PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.3

OUTLINING OF LESSONS LEARNT AND RESULTING RECOMMENDATIONS

D.T2.3.2 TRANSNATIONAL CONCLUSIVE REPORT CONTAINING RECOMMENDATIONS

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1. Introduction

In this report compiled comparative transnational report about the best management practise is derived and assessed in all Pilot Actions resulting in recommendations for adapting of existing land use and flood/drought management and improved policy guidelines. The report contains summarized recommendations and solutions described in *D.T2.2.3 Pilot Action cluster report* for all three clusters, *D.T2.3.4 Strategic identification of needs for action clusters*, *O.T2.1 PA cluster 'mountain forests and grasslands' - implementation, showcasing best management practices*, *O.T2.2 PA cluster 'plains: agriculture, grass/wetland' - implementation, showcasing best management practices* and *O.T2.3 PA cluster 'riparian strips' - implementation, showcasing best management practices*.

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

Pilot Action Cluster 1: Mountain forest and grassland sites,

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

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

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

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

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

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

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

- **PA1.1: Catchment area of the Vienna Water Supply -** the Zeller Staritzen area **(Figure 1)**, and
- **PA1.2: Catchment area of Waidhofen/Ybbs (Figure 2).**

In **PA1.1** karst aquifer presents drinking water source where mountain grassland prevails and in **PA1.2** fractured aquifer is where drinking water is coming from and the main land use are forests.

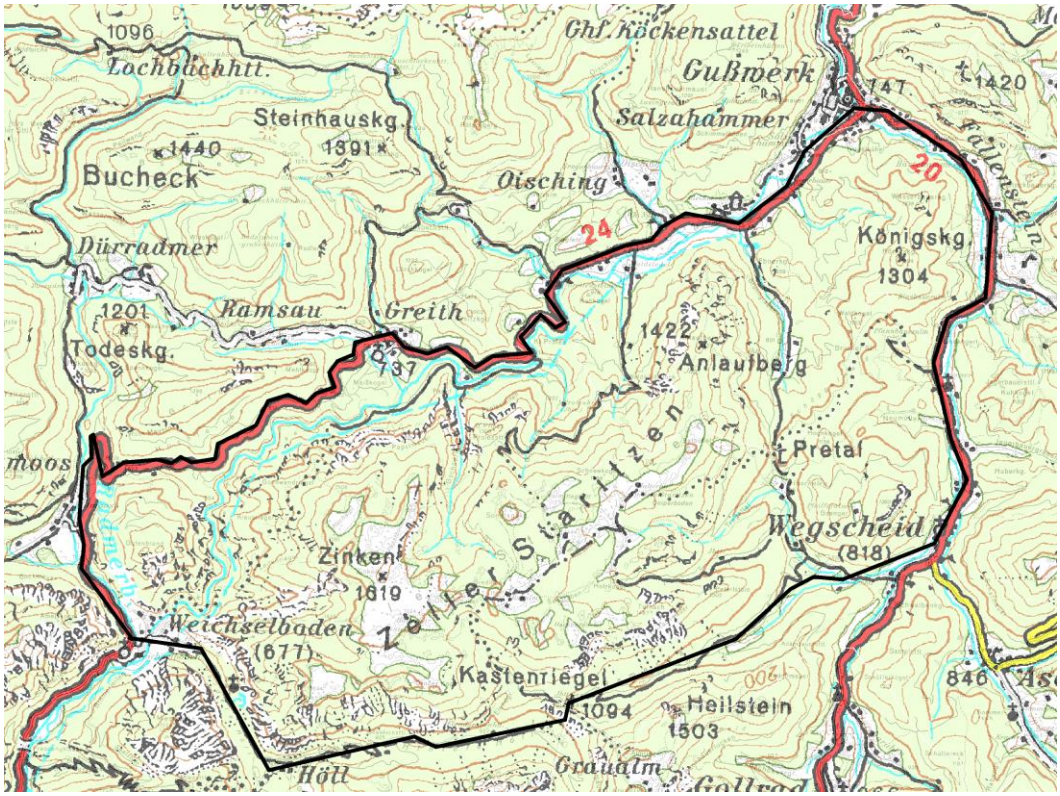

Figure 1: The Zeller Staritzen area (Austria map 200 - ÖK200)

Figure 1: PA1.1 - Water Protection Zone of Central Hochschwab area (shaded) with Zeller Staritzen (surrounded black), the whole extension of PA1.1.

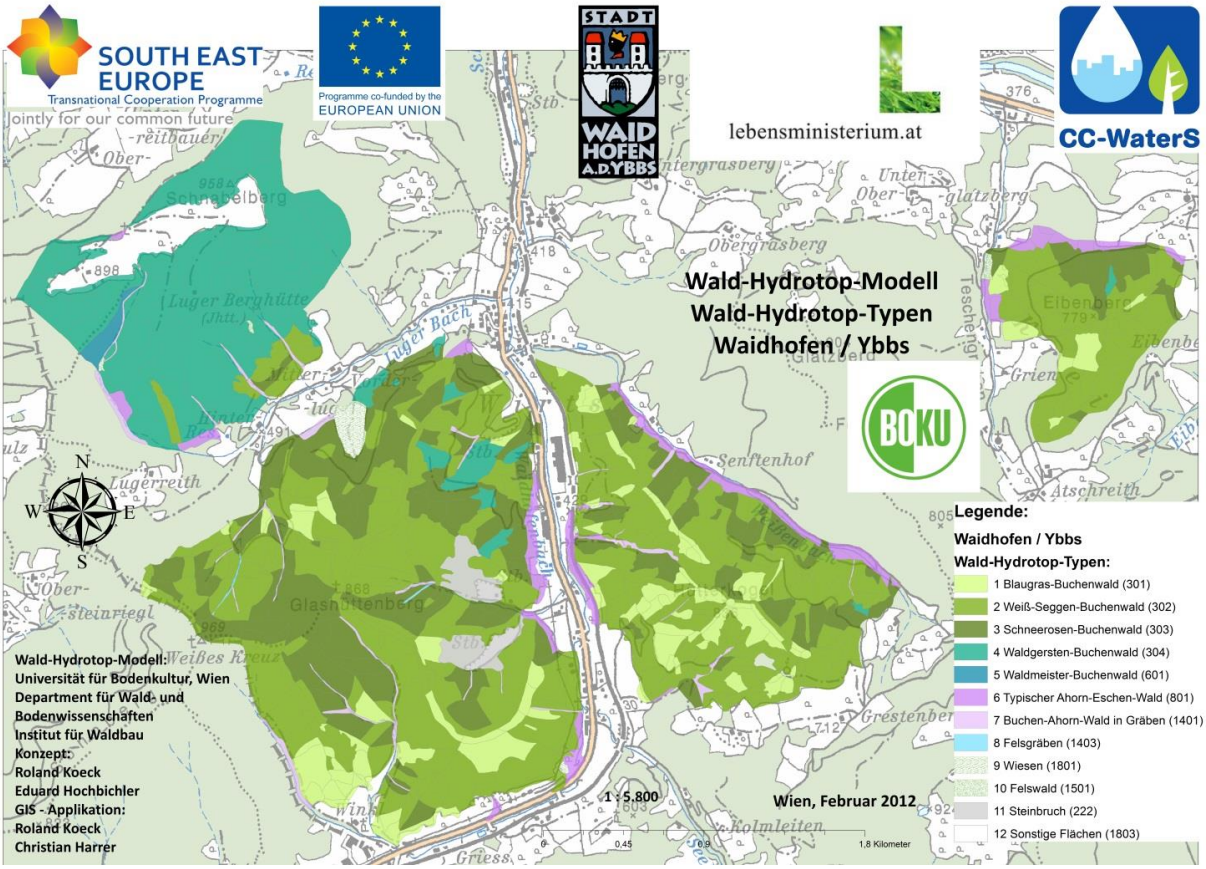

Figure 2: PA1.2 -Forest Hydrotope Map of the Pilot Action Waidhofen/Ybbs (Koeck and Hochbichler 2012).

