PROLINE-CE

WORKPACKAGE T1, ACTIVITY 1.3.4

D.T1.3.4

TRANSNATIONAL CATALOGUE OF STRATEGIES AND MEASURES TO BE INTEGRATED INTO EXISTING POLICY GUIDELINES

January 2018

Lead Institution	HGI-CGS
Contributor/s	AP 16 - Croatian waters
Lead Author/s	Ivana Boljat
Date of last release	January 2018

Contributors, name and surname	Institution
Austria	
Elisabeth Gerhardt	Federal Research and Training Centre for Forests, Natural Hazards and Landscape
Roland Köck	University of Natural Resources and Life Sciences, Vienna, Department of Forest- and Soil Sciences, Institute of Silviculture
Hubert Siegel	Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management; Forest Department
Gerhard Kuschnig	Municipality of the City of Vienna, MA 31 – Vienna Water
Christian Reszler	JR-AquaConSol, Joanneum Research company
Croatia	
Josip Terzić	Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Jasmina Lukač Reberski	Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Ivana Boljat	Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Daria Čupić	Croatian Waters
Matko Patekar	Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Ivona Baničeк	Croatian Geological Survey, Department of Hydrogeology and Engineering Geology
Germany	
Daniel Bittner	Technical University of Munich; Chair of Hydrology and River Basin Management
Prof. Dr. Gabriele Chiogna	Technical University of Munich; Chair of Hydrology and River Basin Management
Prof. Dr.-Ing. Markus Disse	Technical University of Munich; Chair of Hydrology and River Basin Management
Hungary	
Robert Hegyi	General Directorate of Water Management
Magdolna Ambrus	General Directorate of Water Management
Peter Molnar	General Directorate of Water Management
Tamas Belovai	General Directorate of Water Management
Barbara Bezegh	Herman Otto Institute Non-profit Ltd.
Matyas Prommer	Herman Otto Institute Non-profit Ltd.
Mihaly Vegh	Herman Otto Institute Non-profit Ltd.

Contributors, name and surname	Institution
Italy	
Cinzia Alessandrini	Arpae
Silvano Pecora	Arpae
Francesco Puma	EU WATERCENTER
Guido Rianna	CMCC Foundation
Giuseppe Ricciardi	Arpae
Monia Santini	CMCC Foundation
Anna Sperotto	CMCC Foundation
Silvia Torresan	CMCC Foundation
Poland	
Przemysław Gruszecki	Krajowy Zarząd Gospodarki Wodnej
Norbert Jaźwiński	Krajowy Zarząd Gospodarki Wodnej
Marcin Walczak	Krajowy Zarząd Gospodarki Wodnej
Piotr Zimmermann	Krajowy Zarząd Gospodarki Wodnej
Joanna Troińska	Krajowy Zarząd Gospodarki Wodnej
Andrzej Kaczorek	Krajowy Zarząd Gospodarki Wodnej
Edyta Jurkiewicz-Gruszecka	Krajowy Zarząd Gospodarki Wodnej
Grzegorz Żero	Krajowy Zarząd Gospodarki Wodnej
Olga Sadowska	Krajowy Zarząd Gospodarki Wodnej
Anna Goszczyńska-Zając	Krajowy Zarząd Gospodarki Wodnej
Michał Falandysz	Krajowy Zarząd Gospodarki Wodnej
Joanna Czekaj	Górnośląskie Przedsiębiorstwo Wodociągów S.A.
Sabina Jakóbczyk - Karpierz	University of Silesia
Sławomir Sitek	University of Silesia
Andrzej Witkowski	University of Silesia
Jacek Różkowski	University of Silesia
Bartosz Łozowski	University of Silesia
Andrzej Woźnica	University of Silesia
Slovenia	
Barbara Čenčur Curk	University of Ljubljana, NTF
Primož Banovec	University of Ljubljana, FGG
Anja Torkar	University of Ljubljana, NTF
Branka Bračič Železnik	Public Water Utility JP VO-KA
Ajda Cilenšek	University of Ljubljana, FGG

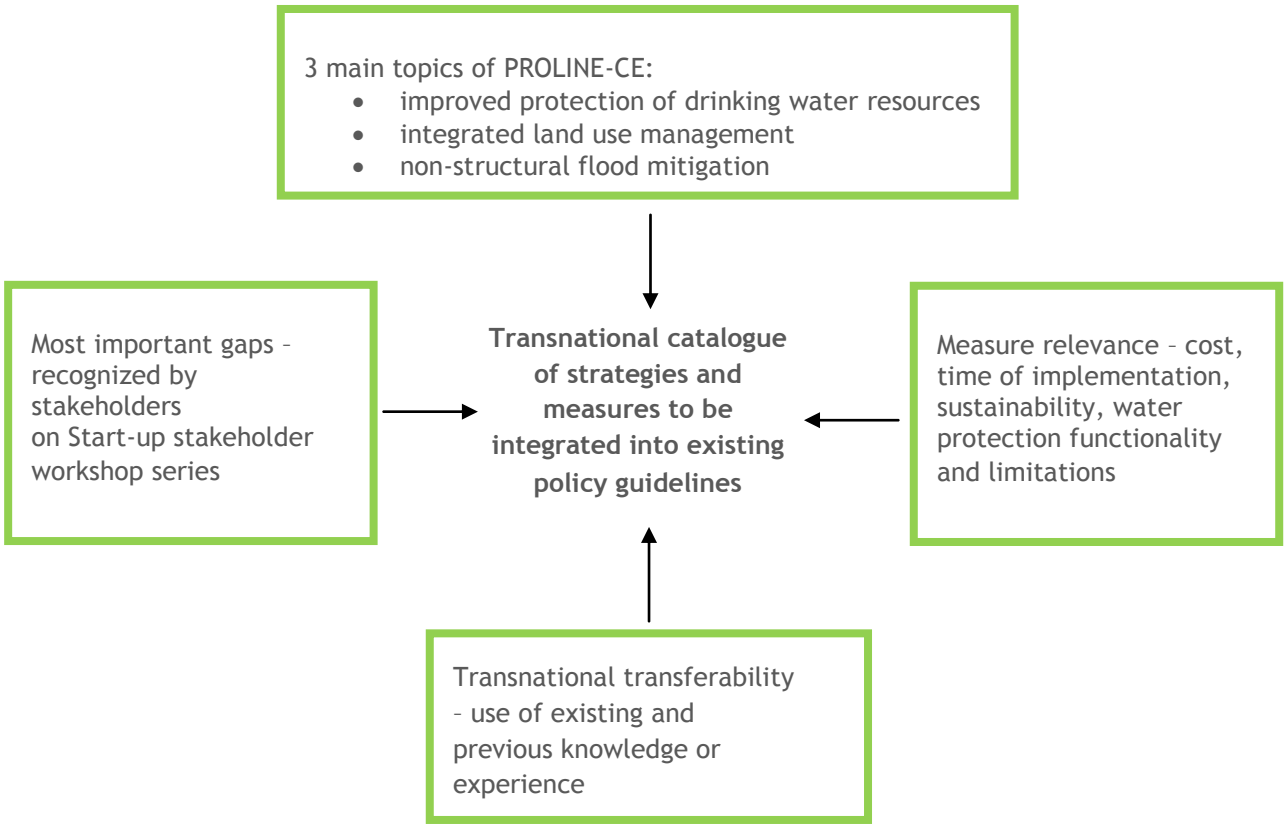
Contents

1. Introduction

D.T1.3.4 “Transnational catalogue of strategies and measures to be integrated into existing policy guidelines” aims to transform the lessons learnt from start-up stakeholders workshops (identification of main gaps in land use and flood management in relation to drinking water protection; proposed solutions; specific action) into measures and solutions which could be integrated into existing practices and policies in water management, land use management, flood management etc., offering improvement of existing and development of new and efficient management, control and behaviour practices. This deliverable will directly contribute to PROLINE-CE Output O.T1.2 “Strategy for the improvement of policy guidelines”.

While selecting the measures to be implemented either on national/regional level, or if possible, in pilot areas, project partners were asked to take the following criteria (**Fig.1**) into consideration:

Figure 1. Selection criteria scheme



2. Measures to be integrated into existing policy guidelines

This chapter presents identified gaps provoking actions and measures in response to those gaps, provided by project partner countries. Each gap/measure is presented within separate form/table. Each gap is accompanied with short description, pointing out the essence of the specific problem, where is it occurring, why is it occurring and upon who/what is negative influence inflicted upon. Section describing measure contains general description of the measure, such as type of land use regarded, general description, relevance, source/reference, limitation, advantages, challenges and location. Location refers both to the country which reported the gap/measure, and to the example or specific location where that measure could be applied. Gaps and measures are sorted according to type of land use (also each type of land use is in another colour).

Legend:

- Forest
- Agriculture
- Urban
- Grassland
- Wetland
- General / all

2.1. Forest

■ Identified GAP provoking action		
GAP short name	**Application of the clear-cut technique in drinking water protection zones (DWPZ)**	
GAP short description	Erosion processes triggered by the clear-cut technique, like mineralisation processes, humus decomposition, surface-flow in the course of strong precipitation events, etc. All those processes can cause source water contamination with various substances like nitrate, dissolved organic carbon (DOC) or sediments.	
■ Measure		
Name of measure	**Avoidance of the clear-cut technique**	
Type of land use regarded	Forest	
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC1)	
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot Action Waidhofen/Ybbs***. Example of successful measure implementation: Austria, Pilot Action City of Vienna – Water Protection Zone of the City of Vienna	
Description of the measure	The sustainable protection of the source water for drinking water supply is the main purpose of any drinking water protection strategy. Within forested DWPZ the application of the clear-cut technique exerts the main risk for source water quality. The avoidance of the clear-cut technique and the creation of continuous cover forestry systems which include small-scale operations for timber yield and for creating regeneration processes hence become essential within DWPZ.	
Measure advantages	The avoidance of the clear-cut technique opens the path for the establishment of Continuous Cover Forest Systems. The whole catalogue of BMP's in the field of forestry becomes accessible for a DWPZ if clear-cuts are avoided there. It can be regarded as the basic condition which has to be fulfilled in order to open the field for the application of the whole BMP catalogue. The main advantage is the improvement of forest soil conditions and the facilitation of forest stand stability, which prevents the mobilisation of soil and humus substances, which in turn could be transformed into contamination for the source water.	
Challenges	The main challenge for the avoidance of the clear-cut technique is the given resistance among forest owners and the related local/regional/national forest authorities. In Austria the clear-cut technique is the main silvicultural strategy for timber yield and forest regeneration. To break the resistance against its avoidance through e.g. consequent application of the Austrian Federal Forest Act or direct talks with the forest owners respectively local forest authorities becomes vital for drinking water protection.	
Relevance	Water protection functionality	High

	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from scientific literature, the CC-WARE BMP descriptions and classic examples of treatments in DWPZ (e.g. Pilot Action City of Vienna).	
Limitations	Limitations to be expected are the already stated resistance of private as well as public forest owners and authorities in Austria, who just want to continue with their business-as-usual approach towards any forest-related themes, and the clear-cut technique is currently applied very wide spread in Austria's economics-dominated forest management.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO Croatia – illegal clear cuts are common, although forbidden by law	
Implementation example	This BMP has been implemented in Austria within the DWPZ of the city of Vienna since decades. No limiting actions were possible due to the fact, that the city owns the DWPZ. There were no limitations or challenges which would oppose this BMP. Also in Slovenia clear-cuts are not applied anywhere throughout the nations forests.	
Comments	The avoidance of the clear-cut technique will open the path within Austrian DWPZ in order to implement integrative drinking source water protection strategies. In current times the implementation of this BMP is realistic in Austria. Adequate financial compensation for additional costs occurring through the implementation of sustainable forest management measures have to be taken into account – for example by means of compensations by the "Rural Development 2014+" (ELER).	

