage system.	
No limitation of road runoff water salinity	Define limitation of salinity of road water run-off	In the narrowest area of water protection zones regulations are prescribed. It is prohibited to carry out activities in the catchment area that could	/	Upgrade on the Decree on the emission of substances in the discharge of meteoric water from public roads.	No limitation of road runoff water salinity



		endanger the ground water quality; among others also salting of undrained surfaces like yards and gravel roads is prohibited. Salting of roads and motorway cannot be prohibited, but the salinity of road water discharge should be limited.			
Abandoning private forests, aging of forests and with it exposing vulnerable forests to natural disasters	Forestry subsidies and encouraging foresters to younger their forests	Aging of Slovenian forest, due to unregularly maintenance is problematical, since older forest is more vulnerable to extreme weather conditions and catastrophes. Logging should take place in time of frozen ground, due to smaller erosion.	The foresters do not completely clean wood and residues after the logging, which is a problem in the fluidity of the streams in case of floods.	Most of the forest in the PA locates in two nature parks: Nature park Tivoli, Rožnik and Šišenski hill and also the natural park Polhograjski Dolomiti. In these parks activities are limited according to Ordinance for each Nature park in order to protect nature but there are no directives for maintaining the safety of the forest and their visitors, even sanitary cutting needs authority's agreement.	

PA2.2. Water reservoir Kozłowa Góra, Poland

Actual management practice (GAP)	Proposed BMP	Proposed solutions and recommendations			Remaining issues to be solved
		Adaptation of existing land use management practices towards the purpose of drinking water protection	Adaptation of existing flood/drought management practices with regard to drinking water protection	Adaptation of policy guidelines	
Small scope of	Establishment of	No adaptation required.	Investment in monitoring	Need of conducting proper,	/



water monitoring	constant, multi-aspects water monitoring in the catchment scale		system contains constant monitoring system.	multi-aspect monitoring of water system should be emphasized in guidelines at local, regional and also national level.	
No complex evaluation of water hazards	Complex catchment modelling	It is highly recommended that within preparation of local land use management plan procedure results of the catchment modelling should be taken into account.	It is highly recommended to use results of the catchment modelling simulation in flood/drought management.	Recommendation to include catchment modelling as a one of the tools using to improve water management.	/
No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	It is highly recommended that within preparation of local land use management plan procedure results of the ecological modelling, integrated with catchment models, should be taken into account.	It is highly recommended to use results of the ecological modelling simulation in flood/drought management.	Recommendation to include the ecological modelling, integrated with catchment models, as a one of the tools using to improve water management.	Good quality input and calibration data.
No DWPZ established	DWPZ establishment proposal	Limitations and prohibitions are included within the proposal.	Limitations and prohibitions are included within the proposal.	Proposal considers current Water Law and policy guidelines.	Good quality input and calibration data.
Low level of society awareness	Raising awareness and increasing knowledge	Participants are getting familiar with current land use management practises and proposal for BMP.	Participants are getting familiar with current management practises and proposal for BMP.	Participants are getting familiar with current policy.	Limited channels of information flow in small communities.



PA2.3 Tisza catchment area, Hungary

Actual management practice (GAP)	Proposed BMP	Proposed solutions and recommendations			Remaining issues to be solved
		Adaptation of existing land use management practices towards the purpose of drinking water protection	Adaptation of existing flood/drought management practices with regard to drinking water protection	Adaptation of policy guidelines	
Increased contamination of surface drinking water resources during flood events	Reducing flood effects on surface drinking water resources	Change of agricultural practices in riparian areas.	Current flood management practices are good, but preparation for extreme flood events caused by CC seems to be necessary.	Guidelines for agricultural practices in riparian areas.	Farmers and the water management sector should prepare for climate change.
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.	Closed manure storage facilities, managing and collecting rainwater (better drainage systems on livestock farms).	Collecting rainwater could be advantageous in drought periods.	Guidelines for farmers about manure storage.	Solve the problem of frequent monitoring of livestock farms with or without involving the authorities, preparing for climate change.
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	Ploughing parallel to the watercourse, usage of green products.	Not relevant	Not relevant	Forecasting how plant production will change as climate changes could be advantageous.