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

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

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

- **PA2.1: Well field Dravlje valley in Ljubljana, Slovenia (Figure 3),**
- **PA2.2: Water reservoir Kozłowa Góra, Poland (Figure 4),**
- **PA2.3: Tisza catchment area, Hungary (Figure 5),**

- **PA2.4: Groundwater protection in karst area, Croatia (PA2.4-1: South Dalmatia: Prud, Klokun and Mandina spring (Figure 6); and PA2.4-2: Imotsko polje springs (Figure 7))**,
- **PA2.5: Neufahrn bei Freising, Germany (Figure 8)**.

Porous aquifer in **PA2.1** (Figure 3) is covered mainly 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%). In **PA2.2** (Figure 4) drinking water source is surface water and its largest part is covered by forest areas (47.8%) and secondly with agricultural lands (42.3%). In **PA2.3** (Figure 5) surface water also presents drinking water source where the largest part is covered by non-irrigated arable lands (35.42%), discontinuous urban fabric (14.06%) and broad-leaved forest (17.36%). Drinking water source for **PA2.4-1** (Figure 6) and **PA2.4-2** (Figure 7) is karst aquifer. The first PA is mainly covered with broad-leaved forests along with the transitional woodland-shrub areas following agricultural lands. In the second PA land use is broad-leaved forests along with land principally occupied by agriculture, with significant areas of natural vegetation covers the majority of PA area. In **PA2.5** (Figure 8) drinking water source is porous aquifer where the area is dominated by (non-irrigated) arable land (44.86 %), and settlement structures (20.56%).

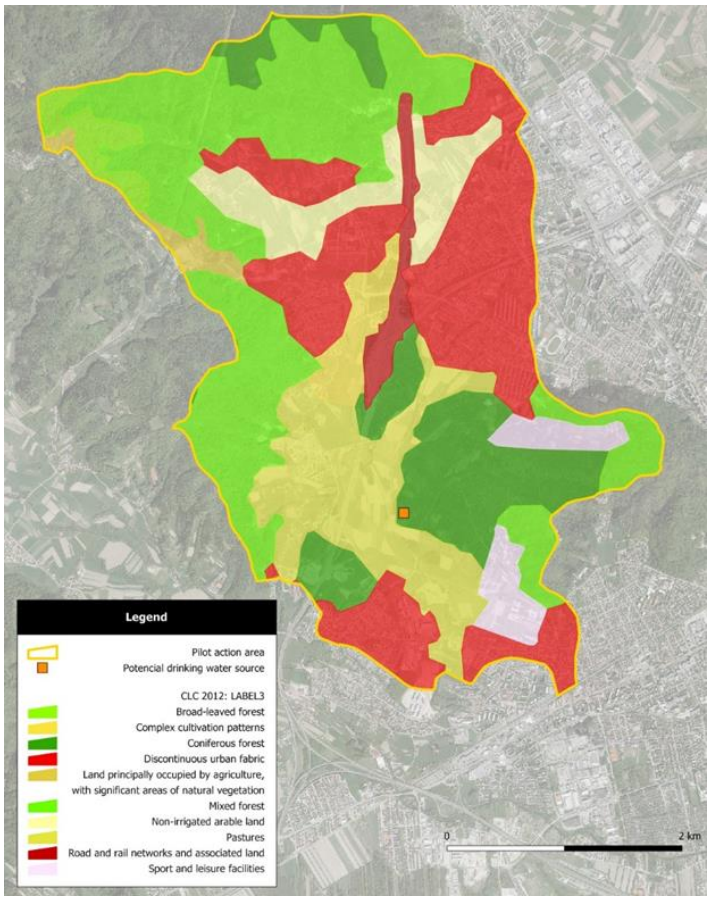

Figure 3: PA2.1 Land use in Dravlje valley pilot area, Slovenia (ARSO, 2017).

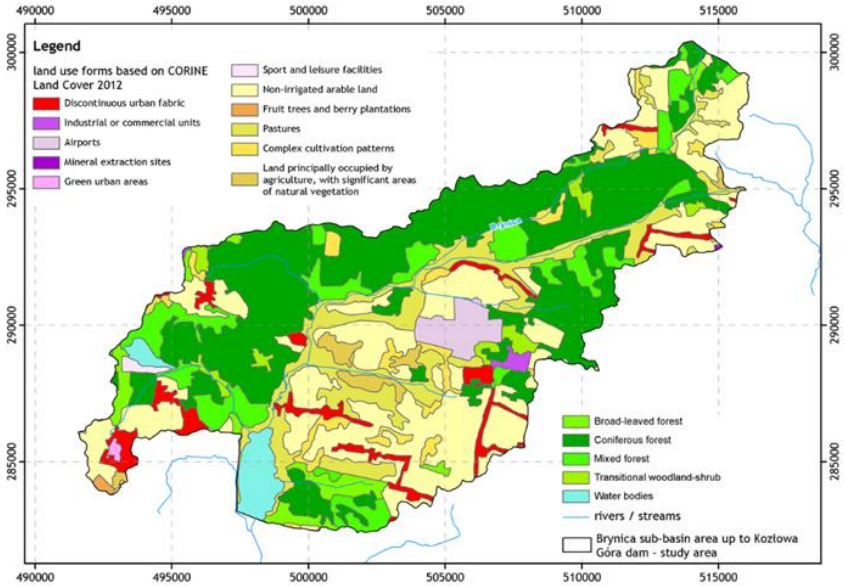

Figure 4: PA2.2 The land-use forms within the Brynica River sub-basin area, upstream the Kozlowa Góra dam, Poland.