■ **Identified GAP provoking action**	
GAP short name	**Elevated densities of unnaturally high stock of ungulate game as result of trophy-hunting activities and resulting browsing and bark-stripping damages**
GAP short description	Unnaturally high stocks of ungulate game elevated through trophy-hunting activities provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-stripping damages. Those inhibit the natural regeneration process of whole forest ecosystems and by the way destabilize them.
■ **Measure**	
Name of measure	**Creation of forest-ecologically sustainable stocks of ungulate game**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1)
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot***

	Action Waidhofen/Ybbs (PAC1.2). Example of partly successful measure implementation: Austria, Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1), but despite this fact the measure remains relevant for this Pilot Action.	
Description of the measure	High stocks of wild ungulate game provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-stripping damages. Those inhibit the natural regeneration process of whole forest ecosystems or destabilize them. Natural regeneration is the crucial process in forest ecosystems, which has to be given on an optimal level for all present tree species, especially within DWPA. This can only be guaranteed, if the stocks of ungulate game are regulated to a forest ecologically sustainable level, hence providing vital regeneration of all tree species. The regulation can be achieved through adequate hunting activities, the abandonment of feeding during winter and through the additional introduction of wild predators like lynx or wolf, which regulate the stocks of ungulate game.	
Measure advantages	Forest ecologically sustainable stocks of ungulate game provide the huge advantage that the forest ecosystems can evolve naturally, can grow according to their natural inner dynamics (self-organisation of forest ecosystems). This includes a vital regeneration layer within the forest stands, encompassing all tree species of the respective natural forest community. It is the most essential precondition for providing the water protection functionality of forest ecosystems, especially under climate change conditions.	
Challenges	In Austria the high stocks of ungulate game is the greatest threat for continuous regeneration dynamics in forest ecosystems. Browsing damages occur wide spread and also several DWPZ are affected. To solve this issue is a true challenge, as the hunter organisations have a strong lobby and do not want to have significant changes, as those could affect their hunting habits. To establish forest ecologically sustainable stocks of ungulate game can be regarded as the main challenge for the Austrian forest sector. The resistance of the hunter lobby and of many forest owners has to be resolved. This task gains high priority within DWPZ, as stable forest ecosystems are the precondition for providing secure drinking water supply in a sustainable form.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as one of the most crucial ones for the establishment of an Austrian source water protection strategy.	
Limitations	Limitations to be expected concerning implementation are above all the resistance of the hunters lobby, and on national level also the related lacking political will. The introduction of wild predators like lynx or wolf, which would regulate the stocks of ungulate game species, is very difficult in Austria as these animals are sometimes killed illegally.	
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☐IT ☐POL ☒SLO	

	Bavaria – implemented in specific case studies
Implementation example	In Austria there exist only few examples, where the creation of forest-ecologically sustainable stocks of ungulate game was successful. Again some parts of the DWPZ of the city of Vienna actually have already achieved this target and are exhibiting vital and abundant natural regeneration of all specific forest tree species. The implementation required consequent hunting activities. Until now none of the two Pilot Actions (DWPZ of Waidhofen/Ybbs and of Vienna) has both adequate hunting practices and the presence of wild predators implemented.
Comments	The creation of forest-ecologically sustainable stocks of ungulate game is one of the biggest challenges for Austrian forestry and would provide the second most important basic condition for a sustainable drinking source water protection strategy within forested DWPZ. In Austria further convincing processes within the involved stakeholders will be necessary in present times and also in future.

▪ **Identified GAP provoking action**	
GAP short name	**Extensive forest road construction within the DWPZ**
GAP short description	Forest Road construction and maintenance can cause several adverse impacts on water bodies and should hence be limited in DWPZ. The increase of surface runoff and of water storage loss is the main negative effect. Forest roads also cause interruptions of the lateral flow, spatial concentrations of surface runoff derived directly from the forest road and gaps in the canopy cover.
▪ **Measure**	
Name of measure	**Limitation of Forest Roads within DWPZ**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1)
Location	Austria All forest areas within all provinces (DWPZ), ***especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2) and Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).***
Description of the measure	Forest Road construction and maintenance can cause several adverse impacts on water bodies and should hence be limited in DWPZ. The increase of surface runoff and of water storage loss is the main negative effect. Hence the construction of forest roads should be generally avoided within DWPZ. Only in cases, if forest roads are necessary for the stabilization of forest areas, their construction could be considered. In those cases their construction has to meet strict environmental restrictions, like e.g. interventions as small as possible, the avoidance of highly vulnerable areas within the DWPZ, an operational drainage system which avoids the concentration of surface-flow and the application of fleece-materials which hinder in case of potential accidents the entrance of oil spills into the aquifer.

Measure advantages	For avoiding potential contaminations and hydrological adverse impacts caused by forest roads, the limitation of their construction within DWPZ is an indispensable need. Also in case of unavoidable forest road constructions, the application of the state-of-the-art technique with integration of fleece-materials and specific drainage systems secures a reduction of potential risks.	
Challenges	In Austria forest roads and their construction is a cornerstone of "normal economic management situations". Foresters appreciate to construct forest roads. Hence it is very difficult to convince them about the need of abstaining from constructing them. Actually there can be identified the tendency to construct forest roads even in very remote or isolated forest areas. Focused information transfer and persuasive efforts will have to be applied in order to avoid their construction or even for the application of the technical adaptations. Forest owners in Austria do not want to be interfered in the course of their decision processes.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as relevant for both related Pilot Actions, for Pilot Action Waidhofen/Ybbs (PAC1.2) and for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Limitations	Actually there can be identified a profound resistance against limitations of forest roads among foresters in Austria, even within DWPZ. Also the local/regional and national authorities did not show any sign to change their attitude towards forest road constructions. Even technical improvements like the application of fleece-materials or drainage-techniques are not included for forest road constructions within DWPZ. Hence the measure implementation seems to be limited fundamentally in Austria under current policies. Only parts of the population have a critical attitude towards forest road constructions, but they are actually not relevant for the decision-processes.	
Implemented in	☐AT ☒BAV ☐CRO ☐HU ☐IT ☐POL ☒SLO Bavaria – implemented in specific case studies	
Implementation example	A similar BMP has not been implemented somewhere else in Austria.	
Comments	It would be a great advantage if forest road construction in Austrian DWPZ would be limited, especially for the sustainable guarantee of drinking water supply security. The current funding policy in Austria is partially counteracting this limitation.	

Identified GAP provoking action		
GAP short name	**Plantation of conifer species on all forest sites**	
GAP short description	Plantation of conifer species instead of using the natural regeneration of the tree species according to the specific Forest Hydrotope Types (natural forest communities).	
Measure		
Name of measure	**Tree Species Diversity According to the Natural Forest Community**	
Type of land use regarded	Forest	
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1).	
Location	Austria All forest areas within all provinces (DWPZ), **especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2)** and to a lesser degree for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Description of the measure	Tree species diversity according to the natural forest community guarantees the highest level of stability and resilience. Tree species diversity provides a high level of adaptability, also under climate change. Forest stands created by diverse tree species can utilize a broader scope of the forest soils, if deep-rooting and shallow-rooting trees are growing together. Knowledge about spatial distribution of the natural forest communities (forest hydrotopes) is required for the operational stratification of the DWPA and adaptive forest management. Man-made conifer plantations with not-natural tree species should be transformed gradually to stands dominated by native species, all time depending on the local experience and legislation.	
Measure advantages	For many Austrian forests, tree species diversity according to the natural forest community would be a definite advantage, as homogeneous conifer plantations are actually dominating the forests. Especially in times of climate change tree species diversity becomes mandatory for achieving forest ecosystem stability. Only stable and resilient forest ecosystems can provide water protection functionality in order to fulfil the related ecosystem-service. Tree species diversity has also positive side effects, like e.g. for conservation purposes.	
Challenges	In most of the Austrian forest areas there can be expected resistance against tree species diversity according to the natural forest community, as the habitual forestry practices in most of the cases had a strong focus on conifer plantations or other homogeneous timber yield focused plantations.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium/High
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2). Within Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1)	

	the measure was already implemented, tree species diversity according to the natural forest community is a declared target for silviculture there.
Limitations	There can be identified in many cases (for many forest owners) a resistance against the implementation of this measure, as many forest owners still perceive Norway spruce as the only valuable tree species in terms of economic perspectives. There also does not exist any national guideline for establishing tree species diversity according to the natural forest community. Especially within DWPZ this should become mandatory.
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☐IT ☐POL ☒SLO Bavaria – implemented in specific case studies
Implementation example	This specific BMP has already been implemented within Pilot Action PAC1.1. As forest succession needs time, the outcome of the measure implementation already becomes visible in some forest districts of the huge DWPZ. The basis for the implementation was the application of the Forest Hydrotope Model as outcome of an aerial forest site mapping survey, which defines the tree species diversity adaptive to the differing forest site conditions within the DWPZ. The Forest Hydrotope Model was elaborated within the PAC1.1 on behalf of the city of Vienna. It is a declared forest management goal to implement the natural tree species diversity according to the different forest hydrotope types. The process is ongoing, as on huge forest areas homogeneous conifer plantations were created in the past century. The tree species shift needs time. The limiting beliefs of the foresters were overcome, as Norway spruce actually suffers more and more from wind-throw events and bark-beetle infestations, a process which supported their learning capacity.
Comments	It is of central interest for drinking water protection to establish within Austrian forest ecosystems in DWPZ tree species diversity according to the natural forest community, as it guarantees the highest level of forest ecosystem stability and resilience.

▪ **Identified GAP provoking action**	
GAP short name	**Cutting of huge, old and stable tree individuals**
GAP short description	Reduction of the natural gene reserves through cutting of old and stable tree individuals in the course of timber yield
▪ **Measure**	
Name of measure	**Foster old, huge and vital tree individuals**
Type of land use regarded	Forest
Pilot action cluster (if relevant)	Mountainous areas: Forestry and Grassland (PAC 1).
Location	Austria All forest areas within all provinces (DWPZ), especially relevant for Pilot Action Waidhofen/Ybbs (PAC1.2) and to a lesser degree for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).