	information to the farmers about climate change.				
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PA2.4 Groundwater protection in karst area

Actual management practice (GAP)	Proposed BMP	Proposed solutions and recommendations			Remaining issues to be solved
		Adaptation of existing land use management practices towards the purpose of drinking water protection	Adaptation of existing flood/drought management practices with regard to drinking water protection	Adaptation of policy guidelines	
Increased water demand	Establishment of groundwater level monitoring network in Imotsko polje and South Dalmatia	If BMP is implemented, more efficient use of water in agriculture could be achieved. On the basis of new findings, agricultural stress on groundwater could be quantified and if necessary, land use change could be prevented.	Groundwater monitoring network will reduce uncertainty and could enable better responses and management action in case of floods and droughts.	Relevant for water market: if necessary, revisions of payments, schemes and quotas.	The measure is simple, but requires funding sources, which is unclear at the moment.
Pressure on water resources quantity	Climate change adaptation and resilience / Reconstruction of public water supply network	Aim of measures is to mitigate negative effects of CC, therefore to prevent negative land use change and spreading of concrete surfaces. Instead, green retention and infiltration zones must be designated.	Flood management practices should include further construction of retention objects in flood prone areas. Agricultural production must adapt to upcoming CC scenarios and prolonged droughts by rationalizing water consumption and making it more effective.	CC Adaptation Strategy 2040-2070 and Action Plan 2019-2023 provide good guidelines for adaptation and resilience for CC. Local authorities should incorporate it in local plans and strategies.	First step is raising awareness on the climate change and adaptive management practices among relevant stakeholders. A timely reaction and development of CC adaptation plans benefits all ESS and population, therefore, it is a prerequisite for freshwater availability of future generations. Furthermore, adaptation plans,



					and strategies could save money in the long run due to prevention, instead of intervention.
Unsanitary and illegal waste disposal	Educative brochure and awareness raising activities	Not relevant	Not relevant	Policy guidelines are good, penalties are prescribed for illegal waste dumping, but inspections are poor, and misdemeanour is not punished.	As above
Unsanitary and illegal waste disposal	Encourage and promote innovative solutions of sustainable waste management	Not relevant	Not relevant	Innovative solutions for waste management are not mandatory, but rather an option. However, positive management examples can serve as a catalyst to improve waste management guidelines.	Stakeholders are a bit doubtful about the success of this measure. Although positive trends can be observed, the process is slow and requires persistence.
Insufficiently effective waste water treatment system that needs to be reconstructed and expanded	Natural waste water treatment system	If measure is to be applied, land use and spatial planning documents and practices must be modified in a way that the municipality designates an area to be utilised as natural WWTS. This usually requires 3-5 m ² per population equivalent, making it ideal for small settlements, industrial sites, farms or landfills.	Natural WWTS must be flood-proof to avoid spreading of pollutants and degradation of water quality.	Plans for the extension of sewage and purification network must shift towards green and innovative methods.	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, which is problematic for high scale systems).
Periodic field	Infrastructure	Non-structural flood	Proposed measures could	Prevention of land use change	Measure is complex, as it faces



flooding	maintenance and reconstruction / Non-structural flood mitigation measures	mitigation measures include prevention of land use change, establishment of protective forests and promotion of cultures resistant to floods (e.g. grapevines).	enhance flood mitigation and management action.	should be included in designated sensitive areas (e.g. prevention of agricultural land spread on the account of Proložsko Blato wetland areas).	resistance of local population, lots of financial compensation for losses, and generally, structural measures are still favoured.
Insufficient number of proclaimed drinking water protection zones on valuable springs in South Dalmatia	Defining and establishing sanitary protection zones in South Dalmatia	If sanitary protection zones are proclaimed, land use management practices must definitely change. This is mostly related to agricultural practices, construction, spatial planning and waste management.	Not relevant	Policy guidelines are well developed concerning DWPZ, but implementation is lacking, inspections are inadequate, and penalties are rarely given.	Stakeholders and experts strongly support implementation of this measure, however, unwillingness of people to cooperate and since there are no legally binding obligations to abide pose a serious threat to the administration of the measure. Further education activities and awareness raising are needed to fully implement DWPZs.