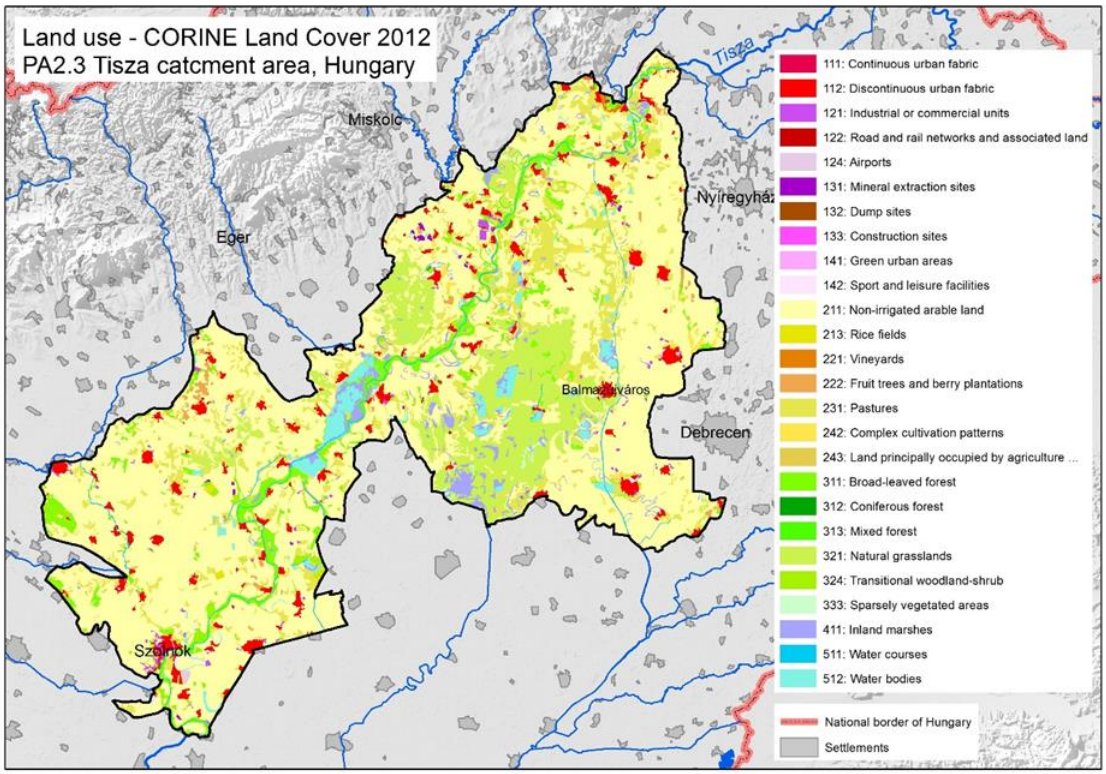

Figure 5: PA2.3 Land use in the Tisza catchment area, Hungary.

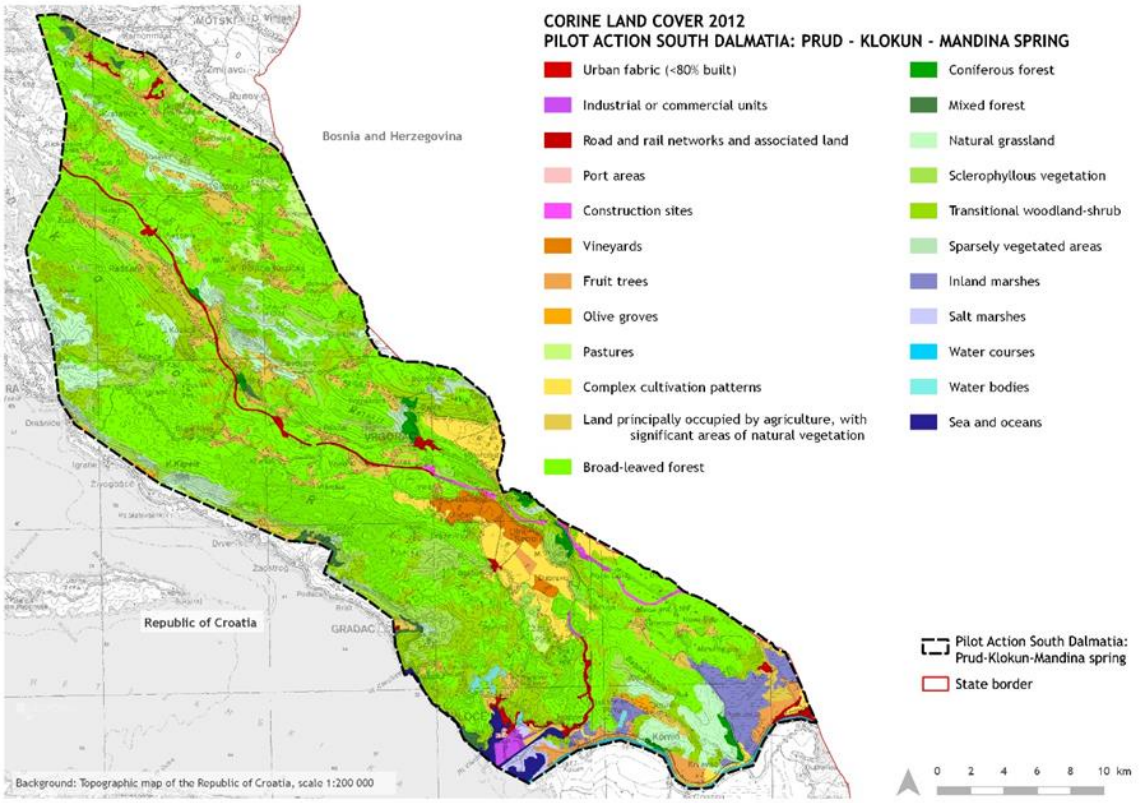

Figure 6: PA2.4-1 Land use in South Dalmatia, Croatia.

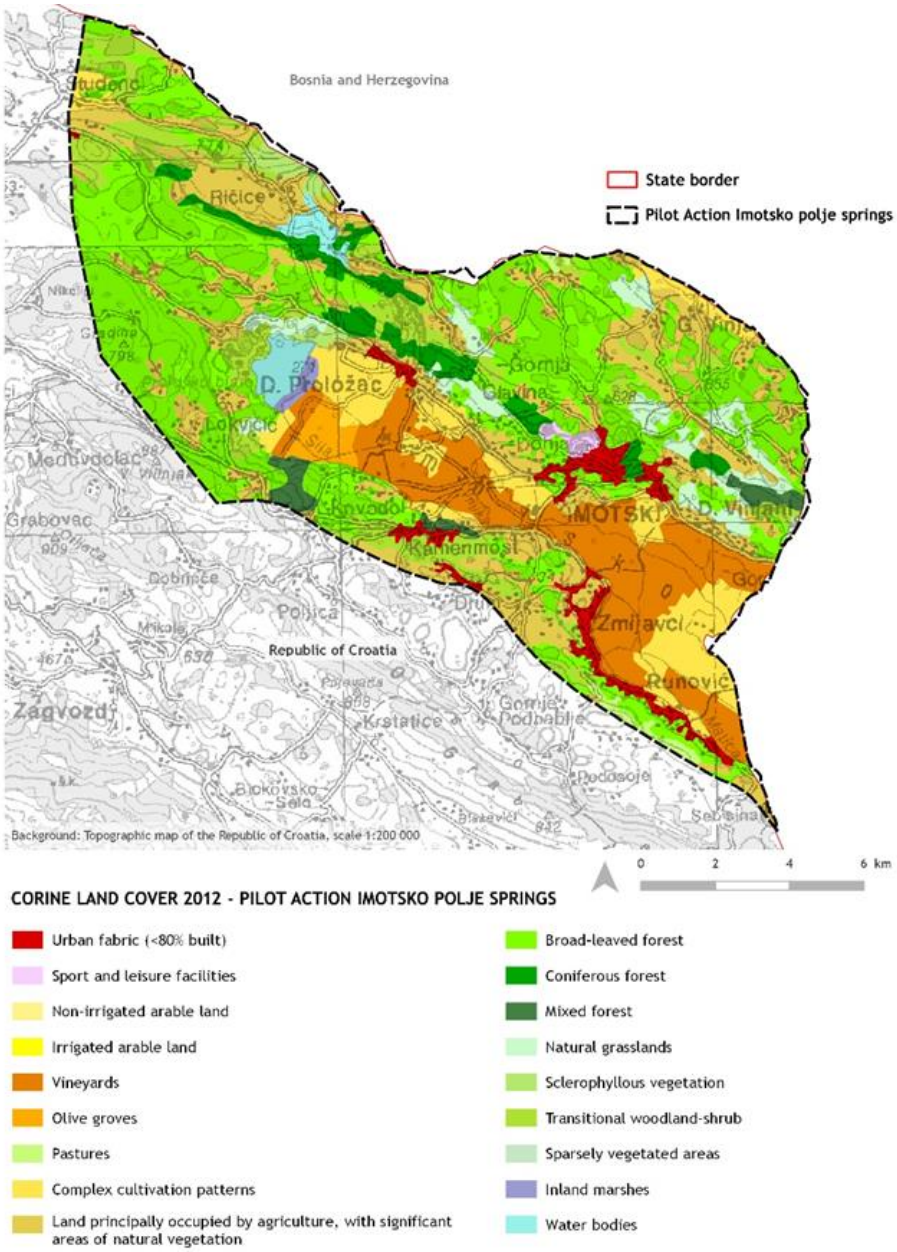

Figure 7: PA2.4-2 Land use in Imotsko polje springs, Croatia.

