PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.3

OUTLINING OF LESSONS LEARNT AND RESULTING RECOMMENDATIONS

D.T2.3.4 STRATEGIC IDENTIFICATION OF NEEDS FOR ACTION FOR CLUSTERS

PILOT ACTION CLUSTER 2

PLAIN AGRICULTURE/ GRASSLAND/ WETLAND SITES

Lead Institution	PP7 - OVF
Contributor/s	See next page
Lead Author/s	Tamás Belovai
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Contributors, name and surname	Institution
Slovenia	
Barbara Čenčur Curk	PP4 - University of Ljubljana, NTF
Jerca Praprotnik Kastelic	PP4 - University of Ljubljana, NTF
Anja Torkar	PP4 - University of Ljubljana, NTF
Primož Banovec	PP4 - University of Ljubljana, FGG
Ajda Cilenšek	PP4 - University of Ljubljana, FGG
Matej Cerk	PP4 - University of Ljubljana, FGG
Branka Bračič Železnik	PP5 - Public Water Utility JP VO-KA
Poland	
Joanna Czekaj	PP11 - GPW S.A.
Mirosława Skrzypczak	PP11 - GPW S.A.
Andrzej Siudy	PP11 - GPW S.A.
Laura Lach	PP11 - GPW S.A.
Tomasz Sędor	PP11 - GPW S.A.
Marek Czechowski	PP11 - GPW S.A.
Aleksandra Słowikowska	PP11 - GPW S.A.
Łukasz Pszczeliński	PP11 - GPW S.A.
with contribution of	
Andrzej Pasierbiński	JARS sp. z o.o.
Agnieszka Kolada	IOŚ-PIB
Agnieszka Pasztaleniec	IOŚ-PIB
Damian Absalon	JARS sp. z o.o.
Eugeniusz Małkowski	JARS sp. z o.o.
Ewa Łupikasza	JARS sp. z o.o.
Mariola Krodkiewska	JARS sp. z o.o.
Hanna Rubin	JARS sp. z o.o.
Marek Sołtysiak	JARS sp. z o.o.
Jacek Francikowski	JARS sp. z o.o.

Krystyn Rubin	JARS sp. z o.o.
Piotr Siwek	JARS sp. z o.o.
Dominika Dąbrowska	JARS sp. z o.o.
Dorota Grabala	JARS sp. z o.o.
Ewa Kaczkowska	JARS sp. z o.o.
Jagoda Wąsowska	JARS sp. z o.o.
Marta Walczak	JARS sp. z o.o.
Rafał Ulańczyk	IOŚ – PIB
Krzysztof Skotak	IOŚ-PIB
Jacek Wróbel	JARS sp. z o.o.
Kinga Ślósarczyk	JARS sp. z o.o.
Tomasz Pecka	IOŚ-PIB
and support of:	
Andrzej J. Witkowski	AP19 - University of Silesia
Jacek Różkowski	AP19 - University of Silesia
Sabina Jakóbczyk - Karpierz	AP19 - University of Silesia
Sławomir Sitek	AP19 - University of Silesia
Bartosz Łozowski	AP19 - University of Silesia
Andrzej Woźnica	AP19 - University of Silesia
Hungary	
Magdolna Ambrus	PP7 - General Directorate of Water Management OVF
Orsolya Both	PP7 - General Directorate of Water Management OVF
Ágnes Tahy	PP7 - General Directorate of Water Management OVF
Róbert Hegyi	PP7 - General Directorate of Water Management OVF
Bence Kisgyörgy	KSzI Kft.
Márton Ganszky	KSzI Kft.
Janka Mezei	KSzI Kft.

Veronika Kiss	KSzI Kft.
Croatia	
Josip Terzić	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Ivana Boljat	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Matko Patekar	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Ivona Baniček	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Daria Čupić	AP17 - Croatian Waters
Jasmina Lukač Reberski	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Tihomir Frangen	PP8 - Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Germany	
Daniel Bittner	PP12 - Technical University of Munich
Gabriele Chiogna	PP12 - Technical University of Munich
Markus Disse	PP12 - Technical University of Munich

TABLE OF CONTENTS

1. Introduction

Review of main land use conflicts and best management practices (BMPs) for drinking water protection and protection against floods on Pilot Action level has already been done in Pilot Action BMPs reports, which were a basis for *D.T2.1.2 Transnational case review of best management practices in pilot actions*. 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 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 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.

For selected BMPs in the particular Pilot Actions implementation possibilities were assessed. In this report strategic identification of needs for action for implementation of best management practices for drinking water protection are presented for Pilot Action Cluster 2.

2. Solutions for case specific adaptation of 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.

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 have to be assessed and implementation strategies have to be determined. 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 with relation to drinking water protection,
- adaptation of policy guidelines.

Solutions for case specific adaptation of best management practices are presented in Table 2.

Table 2: Solutions for case specific adaptation of best management practices.