PA2.5 Neufahrn bei Freising, Germany

Actual management practice (GAP)	Proposed BMP	Proposed solutions and recommendations			Remaining issues to be solved
		Adaptation of existing land use management practices towards the purpose of drinking water protection	Adaptation of existing flood/drought management practices with regard to drinking water protection	Adaptation of policy guidelines	
Lack of public engagement in development of action plans	Finding site-specific solutions by using a hydrologic model with a graphical	No adaptation of existing land use management practices required.	The availability of a hydrological model can provide relevant information for the stakeholders in terms	The value of an available hydrological model is not adequately reported in the current guidelines. This tool	Not applicable



	user interface in a participative approach		of water quantity and quality and support decision makers in the implementation of existing flood/drought management practices. The use of the proposed BMP has to be intended in a broader framework which can serve as decision support system for managers.	is of fundamental importance to find efficient site-specific solutions, to test the implementations of solutions proposed by the various relevant stakeholders and to communicate the decision-making process.	
Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	No adaptation of existing land use management practices required.	Invest in infrastructure to increase the monitoring network in the pilot action. Installation of gauging stations on the Isar river, identification of piezometers usable to monitor groundwater level, installation of multi parametric probe that measures continuously relevant hydrogeochemical parameters (water level, water temperature, electrical conductivity, pH, Nitrate, dissolved oxygen).	The value of monitoring should be more emphasized in the policy guidelines and water suppliers as well as water authorities should receive incentives to better manage available data and to collect more frequently and with a better spatial resolution relevant hydrogeochemical data.	Not applicable



Table 4: Implementation possibilities of best management practices for drinking water protection and flood mitigation with implementation strategies (procedures) (STEP 2: Implementation of BMPs).

PA2.1 Well field Dravljje valley in Ljubljana, Slovenia				
Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation		
		Possibility of implementation	Proposal of procedure for implementation	other
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.	/
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.	/
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.
Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	Possibility for implementation are medium. Information on some pollution /sources could originate from: a) Formalized procedures relative to	To adopt and enforce legislation enabling access to data and reporting on the amount of stored hazardous substances on flood prone areas.	/



		chimney sweepers identifying the location and status of devices (and tanks) b) Identification of stores and storage facilities with hazardous substances.	Maintenance of the dataset. After the identification it is important to raise awareness and provide measures leading to improvements.	
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.	/
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.
River banks vegetation is not maintained	Reducing river banks vegetation	Interest into implementation was shown among many stakeholders and therefore has potential for implementation but it may take some time to process the procedure.	No.	/
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	Strict implementation of construction inhibition on floodplains considering flood hazard map.



			parcels included in municipal spatial planning will be discussed among departments how to implement this legislation and propose an approach of solving this problem.	
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.	/
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.	/
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.	/
Abandoning private forests, aging of forests and with it exposing vulnerable forests to natural	Forestry subsidies and encouraging foresters to younger 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	Snaga d.o.o. already started to inform and aware relevant stakeholders; local farmers and residents through meetings.	/



disasters		increase according to the Municipalities promises.		
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PA2.2 Water reservoir Kozłowa Góra, PL

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

Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation		
		Possibility of implementation	Proposal of procedure for implementation	other
Small scope of water monitoring	Establishment of constant, multi-aspects water monitoring in the catchment scale	/	/	/
No complex evaluation of water hazards	Complex catchment modelling	/	/	/
No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	/	/	Catchment and ecological model already established, integration of these two models is ongoing.
No DWPZ established	DWPZ establishment proposal	/	/	Proposal is currently under legal procedures.
Low level of society awareness	Raising awareness and increasing knowledge	/	/	/