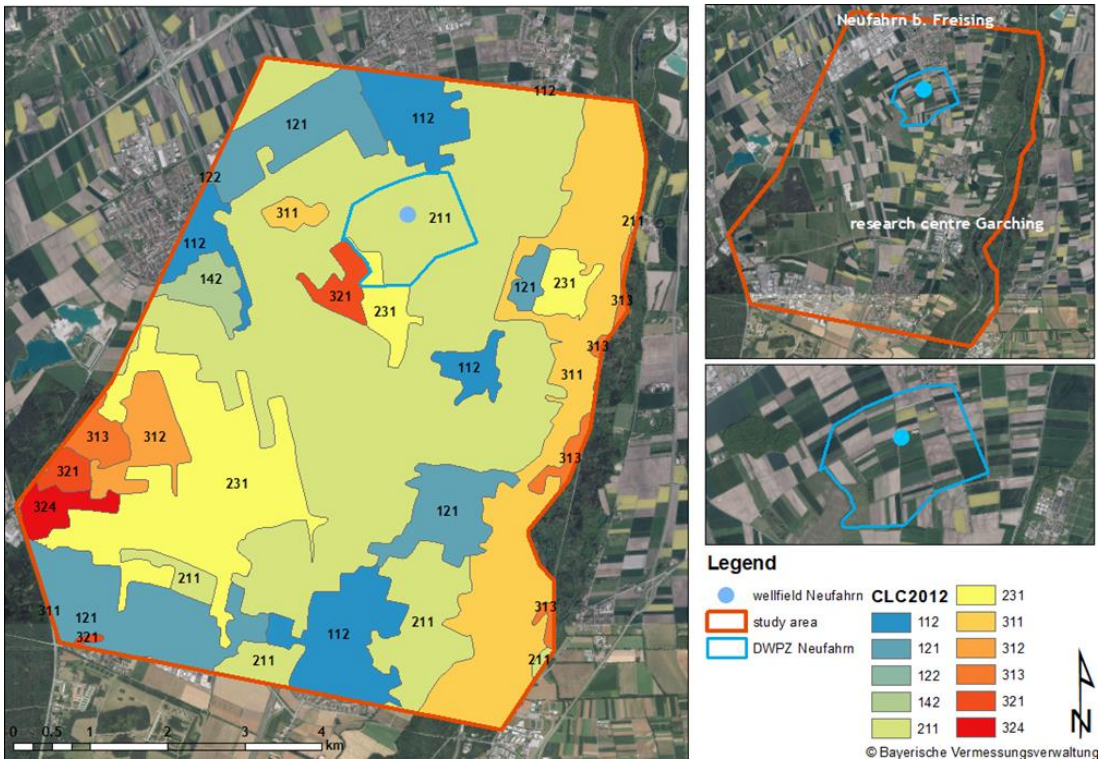

Figure 8: PA2.5 - Land use in the Neufahrn pilot area, Germany.

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

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

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

In **PA3.1** (Figure 9) drinking water source is bank filtration or surface water – groundwater interaction and the area is mostly occupied by agricultural and forest/grasslands areas, which cover respectively 46% and 45% of the basin, while urban and industrial areas concern about 7%. In **PA3.2** (Figure 10) surface water – groundwater interaction is also drinking water source and the area is mostly occupied by non-irrigated arable land (38.5%), discontinuous urban fabric (11.4%), broad-leaved forest (11%) and pasture (6.5%)

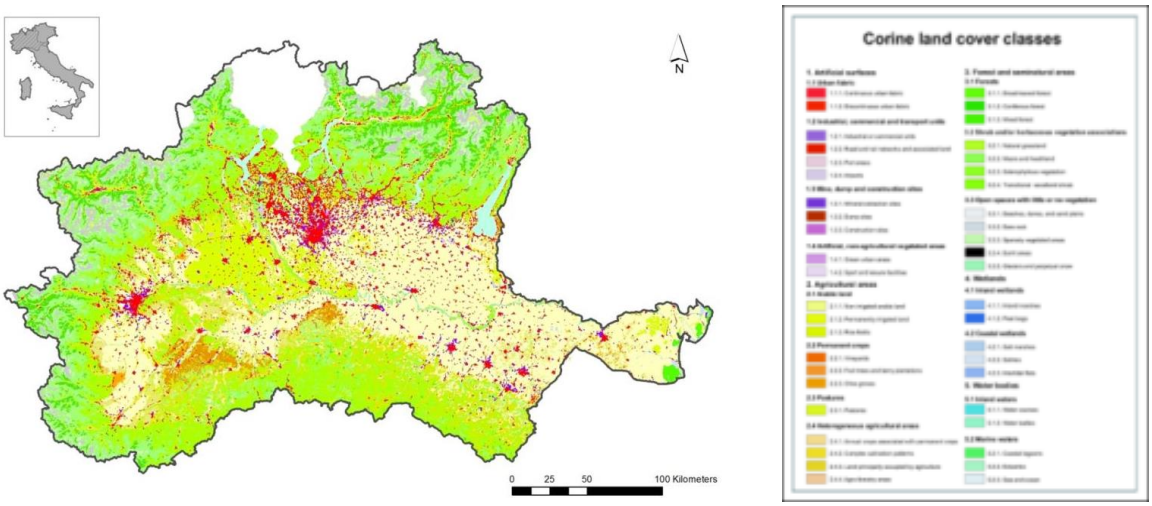

Figure 9: PA3.1 land use map.