Description of the measure	Old, huge and vital tree individuals carry excellent genetic information. They can supply younger and smaller tree individuals with nutrients via their common mykorrhizal network. They also act as structural stabilizing trees for whole forest stands. Thereby they 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.	
Measure advantages	The genetic information provided by old, huge and vital tree individuals has a high value for the stability and sustainability of the forest ecosystem. Old and huge tree individuals can provide stability for the whole forest stand (in a quasi-mechanical way) and are also important for the nutrition of young trees (including the regeneration phase), who may receive nutrients from the old trees via the mycorrhiza-interconnected root system. The genetic information which they carry inside is a treasure for any silvicultural activity but also for the self-organisation capacity of the forest ecosystem.	
Challenges	The old, huge and vital tree individuals have to be selected for remaining in a forest stand. Recently huge trees in Austria are in general selected for being cut for timber yield. The necessary change of behaviour has to be achieved through information and persuasive efforts.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP is derived from the CC-WARE BMP catalogue and was identified as especially relevant for both Pilot Action Waidhofen/Ybbs (PAC1.2) and for Pilot Action City of Vienna – Water Protection Zone of the City of Vienna (PAC1.1).	
Limitations	In present times the old tradition in forestry to protect some exceptional huge, old and stable tree individuals was abandoned and in many areas huge trees are felled for timber yield as they provide lots of biomass. This modern trend in forestry is due to the purpose to maximise timber yield. The implementation of a nation-wide supervising/implementation mechanism could be a solution for this obstacle.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Bavaria – implemented in specific case studies	
Implementation example	In Austria there does not exist a current implementation example. In the past foresters have traditionally protected some exceptional huge, old and stable tree individuals. This was done because they saw the value which those trees provided for natural regeneration and forest stand stability. In present times this tradition was abandoned and in many areas huge trees are felled for timber yield as they provide lots of biomass. Actually the selection of old, huge and vital tree individuals with the purpose to remain in the forest stand may still be envisaged by some foresters. In order to implement this Best Practice more consequently or to re-establish its implementation, information transfer to the foresters would be an adequate solution (e.g. a nation-wide supervising/implementation mechanism).	
Comments	The genetic information provided by old, huge and vital tree individuals has an	

	exceptional high value for the stability and sustainability of forest ecosystems and hence gains importance within DWPZ.

▪ Identified GAP provoking action	
GAP short name	**Forest deployment and cultivation, forestry practice in drinking water resources protection areas**
GAP short description	Particularly important in the external protection area of the river bank-filtered drinking water basin is that the afforestation is successful and their canopy closes rapidly.
▪ Measure	
Name of measure	**Forest installation rules in floodplain of drinking water resources protection area**
Type of land use regarded	Forest stock aiming water resource protection
Pilot action cluster (if relevant)	Forest (in plain areas)
Location	Hungary The most significant bank-filtered groundwater resources of Budapest Waterworks from Szentendre Island and the other partitioned water basins near the Danube.
Description of the measure	As listed in Annex 5 of 123/1997. (VII: 18.) Government decree agricultural part, afforestation in the internal protection area is prohibited - due to the root dams' perishable damaging effect. In external and hydrogeological protection areas, silviculture can be carried out without limitation or any restriction, and also forest refurbishment without chemical treatment can be carried out without limitation in all protection areas. At the same time, plant cultivation, organic fertilization, fertilization, use of pesticides must be carried out on the basis of an environmental impact assessment or a review or a specific test. The same provisions apply to the external hydrogeological protection area and hydrogeological protection area "A". The utilization of wood of the partitioned water basins along the rivers, of the hydro-geological protection area „A“ and of the potable water wells creates the best, close-to-nature state. In many cases, the Budapest Waterworks owns the external protection area and maintains a forest stock, and it manages the installations and renovations. These forests are planned forests. Cultivation of non-invasive, well-closed tree species is difficult, especially with limited use of chemicals. On the external and "A" hydrogeological protection areas, crop production may be continued in such a way that it does not endanger the water supply, in an environmentally friendly way, and water conservation aspects must be put to the fore. Appropriate management rules can be individually defined in the most accurate way, while the general environmental friendly aspects are contained in the regulations of the "Good agricultural practice" set out in the legislation.

	Environmentally friendly farming rules are contained in Decree 59/2008 on "Detailed rules for action to protect waters from nitrates from agricultural sources". (IV.29) FVM regulation, "Decree No 27/2006" on the protection of waters against nitrates from agricultural sources " (II.7) Government Decree and the "Good Agricultural and Environmental Condition" to be fulfilled for the application of the simplified area payments and rural development subsidies FVM regulation, and the definition of the "Good Practice " 4/2004 (I 13) FVM Decree. Waterworks can only ultimately use rabbit chemicals, with great care and questioning the soil protection and plant protection authority. However, forest planting and maintenance activities are fundamentally designed in a chemical-free manner. **Tree species choice:** In view of the fact that the afforestation costs are constant for all types of forests and forest reconstruction works cannot be avoided, in the water conservation area, for non-economic forests, the use of longer tree rotations is preferable. It is important to choose tree species that are well tolerated to the site conditions. In protected areas managed by the waterworks, floodplain areas are often dry in the background of wells. Where the groundwater is unavailable to the roots of the plants because of the drainage of the wells, water demand is solely dependent on rainfall. Over the last decade, the frequency and length of droughts are increasing. All these factors have to be taken into account when choosing a tree species. Decades of experience shows that noble poplar populations in these areas do not develop properly. This is not surprising, as the noble poplar likes particularly intense, well-nutrient, nutrient-rich areas. The installation of very valuable, 100-120 years rotation oak in the background of wells in typically water-deficient areas, is only possible with irrigation or with the application of a substantively different installation technology with the hope of success. In the case of a good place of supply for groundwater from the groundwater, the mixed installation of grey ash and Hungarian ash can bring favourable results. Mixing a couple of white walnuts creates a nice plant together. It is advisable to install mild alder and willow in good water supply but in poor soils. In the case of adequate site conditions, the spread of Hungarian ash and alder is also favourable from a nature protection point of view. Hungarian ash is a very valuable tree of the Danube floodplain. The mildew alder can produce very strong soils shade for 60-70 years, helping to maintain the green maple-free reservation, which is the most popular invasive tree species in the forest. When selecting tree species, spontaneous tree species in the area or in its vicinity can provide guidance. Following the installation, the plant care work has to be done in the seedling age. If the wood is well closed, no further clearing work is required after the 3rd year.
Measure advantages	In addition to proper installation, the fast-lying crown can withhold pollutants, absorb nutrients, invasive species are not settled.
Challenges	Challenges are to create a healthy, well-closed forest in a small area, with different groundwater conditions, special protection needs and to repel invasive species, without plant protection and fertilization intervention with as

	little work as possible.	
Relevance	Water protection functionality	Medium or high
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The installation and maintenance of forest take place as mentioned above in the area of Szentendre's and Csepel's river bank-filtered water resource.	
Limitations	Non-chemical cultivation	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Bavaria – implemented in specific case studies	
Implementation example	Budapest Waterworks Ltd.	
Comments		

▪ Identified GAP provoking action	
GAP short name	**Inadequate management of forests. The conservation and appropriate enhancement of biodiversity**
GAP short description	Deadwood influences the action of water by arresting surface flows on slopes during heavy rainfall and by accumulating in watercourses. Debris dams in streams and rivers generate pools and marshes, deflect flows, generate shoals of silt and small pebbles, and generally diversify the course into a sequence of pools, falls and riffles. Raised water levels and migrating channels create marshes and a variety of other riparian habitats. This habitat diversification, combined with the deadwood acting as a source of energy and nutrients, increases biodiversity and enlarges fish populations.
▪ Measure	
Name of measure	**Establishment of an adequate deadwood management**
Type of land use regarded	Forestry, Agriculture
Pilot action cluster (if relevant)	Plain site, Mountain
Location	Polish forests and backwoods
Description of the measure	Coarse deadwood should be present within all forest hydrotope areas of the drinking water protection headwaters. A tree during the time span from just before its death, as well as during the specific decomposition-phases, is a habitat and an ecological niche for a large amount of organisms and succession-chains which form in specific micro-habitats on continually decomposing tree trunks. Life and death are therefore inseparable in an undisturbed forest (Otto, 1994). The relevance of deadwood for biodiversity was mostly underestimated in the past. It was possible to show, that wood caves created by woodpeckers-

	species in strong upright deadwood trunks, subsequently may be populated by bat, squirrel, marten-species and owl-species. It is also important to mention the first inhabitants of deadwood, like fungi, bacteria, mites and nematodes (Krajick, 2001). For the water protection functionality of forests, coarse deadwood (trunks with strong diameters, upright and horizontal) have a predominant relevance because of the impacts previously mentioned, which nurture forest stand stability. This stand stability is created for example by the regulation of the mouse population by owls and the result ensures regeneration dynamics of beech. On the other hand, the decomposing woody parts of the trees are an area where water storage takes place. The presence and leaving of deadwood in forest ecosystems plays an important role for the biodiversity. Therefore it was proposed and has been accepted as an indicator for biodiversity on the pan-European level. In Bavaria, the establishment of an adequate deadwood management in state-owned forests is regulated by law, whereas this implementation is still voluntary in privately owned forests. Deadwood provides a rich source of nutrients that is continuously released in the process of its decomposition. In particular carbon, calcium and magnesium are provided. In this way, on the one hand this management practice enhances the formation of humus and on the other hand improves the silvicultural productivity. Moreover, deadwood represents an important habitat and ecological niche for several micro- and macroorganisms, e.g. fungus-types, bacteria, different woodpecker species and owls, and thus enables a species-rich ecosystem. Deadwood is an integral part of the soil development process. While fostering the production of humus, deadwood directly helps to increase the water storage capacity of the uppermost soil layer. A thick humus-layer on the one hand enhances the purification of seepage water and on the other hand increases the water storage capacity of the soil. Hence, an adapted deadwood management enhances the ecosystem functions such as water provision, water regulation and water quality regulation. Moreover, deadwood locally regulates the microclimate and helps to keep the living conditions near the soil surface more constant (Schiegg, Pasinelli, Suter (2002)). In terms of soil degradation, deadwood also locally hinders erosion processes and inhibits the outwash of nutrients and soil particles. The Measure advantages of an adequate deadwood content go beyond its direct impacts on the water-related ecosystem functions. In fact, it also positively affects other forest management practices, e.g. natural regeneration. The natural regeneration of spruce, fir and Swiss stone pines has been proved to be very effective on deadwood (Schiegg, Pasinelli, Suter (2002)). Additionally, deadwood helps to protect the young stands from browsing by game making the natural regeneration process more efficient. The ecologically-valuable properties of adequate deadwood content are prerequisites to obtain a stable, vital and especially resilient forest which can fulfil its protective function. This best practice is valid for both mountain and plain sites.
Measure advantages	Dead wood is ecologically important to forests. By slowly releasing carbon back into the atmosphere, dead wood plays a role in long-term carbon

	storage. Dead wood maintains biodiversity by supporting, sheltering, and feeding many species. It also shapes riparian ecosystems by altering the hydrology and morphology of the river channels, and helping to decrease the speed of flood waters. Dead Wood in Riparian Ecosystems Riparian areas are the transitional zones between streams and land adjacent to streams, which are important for in improving the stream health (Ilhardt et al. 2000). When tree branches or logs fall into the water, they hydrologically and hydraulically influence river channels by enhancing slope stability (Gurnell et al. 1995). Large dead wood stabilizes small streams and diverts water flows by controlling and dissipating the river's energy, which substantially reduces bank erosion. By reducing the impacts of fast flow on eroded banks, especially during heavy rainfalls, dead wood stabilizes and shapes the riparian ecosystem (Rose et al. 2001). Dead wood also helps stabilize stream ecosystems by retaining sediment. Logs in the stream reduce the velocity of the nearby water flow and thus lower the amount of sediments carried by the flow. After the debris dam is removed from the pool, the stored sediments trapped by the logs are tremendously reduced. Stored sediments that are 6 trapped and consolidated by logs are sources of nutritional particles, which are an important part of aquatic wildlife food sources (Rose et al. 2001). A stable riparian ecosystem plays an important role in relieving the urban stream syndrome—the ecological degradation of streams due to urbanized land (Pickett et al. 2011). Rushing stormwater, the result of impervious surfaces, can wash off sediments on the bank leading to bank erosion. Stream bank erosion accounts for two thirds of the total sediment load in the Chesapeake Bay Watershed (CBW) (Donovan et al. 2015). Placing dead wood in the riparian ecosystems is effective in reducing the erosion and improving stream health. It is suggested that dead wood should not be removed in the watershed since it acts like a strategic buffer in protecting and enhancing the watershed health by storing large amount of sediments and gravel (Palone and Todd 1998). Other advantages include: ▫ Positive impacts on the ecosystem services water regulation, water provision, water quality regulation; ▫ provision of nutrients and thus improvement of silvicultural productivity; ▫ protective function from browsing by game of young stands; ▫ coupling with other measures (e.g. natural forest regeneration of mixed-forests) can enhance the effect of an adequate deadwood management. ▫ Woodland alongside watercourses where fallen trees and deadwood play an important role in freshwater ecosystems by fostering the development of 'debris dams'
Challenges	▫ May hamper logging procedure; ▫ may increase the vulnerability to bark beetle infestations and forest fires.

Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	KATER II, CCWare	
Limitations	Resistance of population, especially private land and forest owners, lack of proper education, possible conflicts of land use vs water management vs flood management.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Bavaria – implemented in specific case studies	
Implementation example	Galloway Forest Park, Abernethy Forest, Scotland. Balancing management objectives In most woods there will be a need to balance the provision and enhancement of deadwood with other factors, some of which may include: • risks to public and worker safety of retaining and managing standing deadwood • visual and recreational impact of deadwood and of management operations; • other biodiversity objectives; • economic objectives, especially timer and woodfuel production; • the extent to which pests and diseases associated with large amounts of dead and dying trees might be encouraged, to the detriment of living trees.	
Comments		

2.2. Agriculture

■ Identified GAP provoking action		
GAP short name	Funding for land use actions for water protection	
GAP short description	Funding programmes for the implementation of land use measures are not related to water resources protection	
■ Measure		
Name of measure	Linking land use measure funds to water resources protection	
Type of land use regarded	Mostly agriculture	
Pilot action cluster (if relevant)	All areas	
Location	Bavaria	
Description of the measure	Funding programs for eco-friendly land use practices in Bavaria are related to the StMELF (Bavarian State Ministry for Food, Agriculture and Forestry), while concerns about water resources protection measures are related to the StMUV (Bavarian State Ministry of the Environment and Consumer Protection). The proposed measure intends to point to the joint responsibility of the mentioned resorts and highlights the importance to elaborate interlinked funding programs for integrated, water resources-friendly land use practices on relevant sites. Going beyond the targets of existing funding programs (e.g. KULAP, see below), this measure should help land owners and local stakeholders (such as water suppliers) to find adequate, site-specific solutions for a common target.	
Measure advantages	Closing gaps between two ministries may foster closer collaboration and facilitate finding solutions for interdisciplinary matters.	
Challenges	Two important Bavarian funding programs for land owners implementing eco-friendly practices on their farms are KULAP (Kulturlandschaftsprogramm, cultivated landscapes program) and VNP (Vertragsnaturschutzmaßnahmen, natural protection program), awarding payments to farmers on a hectare basis. However, these programs are already widely ascribed to and overstrained. Moreover, these funding programs are related to the StMELF, while funds and questions related to water resources protection measures are matters for the StMUV. Due to this essential splitting of responsibilities on the state level, the elaboration and implementation as well as the generation of funding programs for integrated, water resources-friendly land use practices is hampered.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Medium term
	Time interval of sustainability	Medium term
Reference / source	Stakeholder interviews, Online stakeholder survey (own analysis)	

Limitations	Existing policies, intending public engagement once a plan and measures have been elaborated; Existing mistrust between decision makers, water suppliers and land owners and thus resulting hardened fronts and difficult discussions between the relevant stakeholders;
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☒SLO Bavaria, Slovenia – implemented in specific case studies
Implementation example	
Comments	

■ **Identified GAP provoking action**	
GAP short name	**Deterioration of water quality due to agricultural pollution**
GAP short description	In cases where agricultural land is adjacent to the water bodies (rivers or streams), runoff of commonly used phytosanitary products may cause drastic deterioration of water quality. Additional pressures include on water bodies include phosphorous and nitrogen compounds from manure, sediment runoff and increased erosion. Farmers in Croatia are insufficiently educated, hence agriculture is purely conventional and the use of pesticides and fertilizers is still under the motto of "the more the better".
■ **Measure**	
Name of measure	**Establishment of buffer strips**
Type of land use regarded	Agriculture
Pilot action cluster (if relevant)	PAC2: • South Dalmatia – Prud, Klokun and Mandina springs • Imotsko Polje springs
Location	Croatia Adjacent to all water bodies / agricultural areas
Description of the measure	Establishment of buffer strips along water courses is a conditionality aimed to protect surface and groundwater pollution resulting from agricultural activities. The main polluting agents (nitrates, phosphates, chemical residues and insoluble mineral particles) are generated by excessive application of fertilisers to crop fields, by use of fertilisers inadequate for crop cycles and by inappropriate tillage or irrigation practices. The pollutants transfer is linked to water flows: for substances with lesser absorbance by soil particles (e.g. nitrates) the transfer happens mainly through surface flow or deep percolation of solutions; for highly absorbed substances, (phosphorus compounds), erosion and sedimentation are the main transfer systems. The term “buffer” identifies linear formations of herbaceous vegetation, tree and/or shrub interposed between the crops and the stream/channel which intercept surface and sub-

	surface runoff water, acting effectively as a filter against pollutants / sediments carried by water. Besides agriculture, buffer strips are also useful in forests in a way that they protect the streams from lateral erosion.	
Measure advantages	Buffer strips along streams are common best management practices on global scale. They have high ecological and water protection value since they prevent spreading of contaminants (e.g. nitrates) from adjacent surfaces (e.g. industry, agriculture) towards water bodies.	
Challenges	As usual when dealing with agricultural land willingness to accept this measure depends largely on the amount of compensation payments.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term (if clear cuts are prevented)
Reference / source	PROLINE-CE D.T1.2.2 Transnational best management practice report	
Limitations	Unwillingness to change habits; insufficient education of farmers; lack of government stimulation/compensation	
Implemented in	☒AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO Bavaria, Croatia – implemented in specific case studies	
Implementation example	Best practice on global scale PROLINE-CE examples: Austria, Italy (experimental study in Chienti basin)	
Comments		

■ **Identified GAP provoking action**	
GAP short name	**Application of intensive crop production technology and its impact on water resource protection**
GAP short description	The Hungarian legislation contains rules for the utilization of potable water protection areas for crop production, which gives the opportunity to take into account the different impacts of different cultivation systems and other protection options other than discounts in the licensing of the activity.
■ **Measure**	
Name of measure	**Intensive crop production possibilities in water protection areas**
Type of land use regarded	Agricultural area, crop production
Pilot action cluster (if relevant)	Agricultural production (PAC2, PAC3)
Location	Hungary Part-filtered drinking water resource on Szentendre Island
Description of the measure	On the Szentendre Island the production of strawberries is a tradition, which is carried out by the use of organic fertilizers, fertilizers and irrigation. The

	irrigation used is typically a sprinkling system even today. At traditional cultivation, nitrate from organic and fertilizer is washed through the soil into groundwater. According to the Government Decree 123/1997 (VII 18) the water protection regulations valid in Hungary, growing plants, organic and artificial trimming and pesticide application on internal protection areas is prohibited, while on external and "A" and "B" hydrogeological protection areas may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. From a drinking water quality point of view, nitrate from the plant nutrients is mobilized in the soil and is washed away with water from the surface to the groundwater. To make this process happen, two factors have to occur: there must be nitrogen excess and in the soil layer must be downstream water flow reaching groundwater. In the soil, excess nitrate can be produced by over-fertilization and unbalanced nutrient supply, because the plant utilizes all other nutrients in proportion at the minimum nutrient content. By itself, therefore, reducing the amount of nitrogen does not necessarily have the desired effect. Intensive cultivation systems that follow different plant nutrient requirements at different development stages can achieve more favourable results with multiple nutrient applications in the case of reducing nutrient loss and leaching, like the inadequately extensible systems. On the island of Szentendre, a twin-line rest-balk cultivated strawberry growing plant was established, where the ridges were covered with foil. Micro-irrigation was used and nitrogen nutrition was provided with daily irrigation water after a larger initial organic fertilization. With irrigation the root zone of the plant was moistened, that is the top 20-30 cm soil layer. However, the plant was also exposed to precipitation. During the experimental cultivation, the nitrate profile of the soil was continuously measured up to 150 cm depth. In particular, due to the wet weather, no significant amount of nitrate washes were found, which reached the groundwater hazard. With the use of smart and environmentally friendly pesticides, such intensive systems are suitable, that they minimize the environmental load with continuously controlling and applying to plant needs. Intensive agricultural utilization is also possible in water protection areas.	
Measure advantages	Producers and landowners can use intensive systems that provide greater profitability. There is no need to limit their activity just to regulate.	
Challenges	Implementation of plant protection activities in an environmentally friendly way.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium term
	Duration of implementation	Medium term
	Time interval of sustainability	Long term
Reference / source	Bank-filtered groundwater resources of Szentendre	
Limitations	The shift towards the extensive production method is now more widely accepted under the protection principles.	

Implemented in	☐AT ☒BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO Bavaria – implemented in specific case studies (not necessarily for strawberries)
Implementation example	Budapest Waterworks Ltd.
Comments	

▪ **Identified GAP provoking action**	
GAP short name	**Obsolete conduction of agricultural practices**
GAP short description	Traditional agriculture in terms of fulfilment of crop water requirement, not accounting for potential effects of climate changes (CC) and especially of intra-annual (seasonal) variability of rainfall and temperature regime leading to droughts.
▪ **Measure**	
Name of measure	**Increasing the efficient use of water in agriculture and adapting to climate change and crop irrigation to achieve optimum yields**
Type of land use regarded	Agriculture
Pilot action cluster (if relevant)	Po river basin (upstream, midstream to downstream area) (PAC 3)
Location	Italy Agricultural areas
Description of the measure	The introduction, in farms, of irrigation infrastructures in case of previously rained agriculture, or implementation of more sustainable irrigation techniques for already irrigate agriculture, allow improving the economic performance of agricultural production, facilitating the process of restructuring and modernization, and providing an effective mechanism at farm level for climate-change adaptation and mitigation of the damage caused by droughts. The new construction or modernization of existing farm irrigation systems lead to an increase in water efficiency. The development of irrigation infrastructure should be only undertaken where it does not conflict with the Water Framework Directive (Directive 2000/60/EC) and does not cause any deterioration in water status. Furthermore, all actions include the appropriate prevention and mitigation measures to offset potential environmental impact.
Measure advantages	The measure is aimed to: - Provide efficient systems to avoid water losses and optimize the irrigation application only in case of effective crop needs. - Save irrigation water under increasing rainfall variability under climate change, especially in the context of preserving water for downstream areas

	- Enable the use of irrigation also for crops usually under rainfed agriculture.	
Challenges	High costs, very local scale.	
Relevance	Water protection functionality	High (quantity aspect)
	Cost of the measure	Medium-High
	Duration of implementation	Short to medium term
	Time interval of sustainability	Long term
Reference / source		
Limitations	The advancing of technologies to make water use in irrigation more efficient require relevant initial costs, training of farmers and knowledge transfer to them in order to interpret and maximize results of monitoring/measurements of effective crop water requirement before applying irrigation.	
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO Bavaria – implemented in specific case studies (special consulting related to irrigation or up to a soil moisture of 70% of the usable field capacity)	
Implementation example	A good example of implementation was conducted by CMCC jointly with WWF-Italy in supporting Mutti SpA (one of the main industrial tomato producer). Mutti SpA experimented the use (by providing to farmers) of soil moisture monitoring devices to advise farmers about the exact timing and amount of irrigation needs. This allowed to save water consumption up to 30% and reducing the water footprint of cultivation phases.	
Comments	BP MA9 Increasing the efficient use of water in agriculture and adapting to climate change BP MA26 Irrigate crops to achieve optimum yields (as reported in T1.2.1 National Report)	