PA2.3 Tisza catchment area, HU1

Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation		
		Possibility of implementation	Proposal of procedure for implementation	other
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.	Not relevant
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.	Not relevant
Increased contamination of surface drinking water resources during flood	reducing flood effects on surface drinking water resources	/	/	The Szolnok Surface Waterworks operates well during flood events, purification technology is suitable for the treatment of changing water quality



events				- the operating system and the purification technologies must be reviewed in the context of climate change.
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PA2.4 Groundwater protection is karst area

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

Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation		
		Possibility of implementation	Proposal of procedure for implementation	other
Increased water demand	Establishment of groundwater level monitoring network in Imotsko polje and South Dalmatia	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.	/
Pressure on water resources quantity	Climate change adaptation and resilience / Reconstruction of public water supply network	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.	/
Unsanitary and illegal waste disposal	Educative brochure and awareness raising activities	/	/	/
Unsanitary and illegal waste disposal	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	Small scale application must start in order to provide a positive example for the rest of community.	/



		environmental issues and lack of government stimulations.		
Insufficiently effective waste water treatment system that needs to be reconstructed and expanded	Natural waste water 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 m2 per PE).	Local authorities or county starts the initiative and tries to find financial models.	/
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.	/
Insufficient number of proclaimed drinking water protection zones on valuable springs in South Dalmatia	Defining and establishing sanitary protection zones in South Dalmatia	Realistic	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).	/



PA2.5 Neufahrn bei freising, DE

Actual management practice (GAP)	Proposed BMP	Implementation of best management practices for drinking water protection and flood mitigation		
		Possibility of implementation	Proposal of procedure for implementation	other
Continuous conversion of (permanent) grasslands	Continuous monitoring program in both, surface water and groundwater	/	/	/
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	/	/	/



Table 5: Acceptance of best management practices for drinking water protection and flood mitigation among stakeholders and experts (STEP 3: Stakeholder acceptance).

PA2.1 Well field Dravlje valley in Ljubljana, Slovenia				
Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts		
		Possibility of implementation	Proposal of procedure for implementation	other
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.	/
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.	/
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.	/
Pollution sources in flood prone areas are not known /	Register of potential point pollution sources on flood areas	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	Aggregated list of all potential point pollution sources (industry, heating oil tanks in households, etc.) is needed for



identified	identified in PA		hazardous substances (as activity) in Water Management Information System.	efficient incident management in case of flood event.
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.
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.	/
River banks vegetation is not maintained	Reducing river banks vegetation	The stakeholders are aware of this problematic and are trying to solve it each in their own way; therefore, they will support implementation of guidelines/legislation.	Guidelines have to be prepared and promoted by Ministry of environment and spatial planning or Water directorate.	Slovenian motorway Network company (DARS) is trying to remove ambrosia with steam devices. City of Ljubljana - Department for Environmental Protection implemented the pilot project of production the paper from Japanese Knotweed and did the promotional calendars from that paper.
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.
Inflexible time ban of	Redefinition of time	The Slovenian Environment Agency	Workshops and seminars for local	/



fertilizers and manure application	ban of fertilizers and manure application	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.	farmers would improve awareness and perhaps reduce polluting their local groundwater source.	
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	An initiative was launched and Ljubljana as Green Capital of Europe 2016 is considering it as one of the development potentials. No communication on higher (regulatory) level yet, due to the election procedure and re-organization of the ministries.	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.
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.
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.	/
Abandoning private forests, aging of forests and with it exposing vulnerable forests to natural	Forestry subsidies and encouraging foresters to younger their forests	Implementation depends on the budget of the Park. The main problem presents many private owners of relatively small parcels, hence constant conflicts among them.	The upgrade of the Park's policies in the direction of rejuvenating and regularly maintaining the forest.	/



disasters				
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PA2.2 Water reservoir Kozłowa Góra, PL

Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts		
		Possibility of implementation	Proposal of procedure for implementation	other
Small scope of 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.	/
No complex evaluation of water hazards	Complex catchment modelling	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.	/
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	Ecological modelling, integrated with catchment models, should be included in policy guidelines as important tool for water management.	/



		the tools to simulate water environment and impact of possible hazard on water.		
No DWPZ established	DWPZ establishment proposal	High need of establishing DWPZ at Kozłowa Góra reservoir.	/	/
Low level of society awareness	Raising awareness and increasing knowledge	High need to raise awareness and increase knowledge in society.	Organisation of meeting at local scale.	/

PA2.3 Tisza catchment area, HU1				
Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts		
		Possibility of implementation	Proposal of procedure for implementation	other
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.
Improper or excessive use of pesticides and manure on plant production fields.	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of	/	/	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



	green products, providing information to the farmers about climate change.			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.
Increased contamination of surface drinking water resources during flood events	reducing flood effects on surface drinking water resources	/	/	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.

PA2.4 Groundwater protection in karst area

Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts		
		Possibility of implementation	Proposal of procedure for implementation	other
Increased water demand	Establishment of groundwater level monitoring network in Imotsko polje and South Dalmatia	Stakeholders gave positive feedback, but realistic possibility is questionable (mainly due to financing).	As in previous section.	/
Pressure on water resources quantity	Climate change adaptation and resilience / Reconstruction of public water supply network	Stakeholders gave positive feedback, but realistic possibility is questionable (consensus of all involved groups is hard to reach).	As in previous section.	/



Unsanitary 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.	/
Unsanitary and illegal waste disposal	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.	/
Insufficiently effective waste water treatment system that needs to be reconstructed and expanded	Natural waste water 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 UWWT possibilities will be included in educative brochure (see previous BMP).	/
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).	As in previous section.	/
Insufficient number of proclaimed drinking water protection zones on valuable springs in Dalmatia South	Defining and establishing sanitary protection zones in South Dalmatia	The administration of this measures is expected to be more efficient in near future.	Further education activities and awareness raising are needed to fully implement DWPZs.	/



PA2.5 Neufahrn bei Freising, DE

Actual management practice (GAP)	Proposed BMP	Acceptance of BMPs among stakeholders and experts		
		Possibility of implementation	Proposal of procedure for implementation	other
Continuous conversion of (permanent) grasslands	Continuous monitoring program 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. 4. Find an optimal cost/benefit configuration of the monitoring network. 5. Collect the permission to install new monitoring points. 6. Share the data, maintain the database and proof the quality of collected data. 	Bottlenecks that we identified in the implementation of the procedure are: <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 was not possible to identify the owner of some existing monitoring points).
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. 	Bottlenecks that we identified in the implementation of the procedure are: <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.



			<p>6. Use the model to test scenarios proposed by stakeholders.</p> <p>7. Support decision makers providing the model results in a comprehensible form.</p>	
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3. Conclusions

Six Pilot Action belong in PAC2: *PA2.1 Well field Dravlje valley in Ljubljana, SI; PA2.2 Water reservoir Kozłowa Góra, PL; PA2.3 Tisza catchment area, HU1; P2.4 Groundwater protection in karst area, 2.4.1 - South Dalmatia: Prud, Klokun and Mandina spring and 2.4.2 - Imotsko polje springs, HR; PA2.5 Neufahrn bei Freising, DE.*

PA2.1 Well field Dravlje valley in Ljubljana, Slovenia

PA2.1 is a potential well field in the Glinščica river sub-basin (Dravlje valley in Slovenia). Most of the identified issues are flood related and causing problems both in qualitative and quantitative aspects. Four out of the five BMPs describe a solution based on hydrological/hidraulical models. Model results will be beneficial for decision makers, while the implementation of the measures (proposed solutions) will be beneficial for consumers. There are no remaining issues to be solved within PROLINE-CE.