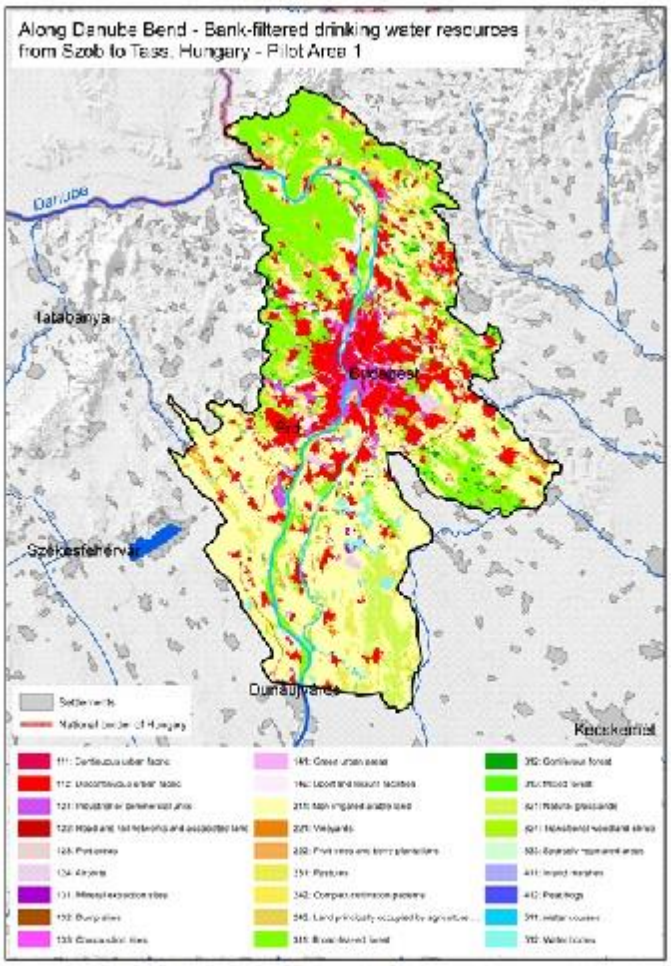

Figure 10: PA3.2 land use map.

2. Recommendations and solutions for adapting the existing best management practices

Best management practices (hereinafter BMPs) for drinking water protection and management derived from T1 were reviewed and relevant BMPs were selected for each particular pilot action within all three Pilot Action Clusters (PAC). BMPs have been established on the basis of actual management practices or GAPs.

In this chapter is summarized 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 of Pilot Action. The overall purpose of all mentioned management adaptations is the sustainable protection of the drinking water resources. Recommendations and solutions for adapting the existing BMPs are given in table 2a. Table 2a is a combined table from all three PAC tables from the PAC reports (D.T2.2.3 and D.T2.3.4), which summarize all the GAPs/BMPs that were identified in PAs. Remaining issues to be solved are listed in Table 2b.

GAPs/BMPs are classified according to what kind of land use type/category each problem is related to: agricultural areas, urban areas, forest and alpine pasture (Table 8). All GAPs/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses. BMPs were classified in the same way as in the T1 BMP catalogue into following categories:

1) general water management (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.

Table 2a: Recommendations and solutions for adapting the existing best management practices for drinking water protection

Category	Actual management practice (GAP)	Proposed BMP	Proposed recommendations and solutions			Country
			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	
GENERAL WATER MANAGEMENT	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard	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.	PL
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale	/	Investment in monitoring system contains constant monitoring system.	Need of conducting proper, multi-aspect monitoring of water system should be emphasized in guidelines at local, regional and also national level.	PL
	Land use activities causing changes in groundwater (GW) recharge and quality (e.g. quarries causing decrease of GW recharge; vulnerability of GW due to cattle grazing)	Continuous monitoring of relevant hydrological data and hydrological/hydrogeological modelling (surface run-off – spring dynamic modelling)	Using hydrological modelling to continuously evaluate the changes of spring discharge due to extending of quarry areas in the pilot area helps to support future decision-making. Through applying a rainfall/run-off model based on observed and defined processes as well as measured and mapped parameters the surface run-off and infiltration will be determined.	Using hydrological modelling to continuously evaluate the changes of spring discharge due to extending of quarry areas in the pilot area helps to support future decision-making. Through applying a rainfall/run-off model based on observed and defined processes as well as measured and mapped parameters the surface run-off and infiltration will be determined – relevant also for flood/drought protection.	/	AT
	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.	PL
	Pressures on water resources management	The Drought Observatory/ Steering Committee and Drought Early Warning System (DEWS)	Improvement of knowledge on links between land use and water resources through: - Periodical updating of the assessment of land use (e.g. agricultural practices) impact on drinking water; - Increasing of number, spatial/temporal detail and type of data about land use and environment representation.	Increase the use and sharing of drought early warning system among stakeholders. Creation within the DEWS system of drought /water scarcity indicators and indices easier to understand for stakeholders. Investment in monitoring, simulation, and analysis. Increase weather, ice/snow cover and ground water information. Operational platforms maintenance, education, and training. Consider site-specific drought impacts on drinking water. Fix water shortage/drought thresholds.	Improvement of potential synergies among stakeholders on water demand and land use. Give more decisional power to the Permanent Observatory on water uses. Support to the implementation of the Water Management Plan.	IT
	Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources	Joined and integrated management of drinking water resources (horizontal and vertical co-operation)	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,	/	/	SI

			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.			
	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	No adaptation of existing land use management practices required.	The availability of a hydrological model can provide relevant information for the stakeholders in terms 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.	The value of an available hydrological model is not adequately reported in the current guidelines. This tool 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.	DE
	Low level of ecological awareness of society	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 flood / drought management practises and proposal for BMP.	/	PL
DRINKING WATER MANAGEMENT	Climate change impacts on drinking water resources (e.g. pressure on water resources quantity)	Assessment of climate change impact on drinking water resources and determination of adaptation and resilience of public water supply (e.g. reducing pipeline leakage and water reuse)	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.	HR
			The proposed solution is to carry out detailed studies about the potential impacts of climate changes and partly related land use change. The main goal is to provide probabilistic evaluations of impacts on drinking water resources accounting for multiple constraints. Furthermore, it could increase the awareness of all the stakeholders about the topic.	Investment in data collection, monitoring, model simulation and analysis, operational platform maintenance education and training. Promote synergic approaches between Disaster Risk Reduction and Climate Change Adaptation communities by considering the cross-dependence between droughts and floods periods. The assessments could support systemic evaluations about the management of extreme events (flood and droughts) achieving solutions effective also for preserving drinking water resources. Moreover, the approaches are straightly exploitable also for other test cases.	Test the implementation of proposed solution by relevant stakeholder's communication in the decision-making process. Improving the decision-making process increasing the awareness of all the stakeholders about the future challenges for effectively preserving drinking water resources.	IT
	Drinking water protection zones (DWPZs) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	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.	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.	Adaptation of Spatial plan of the Municipality of Ljubljana with DWPZ determination and adoption of Decree on the water protection area for this aquifer.	SI
			Limitations and prohibitions are included within the proposal.	Limitations and prohibitions are included within the proposal.	Proposal considers current Water Law and policy guidelines;	PL
			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.	Adaptation is not necessary, Ordinance is already prescribed but implementation and inspection are lacking.	Policy guidelines are well developed concerning DWPZ, but implementation is lacking, inspections are inadequate, and penalties are rarely given.	HR

	Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	It is prohibited to carry out 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.	In case of floods in the area of DWPZ surface waters and groundwater could cause pollution by transportation of pollutants.	Implementation should be supervised by inspectors of the Ministry of Agriculture, Forestry and Food.	SI
FLOOD MANAGEMENT	Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	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.	SI
	Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulical model	Wells heads should be constructed as sealed in a way to prevent the surface water intrusion in the well during the flood event.	Many water supply wells are on flood-prone plains, so the wells heads should be constructed as sealed.	Amendment to the data specification relative to standards 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).	SI
	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.	SI
	Increased contamination of surface drinking water resources during flood events	Reduction of flood effects at the 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.	HU
	Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	Non-structural flood mitigation measures include prevention of land use change, establishment of protective forests and promotion of cultures resistant to floods (e.g. grapevines).	Proposed measures could enhance flood mitigation and management action.	Prevention of land use change should be included in designated sensitive areas (e.g. prevention of agricultural land spread on the account of Prološko Blato wetland areas).	HR
	Flood impact not fully implemented and considered	The Flood Forecast Centre and Flood Early Warning System (FEWS)	Strengthening role and requirements of flood management system in relation to the operational needs in all phases of disaster management (forecast, preparation, and response). Increase synergies among land use planning/management and emergency planning/management. Periodical updating of vulnerability and exposure	Improvement of the monitoring and modelling system, also considering interactions with exposed elements and operational procedures. Investment in flood analysis, operational platform maintenance, education, and training. Consider flood, drought and water management as a unique operational process. Make flood information more understandable to	Integration in policy guidelines of predictability, uncertainty and communication improvement concerning extreme events and related losses, including those for drinking water supply systems. Support to the implementation of the Flood Risk Management Plan.	IT

			evaluation.	citizens. Consider event related flood impact on drinking water.		
	Improper flood protection of bank-filtered wells during high water and flood events	Ensure the drinking water supply during high water or flood	/	Management practices could be applied for better protection of the wells during floods.	/	HU
	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 (Fallopia japonica). 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 spreading. Ambrosia is prescribed to spray with applications to slower the spreading but only with 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 adequate way to permanently remove the plant is to dig it out with its roots.	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 Decree on measures to suppress harmful plants of genus Ambrosia (Official Gazette No. 63/10)) should be accepted also on Japanesee Knotweed. The fees for not cutting river bank vegetation should increase.	SI
	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).	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	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.	HU
	Agricultural surface water and groundwater pollution (e.g. improper or excessive use of pesticides and manure on plant production fields)	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.	Existing practices can generally be adapted to employ better methods (e.g. ploughing parallel to the watercourse, usage of green products).	/	The availability of subsidies acts as a main driver for the implementation of such practices. Guidelines can be adapted to not only prohibit certain practices in sensitive areas but also to better encourage sound practices beyond the required minimum.	HU
	Inflexible time ban of fertilizers and manure application	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 date. If vegetation is not active, the N-compounds pass through soil directly into the groundwater.	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.	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	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.	HR

		water in agriculture				
	Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	/	Invest in infrastructure to increase the monitoring network in the pilot action, e.g. installation of river gauging stations, identification of piezometers usable to monitor groundwater level, installation of multi parametric probes 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.	DE
URBAN AREAS	Insufficiently effective wastewater treatment system that needs to be reconstructed and expanded	Natural wastewater treatment system	If measures are to be applied, land use and spatial planning documents and practices must be modified.	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.	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	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.	SI
	Waste disposal which do not meet technical and environmental standards and illegal waste disposal	Educative brochure and awareness raising activities	Brochure aims to point out problematics related to landfills in karstic areas, which often do not meet minimum technical requirements. Brochure raises awareness on interaction of pollutants, groundwater and fast infiltration in karst terrains as well as remediation of improper landfills and adequate techniques of waste disposal in such vulnerable environment.	Landfill behaviour and associated emissions during flood events are not properly studied and evaluated. Worst case scenario includes heavy leaching of pollutants and potential erosion. Landfills must be floodproof and other hazards must be evaluated as well.	Policy guidelines are good, penalties are prescribed for illegal waste dumping, but inspections are poor, and misdemeanour is not punished.	HR
		Encourage and promote innovative solutions of sustainable waste management	These measures aim to encourage development of geographical software application with locations of illegal waste disposal sites (e.g. speleological objects - pits, caves). This is particularly important for drinking water protection zones. Such application could encourage general public and decision makers to tackle the persistent issue of illegal waste disposal.	In the last years, numerous actions with aim of cleaning speleological objects from waste have been done. This not only improves the quality of groundwater (less pollutant leach) but also improves the intake capacity of sinkholes, pits and ponors, therefore reducing flood peaks in some karstic areas.	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.	
	Lack of sewage system and wastewater treatment	Appropriate collection and treatment of municipal waste water	/	/	Existing policy guidelines already establish required treatment. Unfortunately, in selected areas these guidelines are not yet implemented.	HU
	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.	SI
	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 endanger the ground water quality; among others also salting of undrained surfaces like yards and gravel roads is	/	Upgrade on the Decree on the emission of substances in the discharge of meteoric water from public roads.	SI

			prohibited. Salting of roads and motorway cannot be prohibited, but the salinity of road water discharge should be limited.			
FOREST	Continued application of the clear-cut technique	Avoidance of the clear-cut technique	Application of continuous cover forestry systems and all related BMPs, strategies and measures.	Application of continuous cover forestry systems and all related BMPs, strategies and measures.	Prohibition of clear-cut applications within DWPZ.	AT
	Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages	Forest Ecologically Sustainable Wild Ungulate Densities	Regulation of the wild ungulate densities to a forest ecologically sustainable level, hence providing vital regeneration dynamics of all tree species.	Regulation of the wild ungulate densities to a forest ecologically sustainable level, hence providing vital regeneration dynamics of all tree species.	/	AT
	Abandonment of private forests, resulting aging of the forests and through it elevated vulnerability of the forests towards natural disasters	Forestry subsidies and encouraging foresters to facilitate regeneration dynamics within their forests	Aging of Slovenian forests, due to unregularly maintenance can turn out problematical, since old growth forest ecosystems can be more vulnerable to extreme weather conditions and catastrophes if the natural regeneration dynamics do not take place.	Close to streams (brooks or rivers) logging residues should not be left in order to reduce the danger of driftwood formation during 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 the Ordinance for each Nature park in order to protect nature but there are no directives for maintaining the safety of their visitors, even sanitary cutting needs authority's agreement. Despite that it has to be taken into account that natural forest ecosystems in general show the highest level of stability.	SI
	Extensive construction of forest roads	Limitation of forest roads	Application of skyline-cranes or other techniques for timber-yield.	Construction of forest roads only exceptionally if necessary for forest stabilisation.	Clear guidelines for forest management within DWPZ.	AT
	Creation of conifer plantations, even within deciduous forest communities	Tree Species Diversity According to the Natural Forest Community	Man-made plantations with non-natural tree species should be transformed gradually to stands dominated by native species. In Austria the project-DWPZ are represented through the Forest Hydrotope Map, defining the optimal tree species set for each forest site.	Man-made plantations with non-natural tree species should be transformed gradually to stands dominated by native species. In Austria the project-DWPZ are represented through the Forest Hydrotope Map, defining the optimal tree species set for each forest site.	The guidelines for DWPZ should define the creation of natural and stable forest stands with native tree species as necessary management practice.	AT
	Cutting of old, huge and vital tree individuals	Foster old, huge and vital tree individuals	Old, huge and vital trees provide a substantial contribution to forest stand stability. Hence, they have to be selected and protected, so that they can provide their services as long as possible.	Old, huge and vital trees provide a substantial contribution to forest stand stability. Hence, they have to be selected and protected, so that they can provide their services as long as possible.	Forest Policy in Austria should develop more awareness towards the need to protect old growth forests and tree species.	AT
ALPINE PASTURE	Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces	Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings	In order to avoid the creation of erosion dynamics and concentrations of faeces, more troughs should be provided and distributed strategically over the whole alpine pasture. Construction of concrete basements for the troughs as erosion prevention.	In order to avoid the creation of erosion dynamics, more troughs should be provided and distributed strategically over the whole alpine pasture. Construction of concrete basements for the troughs as erosion prevention.	/	AT
	Grazing of cattle in or close to dolines and sinkholes	Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features	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 stemming from cattle or other grazing livestock.	/	/	AT
	Unwanted cattle grazing (cattle density and grazing patterns)	Grazing management for cattle on alpine pastures (temporally limited grazing on different locations)	Grazing management requires strategic planning, the placing of fences and the punctual change of the grazing cattle from one to the next fenced part of the alpine pasture. It helps to avoid erosion processes.	Grazing management requires strategic planning, the placing of fences and the punctual change of the grazing cattle from one to the next fenced part of the alpine pasture. It helps to avoid erosion processes.	/	AT

Table 2b: Remaining issues to be solved for best management practices, which were selected as relevant BMPs for Pilot Actions (STEP 1: Identification of BMPs).