■ **Identified GAP provoking action**	
GAP short name	**Pollution of watercourses**
GAP short description	Exposure of streams and rivers to lateral erosion, sediment infiltration and pollution (pesticides, fertilizers)
■ **Measure**	
Name of measure	**Encouraging organic farming**
Type of land use regarded	Agriculture
Pilot action cluster (if relevant)	Plain sites, Mountain sites
Location	Poland
Description of the measure	According to the European Commission, between 2014 and 2020, over € 100 billion will be invested in the European Union's rural areas to help farming meet

	the challenges of soil and water quality, biodiversity and climate change. At least 30% of the rural development programmes' budget will have to be allocated to agro-environmental measures, support for organic farming or projects associated with environmentally friendly investment or innovation measures. The support is granted to farmers in the form of direct payments, on the condition that they respect strict rules on human and animal health and welfare, plant health and the environment. Green direct payments account for 30% of EU countries' direct payment budgets. Farmers receiving an area-based payment have to make use of various straightforward, non-contractual practices that benefit the environment and the climate. These require action each year. They include: diversifying crops; maintaining permanent grassland; dedicating 5% of arable land to "ecologically beneficial elements". Organic farmers automatically receive their greening payment for their holding, as they are considered to provide environmental benefits. Additional payments are available, for example for farming methods that go beyond basic environmental protection or for farmers working in areas with natural constraints. The amount of support they receive is not linked to the quantities they produce. Action Plan for the future of Organic Production in the European Union presents strategy for organic production, controls and trade. EU offers funding possibilities to operators for campaigns which aim to increase consumer awareness on the main features of the organic production scheme, on specific products produced according to the EU organic production rules, the EU system of control and on the EU organic logo.
Measure advantages	Ensure awareness of organic farming benefits; Organic farming combines best environmental practices, supports biodiversity and natural resources conservation. Not only does organic farming build healthy soil, but it helps combat serious soil and land issues, such as erosion. A major study comparing adjoining organic and chemically treated wheat fields showed that the organic field featured eight more inches of topsoil than the chemically treated field and also had only one-third the erosion loss. Erosion issues are extremely serious, affecting the land, food supply, and humans. However, organic farming practices do help discourage erosion from occurring. Dwindling water supplies and poor water health are very real threats. When our water supply is at risk, people and the planet end up suffering. Major water pollution threat to rivers is runoff from non-organic farms, such as harmful pesticides, toxic fertilizers, and animal waste. Organic farming helps keep our water supplies clean by stopping that polluted runoff. Organic farming also helps conserve water. Organic farmers, in general, tend to spend time amending soil correctly and using mulch - both of which help conserve water. Cotton, an in-demand crop, requires a lot of irrigation and excess water when grown conventionally. However, organic cotton farming needs less irrigation and thus conserves water. Organic Farming Discourages Algae Blooms. Algal blooms (HABs) result in adverse effects on the health of people and marine animals and organisms. Algal blooms also negatively affect recreation, tourism and thus, local and regional economies. While there is more than one cause of algal blooms, a

	primary human-based cause of algae blooms is runoff from the petroleum-based fertilizers often used in conventional farming.	
Challenges	Compliance to strict EU definition of organic farming and food.	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Orientgate	
Limitations	High costs, resistance of population, lack of supervising/implementation mechanisms, possible lack of market demand – due to product pricing.	
Implemented in	☒AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Italy – implemented but not fully funded Bavaria - Case study specific, but not legally implemented	
Implementation example	ÖPUL – Austrian Program for the promotion of an environmentally suitable, extensive and the natural habitat protecting agriculture explains necessary steps: • Consulting of farmers (focus on water and climate protection) • Promotion of regional marketing initiatives and organic farms • Biogas-eco-power plants (utilization of agricultural fertilizer)	
Comments	On 28 June 2017 the Maltese presidency and the European Parliament reached a preliminary agreement on an overhaul of the existing EU rules on organic production and labelling of organic products. The agreed regulation sets more modern and uniform rules across the EU with the aim of encouraging the sustainable development of organic production in the EU. The new rules also aim to guarantee fair competition for farmers and operators, prevent fraud and unfair practices and improve consumer confidence in organic products. Organic farmland has more than doubled in the last decade and each year 500 000 hectares of land are converted into organic production. However, the legislative framework has not kept up with such market expansion and still includes different practices and derogations. The new rules will: • make the life of organic farmers easier by enhancing legal clarity and allowing for further harmonization and simplification of production rules. A number of past exceptions and derogations will be phased out subject to relevant Commission reports. • increase consumer confidence by strengthening the control system. Preventive and precautionary measures have been clarified and made more robust (e.g. the roles and responsibilities of the different controlling bodies). The new regulation introduces checks on retailers and a risk-based approach to controls, thus reducing the administrative burden for operators in general and SMEs in particular. Specific controls on organic farming will be complemented by the recently introduced rules on official controls along the agri-food chain.	

■ Identified GAP provoking action	
GAP short name	**Inflexible time ban of fertilizers and manure application**
GAP short description	Period of restriction of fertilizers and manure application is defined with exact date and does not adjust to current weather.
■ Measure	
Name of measure	**Redefinition of time ban of fertilizers and manure application**
Type of land use regarded	Agriculture: grassland, arable land
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia
Description of the measure	The restriction period of mineral fertilizers containing nitrogen use is defined from 15th November till 1st March and prohibition of manure and slurry use from 15th November (manure: 1st December) to 15th of February (according to Nitrate Directive and *Decree on the protection of waters against pollution caused by nitrates from agricultural sources*). Vegetation activity depends on current weather conditions which are unstable and yearly changing. If vegetation is not active, the N-compounds pass through soil directly into the groundwater. Consequently the period of restrictions should be redefined according to the weather condition instead of calendar date. The Slovenian Environment Agency (meteorology section) monitors and predicts weather conditions should determine for each year date of fertilizing period. The storage of manure and slurry in the time of application restriction should be properly sealed to be safe from overflowing and consequently contamination of water sources. In order to spread environmental awareness among locals and local farmers, educational lectures should be frequently organized.
Measure advantages	Since some farmers must keep a fertilization plan (only those with fields within on DWPZ and those included in sustainable farming program), supervision over fertilizing has improved. Farmers receiving subsidies are obligated to attend trainings for pesticide use, personalized expert advice and lectures every 5 years. In the first DWPZ fertilizing is forbidden for: mineral fertilizers containing nitrogen, manure and slurry, ploughing of permanent grassland and irrigation with water containing plant nutrients. On the narrowest DWPZ (VVO-I) farmers get money compensations because of fertilizer application limitation and consequently smaller harvest.
Challenges	Farmers are not satisfied with the prohibition and would like to repeal it, therefore main challenge present farmers' approval of implementation of widening the restriction period. A frequent supervision of manure and slurry storages in the period of prohibition would present a better control of the nitrate directive implementation, according to which, the manure and slurry should not be stored longer than two months on the farming area and should be located every year on a different place. The main challenge is to implement integral management of agricultural

	activities within recharge area of drinking water source (and in general in water body), which means that farmers have to be linked up with each other and share manure with farmers needing it (farming and cattle breeding, etc.).	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from bad practice causing deterioration of groundwater quality. REFERENCE: *Nitrates directive* and Slovenian *Decree on the protection of waters against pollution caused by nitrates from agricultural sources*.	
Limitations	Expected limitations are lack of political will and resistance of local farmers - conflicts of land use vs water management, lack of supervising / implementation mechanisms.	
Implemented in	☐AT ☒BAV ☐CRO ☐HU ☒IT ☐POL ☒SLO Bavaria - redefined in the framework of the new drinking water ordinance, but not satisfying for farmers Slovenia – improvement is needed	
Implementation example		
Comments		

2.3. Urban areas

▪ Identified GAP provoking action	
GAP short name	**Pollution caused by inappropriate sludge management**
GAP short description	Sludge is one of the by-products of wastewater treatment plants. Authorities in Croatia have not yet tackled this issue in appropriate manner (which is also case in many EU countries), resulting in poor sludge management (both in planning and operation phase). For now, sludge is deposited on solid waste dumps, causing pollution of soil and water, enhanced by degraded air quality for surrounding population. This issue was brought to public attention when sludge of unknown characteristics (toxicity, chemical and physical characteristics) was deposited on several agricultural fields in northern Croatia.
▪ Measure	
Name of measure	**Effective sludge management**
Type of land use regarded	Predominately urban, but other land uses are also affected (namely agriculture, forest – wherever sludge is deposited)
Pilot action cluster (if relevant)	This measure can be considered relevant for all populated places, including pilot areas. Additionally, pilot areas in Croatia urgently need improvement in

	sewage and wastewater treatment plant infrastructure, hence sludge management is also concerned.	
Location	Croatia Every agglomeration with >2000 P.E (according to Croatia RBMP 2016-2021). Many agglomerations have not yet established UWWTP, which is one of key goals	
Description of the measure	Sludge should not be released into environment without treatment. Many options for sludge handling are available, such as landfilling, thermal reuse (incineration), reuse in production of materials, land application or biomass for power plants. The high organic content in the sludge will result in methane production during landfilling, which should be extracted and used for energy generation to avoid the release of potent greenhouse gases. Groundwater has to be protected from landfill leachate. For incineration, the water content of sludge has to be reduced significantly. It is probably not viable for each treatment plant to install a separate incineration facility, so sludge has to be transported safely to a central facility. Groundwater protection measures have to be applied to the incineration facility and storage of dewatered sludge should be handled accordingly. The reuse of sludge in construction materials is the safest option with regards to groundwater protection as contaminants are immobilised in the cement matrix. This reuse option should be considered in karst areas. If land application is envisaged, any plastics, sanitary items etc. should be disposed of separately during primary treatment and should not be included into biosolids. While pathogens can be largely eliminated through treatment, biosolids have accumulated all contaminants attached to particulates (like heavy metals and persistent organic contaminants) that are not significantly decreased during treatment. Therefore, sludge application in karst areas is prohibited in many European countries (BGR, 2011).	
Measure advantages	Principle is based on turning a potentially harmful substance into useful one. Therefore, main advantages include utilising the energy potential of sludge when it is economically possible; reducing the amount of harmful micro-organisms (also reducing unpleasant odour and potential contamination of soil and groundwaters); recovering phosphorous for agriculture (fertility improvement) and utilisation of sludge incineration products (ash) in construction industry (production of concrete and other building materials); production of biomass for energy plants.	
Challenges	Main challenge is high cost of sludge treatment. Processing and final deposition of the sludge is very expensive procedure, which can generate costs up to 50% of those required to construct and operate an urban wastewater treatment plants. This problem is enhanced by the fact that only 46% of population in Croatia has adequate sewage system and only 35% is connected to wastewater treatment plants. In order to improve sludge management, the latter issue must also be tackled. Principle which should be followed here states that establishing wastewater treatment facilities sooner rather than later is commonly less costly than doing nothing (BGR, 2011).	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Medium to long term
	Time interval of sustainability	Long term

Reference / source	Mogućnost zbrinjavanja mulja koji nastaje u procesu obrade otpadne vode u betonskoj industriji (article in Croatian) http://www.voda.hr/sites/default/files/pdf_clanka/hv_94_2015_277-286_vouk-et-al.pdf sludge2energy - Innovative Sludge Utilisation Concepts http://www.sludge2energy.de/index.html Project RESCUE – Recycling communal sludge for use in construction industry http://www.grad.hr/rescue/ Protection of Jeita Spring; German-Lebanese Technical Cooperation Project https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/abgeschlossen/TZ/Libanon/techn_rep_2.pdf?__blob=publicationFile&v=4 PURE - Project on urban reduction of eutrophication http://www.purebalticsea.eu/index.php/gpsm:good_practices
Limitations	Mainly high costs and long implementation time
Implemented in	☒AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☒SLO
Implementation example	See references
Comments	Sludge application (e.g. as fertilizer) is prohibited in karst areas and drinking water protection zones in Croatia – basically all areas south of Karlovac city.