During the project the following activities were carried out:

- inventarisation of possible polluters in the urban recharge area of potential well field Dravlje, assessment of their impact on drinking water source and elaboration of measures and BMPs for protection of drinking water source,
- strong stakeholder involvement for implementation of best management practices with several national meetings with particular stakeholder (one-to-one) and regular interactive workshops with local stakeholders,
- establishing of distributed hydrological surface runoff model with full hydraulic propagation functions for surface waters, with evaluation of new flood measures (retention reservoir built in 2017) and climate change scenarios,
- simulations of the groundwater pumping effects in the recharge area of planned well field Koseze, taking into account impact of climate change in order to model pumping scenarios according to changed climate and recharge conditions.

PA2.2 Water reservoir Kozłowa Góra, Poland

Within **PA2.2** Kozłowa Góra several GAPS were identified including *Small scope of water monitoring, No DWPZ established, No complex evaluation of water hazards, No information about ecology of water reservoir and Low level of ecological awareness of society.* During PA activities GPW actions responded the identified GAPS. In June 2017 multiscale monitoring of the water resources was set up to investigate and assess water resources, sources of pollution and



possible hazards. Based on the results mathematical models of hydrology and ecology of the Kozłowa Góra reservoir was established. Simulations run allowed to assess a.o. 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 a.o. limitation in land use, waste water management, fishery. The most important BMP is reaching the society and raise the awareness. In a situation where the guidelines, policies exist and are not enforced raising awareness among society, especially small, local ones is crucial to implement.

The remaining issues to be solved are the followings: good quality input and calibration data, limited channels of information flow in small communities.

PA2.3 Tisza catchment area, Hungary

On PA2.3 Tisza catchment area results gained from data evaluation and comparisons highlighted that current practices in livestock farming, plant production and flood mitigation are good enough to keep the raw surface water in an overall good quality. The problem lies in climate change and how it is going to affect the efficiency of the current practices. For instance, open manure storages may not pose a big threat in the current climate conditions, but an extremely intensive rainfall could possibly trigger a surface runoff, even on a flatter land, which could contaminate the nearby watercourses. Current practices should be evaluated in context of future climate conditions. Remaining issues to be solved are the followings (not necessarily within PROLINE-CE): farmers and the water management sector should prepare for climate change, solve the problem of frequent monitoring of livestock farms with or without involving the authorities, preparing for climate change, forecasting how plant production will change as climate changes could be advantageous. These propositions pose benefits for decision makers, and long-term benefits for consumers and farmers.

PA2.4: Groundwater protection in karst areas in Croatia

On PA2.4.1 and PA2.4.2 the main issues are increased water demand (due to rise in agricultural production), periodical field flooding, poor condition of water supply network, illegal waste dumps, inadequate waste water treatment and non-compliance with regulations and restrictions set out by DWPZ ordinance. BMPs are expected to promote topics such as water protection, pollution and climate changes, resulting in an increased awareness among the whole community and water users. Intensive stakeholder involvement is the first step towards the implementation of any BMP. Perhaps the hardest thing to change is the human consciousness and this is where further efforts must be directed - this refers both to decision makers and population. Decision makers must directly stimulate good practices, and vice-versa, the population should adapt and generally change their attitude towards changes in actual management practices (which often include negative financial repercussions). Although PROLINE-CE duration is too short to test the



BMPs in pilot areas, indications towards positive changes in practices could be observable within project timeline. Croatian geological survey is a research institution, and therefore is not competent to directly implement measures and BMPs, but could only push such incentives via brochures, consultation with decision makers, education and further research.

Remaining issues to be solved: First step is raising awareness on the climate change and adaptive management practices among relevant stakeholders. A timely reaction and development of CC adaptation plans benefits all ESS and population, therefore, it is a prerequisite for freshwater availability of future generations. Furthermore, adaptation plans, and strategies could save money in the long run due to prevention, instead of intervention.