Category	Actual management practice (GAP)	Proposed BMP	Remaining issues to be solved	Country
GENERAL WATER MANAGEMENT	No complex evaluation of water hazards	Complex catchment modelling and assessment of hazard	Good quality input and calibration data.	PL
	Small number of sampling locations and sampling campaigns (water monitoring)	Establishment of constant, multi-aspects water monitoring in the catchment scale	/	PL
	Land use activities causing changes in groundwater (GW) recharge and quality (e.g. quarries causing decrease of GW recharge; vulnerability of GW due to cattle grazing)	Continuous monitoring of relevant hydrological data and hydrological/hydrogeological modelling (surface run-off – spring dynamic modelling)	/	AT
	No information about ecology of water reservoir	Establishment of an ecology model of water reservoir	Good quality input and calibration data.	PL
	Pressures on water resources management	The Drought Observatory/ Steering Committee and Drought Early Warning System (DEWS)	- Guarantee resources allocation for maintenance and improvement of existing platforms, procedures, expertise and activities. - Increase awareness on drinking water as a not renewable resource. - Guarantee methodologies for drought and water scarcity characterization. - Environmental and Economic Water accounting. Further developments in: - integration of climate, snow/ice water, reservoirs, surface water, and ground water observation, simulation, and management; - integration of in situ and remote sensing; - coupling of water quality and water quantity observation and simulation; - scalable simulation tools considering different temporal and spatial scales (point, river, network, basin, district); - unification of flood, water shortage and drought observation and simulation platforms; - interactive, spatially based, web based, standardized and open architecture retrieving/ access services (data, metadata, and information); - harmonization among real-time and delayed time applications; - consideration of joint effects/impacts of strategies, guidelines, planning, design management, constraints, and practices; - standardization of tools methodologies, terminology, criteria, and procedures for water shortage damage assessment.	IT
	Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water	Joined and integrated management of drinking water resources (horizontal and vertical co-operation)	Actions for encouraging horizontal and vertical co-operation in drinking water management	SI

	resources			
	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	Not applicable	DE
	Low level of ecological awareness of society	Raising awareness and increasing knowledge	Limited channels of information flow in small communities.	PL
DRINKING WATER MANAGEMENT	Climate change impacts on drinking water resources (e.g. pressure on water resources quantity)	Assessment of climate change impact on drinking water resources and determination of adaptation and resilience of public water supply (e.g. reducing pipeline leakage and water reuse)	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.	HR
			- Enhance in understanding of physical behaviour and increasing in computational power to reduce remarkable uncertainties that characterized, at the moment, several elements of proposed modelling chain. - Adoption of probabilistic approaches or findings provided by ensemble initiatives to manage complex atmospheric processes and gaps about future paths in socio-economic and demographic trends. - Enhance the dissemination of the findings accounting for pros and cons in the modelling chain and permitting to have a clearer view about future state of drinking water resources that could be exploited by stakeholders. - Improve management and use of natural resources and ecosystem services to use and modify less the natural capital. - Encourage natural capital valorisation, circular economy and ecosystem optimal management through climate change simulation. - Implement complex, physically based, socially based and evidence related design, planning and governance tools linking environmental, economic and social resources, services and processes. - Promote the availability and practicality of climate projection ensembles to enable robust decision making thanks to a likelihood-based analysis.	IT
	Drinking water protection zones (DWPZs) do not exist	Determination (e.g. hydrogeological modelling) and establishment of DWPZs	Enabling adoption of decrees on the water protection areas for potential drinking water sources	SI
			Legal procedure for implementation.	PL
			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.	HR
	Lack and not effective control over implementation restrictions for existing DWPZ	Strict implementation and inspection of DWPZ restrictions	More inspectors on field and more effective control.	SI
FLOOD MANAGEMENT	Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources on flood areas identified in PA	Establishing responsibilities and competence for setting up the register of point and diffuse sources of potential pollution on flood areas	SI
	Surface water intrusion in the well	Sealed wells heads on flood areas evaluated according to Hydrological / Hydraulical model	Establishment of control.	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	Farmers and the water management sector should prepare for climate change.	HU

	Periodic field flooding	Infrastructure maintenance and reconstruction / Non-structural flood mitigation measures	Measure is complex, as it faces resistance of local population, lots of financial compensation for losses, and generally, structural measures are still favoured.	HR
	Flood impact not fully implemented and considered	The Flood Forecast Centre and Flood Early Warning System (FEWS)	- Guarantee financial resources allocation for maintenance and improvement of existing platforms, procedures expertise and activities. - Increase awareness on heavy rain and flood as potential cause of not reversible damages. Further developments in: - integration of meteorological, snow water, reservoirs, water devices, surface water and ground water observation, simulation, and management; - coupling of water quality and water quantity observation and simulation; - coupling water and sediment cycles; - unification of flood, water shortage and drought observation and simulation processes and platforms; - interactive, spatially based, web-based, standardized and open architecture retrieving/ access services (data, metadata, models and information); - harmonization among real-time and delayed time applications; - consideration of joint effects/impacts of strategies, guidelines, planning, design management, constraints, and practices, (land use, water use, civil/environmental protection); - Standardization of tools methodologies, terminology, criteria, procedures for flood and heavy rain damage assessment.	IT
	Improper flood protection of bank-filtered wells during high water and flood events	Ensure the drinking water supply during high water or flood	- Further investigation of water chemistry measured in observation wells located on Szentendre Island. - Revising flood management in context of future climate conditions.	HU
	River banks vegetation is not maintained	Reducing river banks vegetation	Education of land owners.	SI
	Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas	Ban on legalization of constructions/buildings on flood areas must be incorporated into existing legislation.	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	Solve the problem of frequent monitoring of livestock farms with or without involving the authorities, preparing for climate change.	HU
	Agricultural surface water and groundwater pollution (e.g. improper or excessive use of pesticides and manure on plant production fields)	Involving farmers to the Agrarian Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.	Forecasting how plant production will change as climate changes could be advantageous.	HU
	Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application	Enforcing cooperation among competent institutions (governmental, local), agricultural chamber, agricultural advisory services experts and farmers. Determination of rules concerning time ban on fertilizers and manure application.	SI
	Increased water demand	Establishment of groundwater level monitoring network (e.g. Imotsko polje and South	The measure is simple, but requires funding sources, which is unclear at the moment.	HR