▪ Identified GAP provoking action	
GAP short name	**Domestic gardens for small-scale cultivation within the drinking water protection areas**
GAP short description	In the case of rural or suburban settlements, the home gardens have significant territorial expansion. In a garden, fertilization, pesticide application and irrigation are used. Thus, the gardens could have significant impacts.
▪ Measure	
Name of measure	**Controlling cultivation - awareness of domestic and small gardens within the drinking water protection area**
Type of land use regarded	Municipal areas with rural or suburban structure where collection, treatment and disposal of waste water and waste is solved. The gardens are partly ornate gardens, kitchen gardens and orchard areas.
Pilot action cluster (if relevant)	Polluting effect of agricultural crop production at small gardens in municipal area. (PAC 2, PAC 3)
Location	Hungary Our example comes from Szentendre Island, where our practical experience is the most significant regarding bank-filtered groundwater resources of Budapest Waterworks.
Description of the measure	In case of ornamental or cognate plants or fruit trees, nutrient and water demand are important, as well as protection against pests and pathogens

	are required. According to the Government Decree 123/1997 (VII. 18), the regulations in force in Hungary the small-scale cultivation is prohibited on internal and external protection areas, while on hydrogeological protection areas "A" and "B" it could be permitted, depending on the results of an environmental impact assessment or an environmental review or a specific test with adequate content. Implementation of this cannot be expected from the owners of the gardens, also the large number of licensing procedures cannot be handled by the environmental authorities, and by the specialized authorities. In Hungary, the polluting effects were investigated, including the cultivation of small gardens and, if necessary, the possibility of reducing the impact during the development of the protection systems for drinking water resources. However, the legislative measures and the provisions on water protection systems have not been put into practice. Recently, on the Szentendre Island, the integrity grows, thus small-scale cultivation rate grows, with this the significance of their effects is also increasing. It will be increasingly important, that garden owners consciously cultivate their garden, from water protection, nature conservation and their own health protection point of view. The owners of the gardens are typically hobby gardeners who, in the hope of higher yields, use a significant amount of organic fertilizer and fertilizer. Their plant protection activity is also non-proper but luckily, the freely available vermicides that they can buy are not dangerous in terms of toxicity. In the gardens clearings are getting more and more habitual, especially total clearing and soil disinfection. These tendencies may cause significant soil erosion, meaning infiltration of f soil and groundwater through the soil into the aquifer. Stopping and reversing these processes requires intervention. This intervention cannot be legislative, because it is not possible to implement within such a fragmented and uncontrolled situation. Exceptions could be the local regulations by the local governments, which can help to regulate certain (plant protection) activities. The garden owner's attention should be attracted to the importance of their activities. With professional advice, adequate and effective nutrition, plant protection and the choice of suitable breeds can be promoted. It is necessary to encourage the cultivation of resistant varieties (ancient landscape varieties) whose plant protection needs are minimal. The propagation or distribution of these varieties, professional counselling could be carried out with the help of local governments and social organizations in the area, with the involvement or establishment of garden friendly associations. By supporting the users of drinking water, garden-friendly associations or municipalities can organize professional lectures for garden owners. In village celebrations and other community events, for owners of the small garden can be also incorporated professional programs. In addition to or in favour of beautiful gardens, the activity could be strengthened by introducing environmentally friendly gardens. In schools, environmental education could also provide students with environmentally friendly,

	animal-friendly, small-scale cultivation knowledge. The use of slow-moving fertilizers should be encouraged, or perhaps the organization of discounted fairs and study tours in the area.	
Measure advantages	Environmentally conscious small-scale farming encourages the public to be able to influence the environment and to change it. This kind of way of thinking is also incorporated into other areas of life. The environmentally-friendly cultivation of the gardens helps to keep the soils and groundwater clean, and increases the rate of near-natural plant associations and increases the living space of insects, birds and small mammals.	
Challenges	The modification of the current general horticulture and the way of thinking of the population about horticulture need to be changed. Compliance with regulatory requirements cannot be enforced nor controlled, but only on a voluntary basis. It is necessary to actively support the water utility or other professional organization, financial help, the professional commitment of local governments, the involvement of local social organizations or other relevant organizations.	
Relevance	Water protection functionality	Medium or High
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The protection measures of the bank-filtered groundwater resources in Szentendre Island include the main elements of the above.	
Limitations	Slow change in residential gardening practice	
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Discharge of rainwater from the inner road network into soil**
GAP short description	On the drinking water protection areas, the placement of rainfall collection systems of existing road network is carried out in the soil by scavenging in an uncovered rainwater collecting ditch. In the case of a new road or rainwater drainage system, a rigorous licensing procedure and annual control measurements shall be used to demonstrate the appropriateness of the solution. This is the case for all investment phases. Authorization is too complicated and fragmented, monitoring measurements are ineffective.
▪ Measure	
Name of measure	**Impact assessment and pollution prevention of rainwater from the inter-urban road network to groundwater**
Type of land use	Interior, road network, parking areas

regarded	
Pilot action cluster (if relevant)	
Location	Hungary Road network, which is in bank-filtered groundwater resources protection area, Szentendre and Csepel Szigeti water resource
Description of the measure	In the Government Decree 123/1997 (VII.18) regulating the protection of water resources, it is forbidden to use a system of watertight rainwater systems of the motorway in the inner protection area, while on external and "A" hydrogeological protection areas it may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. There is no restriction in hydrogeological protection zone "B". Other roads with waterproofed rainwater systems are not limited in the hydrogeological protection area "A" compared to the above. Other roads (with non-impermeable rainwater drains) are prohibited in the inner protection area, while on external and on "A" hydrogeological protection areas it may be permitted depending on the results of an environmental impact assessment or an environmental review or a specific test. There is no restriction in hydrogeological protection zone "B". It is also forbidden to build a car park within the protection area. In practice, the road network has been built up in the past with terrain ditch rainwater drainage. With the development of inner areas, the pavement and reconstruction of the unpaved roads is further developed. When a road is paved and rainwater drainage and discharge systems are installed, then the introduction of pollutants is archived into the geological medium (hydrocarbons that may be discharged from the road), which is a subject of an authorization under Regulation 219/2004 on the protection of groundwater. (VII.21.) of the Hungarian Government on the basis of the specified content and form requirements. Typically, a monitoring system should be used for this activity. Given that the investments are progressively implemented, each of them is individually, the license applications and their assessment are also individual. In the highlighted water resources protection areas, the features and effects are well-known, professionally the situation and the necessary specifications do not change within a region. If, in such cases, legislation could allow a simplified procedure based on the professional judgment of the licensing authority, it would greatly help to make the licensing process faster and simpler, making it cheaper. A common, combined monitoring system would be possible. The effectiveness of protection would not be reduced, but savings for small settlements are important. This provision affects only the new investments. The impact of the existing road network on the water resources can be detected from water quality inspections wells monitoring system operated by the water producer.
Measure advantages	The advantage of extending simplified procedures is faster administration, the lower cost for investor and maintainer, reducing the number of licensing and specialist authorities.

Challenges	It is necessary to change the legal regulations and practice so far and to review the situation of the environmental status of the given area.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Low (results savings)
	Duration of implementation	Medium term
	Time interval of sustainability	Long term
Reference / source	bank-filtered groundwater resources	
Limitations	Changing legislation and changing the course of licensing	
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☐IT ☐POL ☒SLO Slovenia – improvement is needed	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Not arranged road rainwater discharge**
GAP short description	Road rainwater discharge of roads in DWPZ is not led to the road rainwater colleting system and it is not treated.
▪ Measure	
Name of measure	**Collection and treatment of road rainwater discharge, particularly within drinking water protection areas**
Type of land use regarded	Urban area
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia
Description of the measure	Roads in the DWPZ should have arranged road rainwater discharge. In order to control and to collect rainwater which rinses sediments, waste and waste oil from the road, impermeable rain water drains along roads have to be arranged, with collection of rain water in storm water management pond (retention basins with variety of grasses, shrubs and/or wetland plants) for sedimentation of suspended material and for treatment of polluted water with oil-grit separators (OGS) or oil-sediment separators (OSS). However on motorways and main roads rainwater drainage and retention ponds with treatment are arranged but the infrastructure is not maintained.
Measure advantages	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. Furthermore

	road rainwater should not run through public sewage system.	
Challenges	Regulations are hard to change.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from bad practice. References: Slovenian legislation: Rules on road design. Decree on the emission of substances in the discharge of meteoric water from public roads. Decree on the emission of substances and heat when discharging waste water into waters and the public sewage system.	
Limitations	Expected limitation is a lack of political will to change regulation and/or municipalities to implement the measure in spatial plans.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☒SLO Croatia, Slovenia – improvement is needed	
Implementation example		
Comments		

2.4. Grassland

▪ Identified GAP provoking action	
GAP short name	**Pollution of watercourses**
GAP short description	Exposure of streams and rivers to lateral erosion or flooding
▪ Measure	
Name of measure	**Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding**
Type of land use regarded	Grassland
Pilot action cluster (if relevant)	Grassland, Mountain sites
Location	Poland Tatra Mountains
Description of the measure	The purpose of this best practice is to establish a new sward by sowing a low productivity grass mix containing at least four flowering species. The sward has to be established before beginning of June (in the first year) – sawing in spring or autumn. The wildflower mixture should be made up of autochthonous species. At least 15% of the mixture should be herbs and the rest grasses. Grazing animals are good at creating variety with their trampling, dunging and eating. Grazing should be at light to moderate levels to keep the sward at a range of heights and to allow some plants to flower. A way to create as diverse habitats as possible and to consider as many species as possible is „rotational grazing", which means a spatial and temporal change of grazed and un-grazed areas. Where no stock are available to graze, grassland should be cut (not before mid of August) to a height between five and ten centimetres.
Measure advantages	The benefit of this BP is the improvement of soil and water quality as well as biodiversity within arable fields which are prone to flooding and / or soil erosion. The grass area should be located within fields or areas at risk to help prevent soil erosion. For example: ▫ Particularly long uninterrupted slopes; ▫ field valleys, low corners or other areas which tend to concentrate run-off; ▫ light soils (with a relatively high sand or silt content) tend to be more prone to erosion particularly those with a low organic matter content; ▫ areas which drain directly to a watercourse will be of greater risk of transferring eroded soil to the watercourse;