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	
NO determination/ establishment of DWPZs	With hydrogeological modelling DWPZ areas will be determined	A Hydrogeological model is a mathematical model simulation for low and high groundwater level. DWPZs are defined according to mathematical model prediction of 50-day isochrone (DWPZ I) and 400-day isochrone (DWPZ II) according to how many days takes the water to inflow from vadose zone.	Not relevant	Adaptation of Spatial plan of the Municipality of Ljubljana with DWPZ determination.	-
NO determination/ establishment of DWPZs	Proposal of DWPZ establishment	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.
NO determination/	Defining and	If sanitary protection	Not relevant	Policy guidelines are well	Stakeholders and experts strongly

establishment of DWPZs	establishing sanitary protection zones in South Dalmatia	zones are proclaimed, land use management practices must definitely change. This is mostly related to agricultural practices, construction, spatial planning and waste management.		developed concerning DWPZ, but implementation is lacking, inspections are inadequate, and penalties are rarely given.	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.
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.	-
Small scope of water monitoring	Establishment of constant, multi-aspects water monitoring in the catchment scale	No adaptation required	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.	-
Low level of ecological awareness of	Raising awareness and increasing	Participants are getting familiar with current land use management	Need of conducting proper, multi-aspect monitoring of water	Participants are getting familiar with current policy.	Limited channels of information flow in small communities.

society	knowledge	practises and proposal for BMP.	system should be emphasized in guidelines at local, regional and also national level.		
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.
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	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,

			effective.		instead of intervention.
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 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).	-

Torrential water flooding - excessive surface runoff, lack of water for animals and watering the plants	Collecting torrential water in wider channels, small retention pond (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.	-
Water balance status and effective mitigation measures are not known (identified)	Water balance status will be determined with Hydrological / Hydraulical modelling	Not relevant	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	Flood risk map as an adaptation of evaluation of parcels included in Municipal spatial planning.	-

			management, in order to support decision makers and operational water managers. Hydrological models also allow us to do scenario analysis.		
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.
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).	Measure is complex, as it faces resistance of local population, lots of financial compensation for losses, and generally, structural measures are still favoured.
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 of	The value of an available hydrological model is not adequately reported in the current guidelines. This tool is of fundamental	Not applicable

	user interface in a participative approach		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.	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.	
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	Involving farmers to the Agrarian	Ploughing parallel to the watercourse, usage of	Not relevant	Not relevant	Forecasting how plant production will change as climate changes

pesticides and manure on plant production fields.	Environmental Program, emphasizing the importance of green products, providing information to the farmers about climate change.	green products.			could be advantageous.
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
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	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	Not applicable

			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).	to collect more frequently and with a better spatial resolution relevant hydrogeochemical data.	
Insufficiently effective waste water treatment system that needs to be reconstructed and expanded	Natural waste water 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.	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).
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.	Policy guidelines are good, penalties are prescribed for illegal waste dumping, but inspections are poor, and misdemeanour is not punished.
Unsanitary and illegal waste	Encourage and promote	Not relevant	Not relevant	Innovative solutions for waste management are not	Stakeholders are a bit doubtful about the success of this

disposal	innovative solutions of sustainable waste management			mandatory, but rather an option. However, positive management examples can serve as a catalyst to improve waste management guidelines.	measure. Although positive trends can be observed, the process is slow and requires persistence.

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 is a potential well field in the Glinščica river sub-basin (Dravlje valley in Slovenia). It lies within urbanized area crossed by Ljubljana's ring-road. Large open spaces (mainly agricultural areas), urban area and industry causing high pressure on land use. This is also a flood prone area without efficient surface water regulation. This is a problem mostly because non-regulated surface water coming from the hilly hinterland can enter the urban sewage system, which in high waters cannot receive that much water and are flooded. Most of the 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.

There are no remaining issues to be solved.

Within **PA2.2** Kozłowa Góra several GAPs were identified included 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 following: good quality input and calibration data, limited channels of information flow in small communities.

On **PA2.3** Tisza catchment area 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. Data on chemical parameters (NO_3^-, NH_4-N, COD_{Mn}, NO_2^- and pH) measured at Szolnok *(Szolnok Waterworks)* were evaluated and showed very few momentary contamination events from the last six years. Although on most of the livestock farms open manure storages are still in use, the runoff coefficient is so small on the pilot area that the water originating from in situ precipitation is negligible. Overall few annual precipitation, high temperature and radiation contribute to the fact that contaminated rainwater rather evaporates back to the atmosphere or infiltrates into the soil. Water quality did not deteriorate considerably during the serious flooding in 2013 either.

The above shows that the situation is satisfying at the moment. 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. As it was mentioned by BRUNETTI et al. (2001) and BATES et al. (2008) (and many more) for countries in the temperate zone, climate change will decrease the number of rainy days but increase the average volume of each rainfall event.

Current practices should be evaluated in context of future climate conditions.

Remaining issues to be solved are the follows: 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.

On **PA2.4** 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” measures Measure is complex, 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" measures: 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 "Encourage and promote innovative solutions of sustainable waste management" measure. Although positive trends can be observed, the process is slow and requires persistence.

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 is no remaining issues to be solved.

Classifying the GAPs/BMPs showed that most of the issue find 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 a deterioration in both drinking water quality and quantity. 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 law quality data, high cost of measures (lack of funds), lack of trans-border cooperation;
- in agriculture: financing, lack of willingness of farmers to cooperate (a change to green production is expensive);

- in urban areas: unwillingness of the local community to adopt new environmentally friendly habits as a consequence of insufficient education on environmental issues and lack of government stimulations.

In 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.

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: PA2.1 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: 2.5 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

- D.T2.3.1 Evaluation reports for each pilot action. PILOT ACTION: PA2.2 Water reservoir Kozłowa Góra, PL
- D.T2.3.1 Evaluation reports for each pilot action. PILOT ACTION: PA2.3 Tisza catchment area, HU1
- D.T2.3.1 Evaluation reports for each pilot action. PILOT ACTION: PA2.4 Groundwater protection in karst area, HR
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