		Dalmatia) for monitoring of irrigation water demand in order to assure efficient use of water in agriculture		
	Continuous conversion of (permanent) grasslands	Continuous monitoring in both, surface water and groundwater	Not applicable	DE
URBAN AREAS	Insufficiently effective wastewater treatment system that needs to be reconstructed and expanded	Natural wastewater 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, which is problematic for high scale systems).	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	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.	HR
		Encourage and promote innovative solutions of sustainable waste management	Stakeholders are a bit doubtful about the success of this measure. Although positive trends can be observed, the process is slow and requires persistence.	
	Lack of sewage system and wastewater treatment	Appropriate collection and treatment of municipal wastewater	- Development of sanitary coverage in Pócsmegyer and Szigetmonostor. - Identification of contamination source at Dunakeszi.	HU
	Unarranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas	Enforcing more strict regulation for collection and treatment of road rainwater discharge, within drinking water protection areas	SI
	No limitation of road runoff water salinity	Define limitation of salinity of road water run-off	Enforcing cooperation among competent institutions (governmental) and experts for determination of salinity limitations for meteoric waters discharged from public roads.	SI
FOREST	Continued application of the clear-cut technique	Avoidance of the clear-cut technique	The avoidance of the clear-cut technique has to be applied within all DWPZ in Austria, what will be a challenge in many cases.	AT
	Unnaturally elevated wild ungulate densities as result of trophy-hunting activities and resulting browsing and bark-stripping damages	Forest Ecologically Sustainable Wild Ungulate Densities	The regional and provincial forest authorities have to be forced to act according to the Provincial Hunting Acts.	AT
	Abandonment of private forests, resulting aging of the forests and through it elevated vulnerability of the forests towards natural disasters	Forestry subsidies and encouraging foresters to facilitate regeneration dynamics within their forests	Establishing of subsidy system.	SI
	Extensive construction of forest roads	Limitation of forest roads	Limitation of forest road constructions within DWPZ will cause resistance of some forest owners.	AT

	Creation of conifer plantations, even within deciduous forest communities	Tree Species Diversity According to the Natural Forest Community	For DWPZ outside the PROLINE-CE project space it will be a challenge to establish the optimal native tree species set for each forest site.	AT
	Cutting of old, huge and vital tree individuals	Foster old, huge and vital tree individuals	The protection of old growth trees and forests in Austria is in general lacking, it has to be improved.	AT
ALPINE PASTURE	Erosion processes around water troughs for cattle due to open soils without vegetation cover, as well as washing out faeces	Placing of water troughs for cattle more frequently, avoiding concentrations of cattle / Concrete basements for the troughs and their surroundings	Water trough spacing, and construction of concrete basements could be difficult on some alpine pastures.	AT
	Grazing of cattle in or close to dolines and sinkholes	Fencing of dolines and sinkholes in order to keep cattle in distance from those karstic features	Fences around dolines and sinkholes have to be maintained continuously for providing sustained functionality.	AT
	Unwanted cattle grazing (cattle density and grazing patterns)	Grazing management for cattle on alpine pastures (temporally limited grazing on different locations)	The challenge of this BMP is the necessity of a strategic planning process which requires detailed knowledge about the pasture quality on the alpine pasture and the consequent implementation through the strategic placing and spacing of fences. To achieve this, training of the alpine staff and persuasive efforts will be necessary.	AT

3. Conclusions

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

In representative PAs implementation strategies of BMPs which are important for water protection were elaborated. The relevant BMPs selected for particular PA represents 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, forest and alpine pasture. All GAPs/BMPs related to water management (general, drinking water and flood management) are actually related to all land uses.

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.

BMPs identified for all PAs include actions for the protection and management of drinking water resources in terms of quality and quantity accounting for, at the same time, the impacts of flood events. Table 3 present summarized recommendations and solutions for BMPs implementation. On the project level **40 GAPs** were identified, following the **41 BMPs**, which have together **39 proposed recommendations and solutions for adapting existing land use management**, **39 for adapting existing flood/drought management** and **36 for adapting policy guidelines**. Nevertheless, during the project progress it was found out those operative actions are still

needed as consequence of remaining gaps between the actual management practices and the revised BMPs.

Table 3: Number of defined GAPs / BMPs and recommendations and solutions for implementation of BMPs for drinking water protection.

Category	Number of identified GAPs	Number of proposed BMPs	Number of proposed recommendations and solutions		
			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
1) general water management	8	8	7	7	5
2) drinking water management	3	3	6	6	6
3) flood management	9	9	7	9	8
4) agricultural areas	5	5	4	4	5
5) urban areas	6	7	6	5	7
6) forest and	6	6	6	6	5
7) Alpine pasture	3	3	3	2	0
Summarized	**40**	**41**	**39**	**39**	**36**

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 and 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 Center 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 problem 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, 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 ***forestry***. 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 autochthonous tree species.

Finally, three GAPs are classified in the group of ***alpine pastures***. They all address grazing management for cattle on karstic alpine pastures to prevent erosion processes and groundwater pollution.

The main goal of the selected BMPs is drinking water protection with considering climate change; therefore the final aim is good drinking water quality and sufficient drinking water quantities. Many BMPs are linked to increased awareness among the whole community and water users. Intensive stakeholder involvement is the first step towards the implementation of any BMPs.

A tough nut to crack is how to change the human perception and this is where further efforts must be directed – this refers both to decision makers and general public. Decision makers must directly stimulate best management practices, and vice-versa, the general public should adapt and generally change their attitude towards changes in actual management practices (which often include negative financial repercussions). Although PROLINE-CE project duration is too short to test the majority of proposed BMPs in pilot areas, indications towards positive changes in practices could be observable within project timeline.

Regarding BMPs implementation many remaining issues still have to be solved. The 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 drinking water availability of future generations. Furthermore, adaptation plans and strategies could save money in the long run due to

prevention, instead of intervention. Moreover, one of the main issues is how changing climate is going to affect the efficiency of the current best management practices.

Furthermore, another relevant point is the need of the increasing awareness in community and preparedness about water resources issue, in order to cope with drought and flood events, which could be also enhanced by climate change. It results also fundamental assuring incentives and investments to prevent, mitigate and better manage drinking water resources. Finally, the activities carried out in PROLINE-CE project highlighted the importance of communication, dissemination and stakeholder involvement in all the operative phases of the management.

As emerged during the partner's meeting, stakeholders have a strong interest in the identified BMPs, especially in relation with flood and drought modelling. For this flood and drought forecast are very important, therefore the Flood Early Warning System (FEWS) and Drought Early Warning System (DEWS), developed by Italian partner, are samples cases. Stakeholders are very interested in the possible application of these systems in the operational daily management, whilst the climate change simulated scenarios could be useful to address water safety plans, strategic planning and investment options on the management of new supply resources.

Considering the BMP related to the analysis of climate changes impacts on drinking water resources, the main activities are related to: i) the assessment of the expected changes in weather forcing; ii) the evaluation of the variations in Land use and land cover LULC through an ensemble approach (taking into account variations in socio-economic, demographic and climate conditions); iii) the projection of climate change and land-use change impacts on drinking water resources. Furthermore, activities related to this BMP include the development of a regional and urban adaptation plan that, following EU Directive, should explicitly account for CC issue.

The sustainability of BMPs implementation within the PAs will depend on the continuation of efforts put on this thematic field. This will have to last far beyond project life-time.

4. References

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.T2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 1 - Mountain Forest and Grassland Sites
- D.T2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 2 - Plain agriculture/ grassland/ wetland sites
- D.T2.3.4 Strategic identification of needs for action for clusters. PILOT ACTION CLUSTER 3 - Special sites (riparian strips)

PROLINE-CE WORKPACKAGE T2, OUTPUT REPORTS:

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