<table>
<tr><td></td><td colspan="2">▫ areas with flooding risk (adjacent to watercourses).</td></tr>
<tr><td>Challenges</td><td colspan="2">Challenges associated with this measure can be seen on Austria's example in the so-called "Austrian Agrarian Environmental Programme" ÖPUL for environmentally friendly management of agrarian land provides a funding system for certain sustainable measures:
▫ Protection, restoration and conservation of biodiversity also in Natura 2000 sites, endangered or rural areas, land management with high nature value;
▫ enhancement of water management incl. manure management and pesticides;
▫ reduction of soil erosion, enhancement of soil management;
▫ reduction of emissions from agriculture (through site-appropriate cultivation, reduction of fertilisation, field-related fertilisation accounting in combination with soil samples, compulsory participation at trainings);
▫ promotion of carbon storage in agriculture and forestry;
▫ Nitrate Action Plan 2012: regulation of nitrate-fertiliser;
▫ promotion of buffer strips, especially along water courses to avoid erosion and pollution through nutrients;
▫ Groundwater 2020 (in Upper Austria): comprehensive protection of groundwater sources and the respective funding of sustainable land-use management measures.</td></tr>
<tr><td rowspan="4">Relevance</td><td>Water protection functionality</td><td>High</td></tr>
<tr><td>Cost of the measure</td><td>Medium</td></tr>
<tr><td>Duration of implementation</td><td>Long term</td></tr>
<tr><td>Time interval of sustainability</td><td>Long term</td></tr>
<tr><td>Reference / source</td><td colspan="2">Orientgate, ÖPUL</td></tr>
<tr><td>Limitations</td><td colspan="2">High costs, lack of political will, resistance of population,</td></tr>
<tr><td>Implemented in</td><td colspan="2">☐AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO</td></tr>
<tr><td>Implementation example</td><td colspan="2">Scottish Government Riaghaltas na h-Alba – Rural Payments and Services Scheme
The majority of support schemes available to UK farmers have their origins in the EU's Common Agricultural Policy (CAP). Structured in two parts, Pillar 1 and Pillar II, CAP 2014-2020 provides funding to support environmental, economic and rural development. The amount of CAP funds available from the EU was agreed within the Multi-annual Financial Framework (MFF) and for 2014-2020 is €387 billion. The funds are allocated to Member States, including the four UK devolved administrations, which have their own implementation models for delivering funding from both Pillar I and II. In some years, if the expected Pillar I budget is likely to exceed the available funds, the European Commission implements a mechanism called Financial Discipline. This effectively reduces the total value of Pillar I payments across all Member</td></tr>
</table>

	States. In 2016 this reduction was 1.35391%. The following sections provide an overview of the individual CAP schemes adopted in each UK administration. Relevant government websites should be viewed for more detailed information and up-to-date guidance. Note: Although the UK's referendum decision to leave the EU has created uncertainty over future CAP payments the UK Government has pledged to keep overall payments at the same level until 2022. Agri-Environment Climate Scheme - targeted support is available for land managers to undertake management and capital work that will deliver biodiversity benefits, manage water quality and flood risk, conversion and maintenance of organic farming and improve public access. Creation of Low-Input Grassland to Convert Arable Land at Risk of Erosion or Flooding (Scottish Government, 2015g) option and must be utilised in combination with: • Converting Arable at Risk of Erosion or Flooding to Low-input Grassland • Management of Floodplains • Wetland Management. This funding mechanism offers improved soil structure, water quality and attenuation of runoff but requires evidence that the conversion will provide this. The capital payment rate is £333.51/ ha.
Comments	

■ Identified GAP provoking action	
GAP short name	**Continuous conversion of (permanent) grasslands**
GAP short description	Political and socio-economic conditions fostering a continuous conversion of (permanent) grasslands to arable land, e.g. leading to a considerable increase of leached nitrate
■ Measure	
Name of measure	**Preservation of existing (permanent) grasslands**
Type of land use regarded	Grassland
Pilot action cluster (if relevant)	Plain areas
Location	Bavaria
Description of the measure	Grasslands represent ecologically valuable spaces in most water protection zones. Basically, grassland experience less intensive use as compared to arable lands, thus offer considerable water provision, purification and regulation functions.
Measure advantages	The enriched content of soil organic matter of the topsoil of permanent grassland favours the water storage capacity and the process of water purification. Generally, the activity of soil organisms is high and keeps the

	bioturbation on an adequate level (BAUCHHENß, 2005). Bioturbation positively affects the soil (aggregate) structure; it improves the connectivity of macropores and enhances the infiltration capacity (SCHEFFER et al., 2010). Additionally, the intensity of bioturbation positively correlates with the distribution of macropores which in turn is crucially important for the water provision and water regulation function of the soil system. Moreover, a dense turf on permanent grasslands provides a protection function against erosion processes, soil aggregate destabilization and evaporation losses. The turf decreases the susceptibility to surface sealing and lower the probability of breaching the infiltration capacity and the resulting Hortonian Overland Flow. Analogous to less surface sealing, enhanced vertical connectivity and increased losses through interception and evaporation, this measure can enhance the mitigation of floods in small catchment areas during convective storm events (DWA, 2015).	
Challenges	Farmers try to avoid the status of permanent grasslands due to a lower sales value and the ban on plowing. Thus, the implementation of ecologically valuable permanent grasslands is difficult since the economic value of arable land sites and permanent grasslands as well as the legal restrictions on both land use entities mostly are of top priority. A further challenge of preserving existing grasslands is the new definition of a permanent grassland introduced by the European Court of Justice in 2014, defining a permanent grassland as an *'agricultural land which is currently, and has been for five years or more, used to grow grass and other herbaceous forage, even though that land has been ploughed up and seeded with another variety of herbaceous forage other than that which was previously grown on it during that period'*. According to the stakeholders involved, this new definition further increases the spatial share of converted grasslands.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Short term
	Time interval of sustainability	Short term
Reference / source	Stadtwerke Freising (https://www.lfu.bayern.de/wasser/trinkwasserschutzgebiete/kooperation_mit_landwirten/doc/freising.doc)	
Limitations	Legislation mandating that land owners cannot return to arable land what has been classified as permanent grasslands (according to the new definition as mentioned above); Lower sales value of permanent grasslands Internal structures, e.g. focus on farmland and no livestock, making grasslands unprofitable	
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO	
Implementation example		
Comments		

2.5. Wetland

▪ Identified GAP provoking action	
GAP short name	**Pollution of watercourses**
GAP short description	Exposure of streams and rivers to lateral erosion, sediment infiltration and pollution (pesticides, fertilizers)
▪ Measure	
Name of measure	**Wetland restoration**
Type of land use regarded	Wetlands
Pilot action cluster (if relevant)	Plain areas: Wetland
Location	Poland
Description of the measure	Wetlands perform multiple essential functions including flood and erosion management, climate and water regulation. Wetlands induce wave and tidal energy dissipation and act as a sediment trap for materials, thus helping to build land seawards. The dense root mats of wetland vegetation also help to stabilise soil and sediments, thus reducing erosion. Wetland restoration means re-establishes these advantageous functions for the benefits of floods, erosion and water protection. Restoration of existing wetland ecosystems and their services is required as they have been increasingly degraded by both natural and human activities. Different kinds of techniques can be used to reintroduce wetlands in areas where they previously existed depending on the habitat type and the level of degradation. In terms of flood and water quality protection, the main benefit of wetland restoration is related with their function to act as "buffer zone", improving flooding and erosion protection by reducing incoming wave and tidal energy. In contrast to hard defences, wetlands are capable of undergoing 'autonomous' adaptation to increase sea levels, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005). In this way, coastal wetlands also provide a natural barrier to salt water intrusion into coastal aquifers, which can be maintained without additional investments. Restored wetlands also provide a number of additional ecosystem services including water quality and climate regulation, representing valuable accumulation sites for sediment, contaminants, carbon and nutrients coming from productive activities located upstream. Challenges of wetland restoration are minimal if compared with benefits provided.
Measure advantages	Restored wetlands improve water quality by reducing concentrations of targeted pollutants (nitrogen, phosphorus, sediment) in runoff or subsurface flows before they reach other surface waters. The basic biogeochemical processes involved in nutrient and sediment removal as well as mercury methylation. Nitrate removal or denitrification occurs mainly through plant uptake and microbial mediated processes. Nitrogen is an essential plant nutrient and some plants are able to absorb and use nitrate directly as a nitrogen source for their growth h, however denitrification is a more important process for nitrogen removal. Denitrification requires a retention time long

	enough to maximize nitrate removal, anoxic conditions (without oxygen) and enough organic carbon to support bacterial activity. Since denitrification is a biological process, it is also temperature-dependent (Kadlec and Knight 1996, Crumpton 2001). Phosphorus reduction and cycling in wetlands is a highly complex process. Initially, the restored wetland can intercept and retain a significant amount of phosphorus. However, as the wetland matures and reaches a saturation point (or as the water regime changes) the wetland begins to export phosphorus (Kadlec and Knight, 1996). Wetlands are more prone to phosphorus saturation when they are well connected to upstream drainage networks, especially a drained catchment area more than 5 times the size of the wetland basin. Once a wetland is saturated, phosphorus may pulse out of the wetland into downstream lakes and streams via the drainage network. During rainfall events and snowmelt periods, fine sediments are transported from land to rivers, streams, lakes, and wetlands via overland runoff and, to a lesser extent, via drainage systems. The sediment load is related to the hydraulic energy of overland or subsurface flows. High-energy flows also significantly increase streambank erosion, which increases sediment loads in streams. Properly designed wetland restorations can reduce the hydraulic energy of the water flowing through them and intercept sediments before they reach other waters. Mercury is a potent neurotoxin. Environmental exposure and damage from mercury is particularly problematic when the mercury is methylated. Mercury methylation is a complex biogeochemical change that occurs in wetlands. Methyl mercury (MeHg) is more toxic and bioavailable than elemental mercury (Hg). Mercury methylation is known to occur in inundated and saturated soil wetlands and, therefore, the production and release of methyl mercury (MeHg) due to wetland restorations has been suggested as a potential pollution concern. However wetlands can also effectively capture and remove mercury from downstream waters. The MPCA recently compared mercury cycling in three types of wetlands: natural wetlands, stormwater wetlands and wetlands that receive water from agricultural lands.All behaved similarly in terms of mercury removal and MeHg production. However, through-flow wetlands receiving extensive urban or agricultural drainage water had a higher percentage of MeHg to total Hg. This may be at least partly due to the residence time and drainage area. Other advantages include: • Improved surface and ground water quality by collecting and filtering sediment, nutrients and pesticides in runoff; • Reduce soil erosion and downstream floods by slowing overland flow and storing runoff water; • Wetland plants utilize trapped nutrients, restore soil organic matter and promote carbon sequestration; • Provide food, shelter and habitat for many species and enable the recovery of rare or threatened plant communities; • May significantly reduce sea water intrusion into coastal aquifers; • Improve groundwater supply recharge by slowly releasing water into the ground;