Stakeholders and experts strongly support implementation of “Defining and establishing sanitary protection zones in South Dalmatia” measure, however, unwillingness of people to cooperate and since there are no legally binding obligations to abide pose a serious threat to the administration of the measure. Further education activities and awareness raising are needed to fully implement DWPZs.

“Infrastructure maintenance and reconstruction / Non-structural flood mitigation” is a complex measure, as it faces resistance of local population, lots of financial compensation for losses, and generally, structural measures are still favoured.

“Establishment of groundwater level monitoring network in Imotsko polje and South Dalmatia” measure is simple, but requires funding sources, which is unclear at the moment.

“Natural waste water treatment system” challenges include high costs (which is also case with other purification methods) and extensive land surface is needed for the method (up to 5 m² per PE).

“Educative brochure and awareness raising activities”: policy guidelines are good, penalties are prescribed for illegal waste dumping, but inspections are poor, and misdemeanour is not punished.

Stakeholders are a bit doubtful about the success of BMP “Encourage and promote innovative solutions of sustainable waste management”. Although positive trends can be observed, the process is slow and requires persistence.

PA2.5 Neufahrn bei Freising, Germany

On PA2.5 proposed BMPs are *continuous monitoring program of hydrological data* with a high resolution in time and space as well as *hydrological modelling*. In the light of continuous changes in management practices as well as strongly economic-driven land use changes, a monitoring of relevant parameters in surface water and groundwater, such as water level, electrical conductivity, temperature, pH, nitrate among others, sets an appropriate frame to detect impacts of ongoing changes in the hydrological system. Given the enhanced database, a hydrologic model serves to relate any kind of changes to particular changes in the management



system. Moreover, the hydrologic model allows to pre-evaluate the impacts of a planned action and, thus, supports the decision-making process from the beginning to the end of an implementation process. Moreover, a comprehensive, understandable and applicable modelling framework can serve as a common tool for all stakeholders, from land owner to decision maker, to jointly elaborate action plans, making decision-making more participatory. An enhanced public engagement further helps to reduce the mistrust between the engaged parties.

There are no remaining issues to be solved.

Summary

Most of the issues found on the pilot sites are related to flood events, the lack of measures, tools, or information in water management, or the negative effects coming from agricultural production. 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 implementation of proposed solutions (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.

Elimination of these factors has already been started and has to go on beyond PROLINE-CE lifetime.



4. References

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

- D.T2.1.2 Best management practices report. PILOT ACTION: PA2.1 Well field Dravlje valley in Ljubljana, SI
- D.T2.1.2 Best management practices report. PILOT ACTION: PA2.2 Water reservoir Kozłowa Góra, PL
- D.T2.1.2 Best management practices report. PILOT ACTION: PA2.3 Tisza catchment area, HU1
- D.T2.1.2 Best management practices report. PILOT ACTION: PA2.4 Groundwater protection in karst area, HR
- D.T2.1.2 Best management practices report. PILOT ACTION: PA2.5 Neufahrn bei Freising, DE

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

- D.T2.2.2 Partner specific pilot action documentations. PILOT ACTION: Well field Dravlje valley in Ljubljana, SI
- D.T2.2.2 Partner specific pilot action documentations. PILOT ACTION: PA2.2 Water reservoir Kozłowa Góra, PL
- D.T2.2.2 Partner specific pilot action documentations. PILOT ACTION: PA2.3 Tisza catchment area, HU1
- D.T2.2.2 Partner specific pilot action documentations. PILOT ACTION: PA2.4 Groundwater protection in karst area, HR
- D.T2.2.2 Partner specific pilot action documentations. PILOT ACTION: PA2.5 Neufahrn bei Freising, DE

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

- D.T2.3.1 Evaluation reports for each pilot action. PILOT ACTION: PA2.1 Well field Dravlje valley in Ljubljana, SI
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- D.T2.3.3 PA reports about climate change issues in pilots. Transnational report.
 - D.T2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 2 SPECIAL SITES (Plain agriculture/ grassland/ wetland sites)