<table>
<tr><td></td><td colspan="2">• Provide recreational and aesthetical functions.</td></tr>
<tr><td>Challenges</td><td colspan="2">• Require large surface to be implemented which is likely to create conflicts with alternative land uses (i.e. agriculture, forestry);
• Require a degree of expertise, especially in locations where wetland re-colonisation has to be encouraged by transplanting wetland plants.</td></tr>
<tr><td rowspan="4">Relevance</td><td>Water protection functionality</td><td>Medium</td></tr>
<tr><td>Cost of the measure</td><td>Low</td></tr>
<tr><td>Duration of implementation</td><td>Long term</td></tr>
<tr><td>Time interval of sustainability</td><td>Long term</td></tr>
<tr><td>Reference / source</td><td colspan="2">OrientGate Project</td></tr>
<tr><td>Limitations</td><td colspan="2">The restoration of wetlands is often associated with potentially conflicting issues such as the demands of food production against the requirement to enhance biodiversity. Embedded in these issues is the limiting factor of how wetland restoration will be financed. In some EU member states the restoration of wetlands or actions for their conservation are considered agri-environmental measures which are eligible for financial support within rural development plans. The criteria to access state financing for wetland restoration in the agricultural landscape are mainly based on the delivery of positive impacts on biodiversity or nutrient retention. However, in most cases agricultural landowners have to prioritise production to ensure economic viability, and often it is incumbent on the landowner to take the final decision regarding initiating a restoration project. Consequently, there is a strong need to find new ways of engaging landowners and other key stakeholders in wetland restoration. In this respect, the promotion of multi-functional wetlands may be a promising way forward (Andersson, 2012). From a farming perspective, the appealing wetland services include the provision of irrigation water and hunting and fishing opportunities, offering recreational benefits with an economic return. From a societal perspective, the flood buffering capacity of wetlands may be valuable (Jenkins et al. 2010). To achieve flood risk protection, it is necessary to consider the implementation of a broad range of wetland systems such as wet grasslands and larger wetlands with permanent water, preferably developed at a catchment level (Mitsch & Gosselink, 2000). Applying a catchment approach supports more coordinated actions and facilitates large-scale impact modelling and monitoring. Schemes that deliver payments for ecosystem services (PES) represent potential instruments to create new financial arrangements to support wetland restoration and conservation. For instance, landowners who convert drained cropland into wet grasslands facilitating seasonal flooding can be financially rewarded for providing a flood risk reduction service. Under such initiatives the role of farmers is rebalanced from primarily producing food to delivering a broader suite of ecosystem services. This has the potential for new actors to be engaged in wetland restoration. …</td></tr>
<tr><td>Implemented in</td><td colspan="2">☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO</td></tr>
<tr><td>Implementation example</td><td colspan="2">Hortobagy National Park Directorate
The project aimed at expanding a 4 ha lake into a 9 ha habitat to ensure the survival of fish living in the marsh during winter. Meanwhile, wetland restoration has already been completed in the 10 ha Fekete-rét area. The</td></tr>
</table>

	overall ecological restoration plan has paved the way for larger overnighting sites for transiting water birds. In addition, existing infrastructures have been improved – these include an educational nature trail to boost ecotourism. The trail presents the area's development and the education activities of the National Park's Directorate. The park's observation tower has also been revamped and orientation signs have been installed.
Comments	

▪ **Identified GAP provoking action**	
GAP short name	**Flood risk reduction, Erosion / sediment control**
GAP short description	Exposure of streams and rivers to lateral erosion, sediment infiltration, mitigation of possible flood and drought scenarios.
▪ **Measure**	
Name of measure	**Preservation and revitalization of wetlands on floodplains**
Type of land use regarded	Floodplain restoration can be applied on any type of land use, as long as a (current or former) natural floodplain is present. If artificial areas (urban, industrial) are located on the floodplain though, the associated cost for the measure's implementation is likely to be higher, due to land acquisition costs and to the high land anthropization. These costs will also be important for agricultural areas.
Pilot action cluster (if relevant)	Plain areas: Wetland
Location	Poland Any large floodplain
Description of the measure	Floodplains are areas immediately adjacent to the stream and are periodically inundated with water. They present a vital part of the river ecosystem. The main function of these areas is carrying excess water in time of flood events and consequently reducing the flood water's potential energy. Besides, the functions of these areas are improving water quality, reducing runoff and erosion, providing an environment for a diversity of plant and animal life and helping to sustain base flow of adjacent streams and rivers during drought conditions. Floodplains are also important regulators of the movement of energy and materials through the catchment area towards the river and water flowing from surrounding hills and across the floodplain. Wetlands are often located within floodplains and provide important functions within the context of water quality and quantity. They work as natural water treatment areas, removing pollutants from inland river waters, maintain sufficient quantity of water during the whole year and represent one of the most productive and biologically diverse ecosystems, providing the essential breeding and feeding habitats for many species of water birds, fish, invertebrates and plants. The preservation or revitalization of those wetlands encompasses all measures necessary for this purpose.

Measure advantages	The preservation of wetlands in floodplains is of crucial importance for both the protection of drinking water resources and for the protection against floods. Only if the wetland areas are in natural or close-to-nature conditions, their ecosystem services can be rated as functional for water protection. Ecosystem services benefits include: • Water storage - Floodplain restoration aiming at promoting actions against soil impermeability and increasing buffers and storage areas will help the floodplain in ensuring its natural storage role. • Fish stocks and recruiting and natural biomass production - By promoting natural functioning of the aquatic ecosystem and of immediate and remote environments, floodplain restoration measures will have a positive impact on water quality, vegetation population, temperatures and habitat conditions. This will naturally be followed by a recovery of the aquatic ecosystem, and thus an increase in fish populations, a greater biodiversity and a higher natural biomass production. • Biodiversity preservation - the restoration site could be planted with native grasses, shrubs, and trees. This is the first step to develop biodiversity. Environment resilience could be very important especially when the original seed bank, which has been covered by legacy sediment, is once again near the surface, and the dormant seeds begin to germinate and grow. So native flowering plants that have not been planted could appear. Creating a more natural stream channel and floodplain should also be accompanied by the immediate removal of invasive species on the site. The post-construction planting of native vegetation along the stream corridor discourages the re-establishment of invasive, non-native vegetation. Leaf litter from riparian woody plants also provides a source of food for macroinvertebrate life in the stream. • Climate change adaptation and mitigation - Large floodplain restoration could have an impact on climate change through CO2 storage linked especially to afforestation. • Groundwater / aquifer recharge - Measures for floodplain restoration can have low to high impact on groundwater recharge. In particular, wetland restoration enhances high aquifer recharge due to high water connection between surface flows and groundwater. Revegetation measures can also more or less favour groundwater recharge, as they enhance water infiltration in soils. • Flood risk reduction - By allowing the stream naturally functioning, with controlled flooding, floodplain restoration measures reduce the risk of flooding damages. Buffer zones and storage infrastructures slow the water transfer time between the floodplain and the river, thereby spreading the flow and thus decreasing the flood intensity. Remark: For a high positive impact, floodplain restoration measures should be accompanying by management measures, corresponding to the full range of codes, ordinances and other regulations adopted for minimizing flood damage, including zoning codes, building codes and subdivision regulations that may either prohibit construction in flood-prone areas or allow some construction under certain conditions.

	Floodplain regulations also may be enacted to prevent consumer fraud by requiring disclosure of possible flood hazards. • Erosion / sediment control - Land use and cover on riverbanks are closely linked to the river capacity for erosion and sediment control, by protecting soils, regulating flows and protecting the most vulnerable areas of erosion as the banks (increasing their cohesiveness). By reducing flood intensity, floodplain restoration decreases streambed and banks erosion during extreme events. River morphology may change as the water and sediment discharge conditions change. Restoring a balance between erosion and sedimentation conditions will help in recovering adequate hydrologic functioning and hydromorphologic conditions. • Filtration of pollutants - Herbaceous plants in the wetland pockets help in reducing nutrients through nitrogen and phosphorus trapping. Riparian vegetation also provides a pollutant filtration action.
Challenges	Wetlands as one of the most complex ecosystems of paramount importance due to their biodiversity and role in water regime, are also most threatened ones. Around 50% of world's wetlands have disappeared in the last century. In Europe they are among most endangered landscapes due to land reclamation, drainage, pollution and overexploitation of its resources. According to the European Commission, it is estimated that two thirds of Europe's wetlands have disappeared since the beginning of the 20th Century, mainly lost through development processes which did not take their functions and values adequately into account. Overall, drainage and conversion to farm land alone have reduced the wetland area in Europe by some 60%. Despite recognized significance and considerable interest in their global protection, comprehensive overview of the remaining wetlands without appropriate protective status is still lacking. Numerous wetlands proclaimed as Ramsar sites are surrounded with agricultural land, making them vulnerable to farming practices. Throughout Europe roads and railway generate proximity problems and hence pressure on these habitats. Furthermore, wetlands hydrological function and regime can be degraded by activities such as improper forestation, water regulation (changing of river flow and channelization), over-exploitation of groundwater resources etc. Therefore, spatial planning along with river basin management planning must consider objectives for conservation of these types of habitats. For example in Austria, floodplain wetlands were under threat during the last half of the 20th century, when various hydro-electric power plants were constructed at the main rivers like Danube or Mur. In 1984 protests allowed the creation of the "Donau-Auen National Park" (Danube Floodplain National Park), that now protects the hugest floodplain area and forest in Europe and also the wetlands within. From this huge floodplain area, the City of Vienna also derives drinking water for the supply in critical situations (drought periods or other challenging situations). The share of floodplain wetlands is actually very low in comparison to the times prior to human settlements (pre-Neolithic phase). At those times the wetlands in the floodplains were a hindrance for human settlements (marshes and malaria) now the last floodplain wetlands have to be protected for the purposes of water protection. A floodplain is the area bordering a river that naturally provides space for the

<table>
<tr><td></td><td colspan="2">retention of flood and rainwater. Floodplain soils are generally very fertile and they have often been dried-out to be used as agricultural land. Floodplains in many places have also been separated from the river by dikes, berms or other structures designed to control the flow of the river. They have also been covered by legacy sediments.

Major floodplains roles have thus been lost, due to land drainage, intensive urbanization and river channelization. The objective is to restore them, their retention capacity and ecosystem functions, by reconnecting them to the river.

Restoring the floodplain roles requires measures such as:

- modification of the channel,

- removing of the legacy sediment,

- creation of lakes or ponds in the floodplain,

- new/modification of agricultural practices,

- afforestation,

- plantation of native grasses, shrubs and trees,

- creation of grassy basins and swales,

- wetland creation,

- invasive species removal,

- riparian buffer installation and development.</td></tr>
<tr><td rowspan="4">Relevance</td><td>Water protection functionality</td><td>High</td></tr>
<tr><td>Cost of the measure</td><td>Medium</td></tr>
<tr><td>Duration of implementation</td><td>Long term</td></tr>
<tr><td>Time interval of sustainability</td><td>Long term</td></tr>
<tr><td>Reference / source</td><td colspan="2">Orientgate</td></tr>
<tr><td>Limitations</td><td colspan="2">High costs, lack of political will, resistance of population</td></tr>
<tr><td>Implemented in</td><td colspan="2">☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO</td></tr>
<tr><td>Implementation example</td><td colspan="2">Room for the Waal project, Netherlands

The Nijmegen Room for the Waal project is one of the largest and most awe-inspiring of the projects being realised within the framework of Rijkswaterstaat’s national Room for the River flood risk management programme. By widening the river, the risk of Nijmegen and the surrounding upriver area becoming flooded, today or in the future, has been considerably reduced.

The Waal takes a sharp bend near Nijmegen and becomes narrower, forming a bottleneck. At times of high water, the river could not cope with the volume of water. To protect residents from flooding, the dyke has been moved 300 metres inland and a 4-kilometre-long secondary channel has been dug. This has created an island in the centre of the city. Three new bridges connect the island to Nijmegen-Noord. The work commenced in January 2013. Fifty households had to be relocated as a result of the flood risk management</td></tr>
</table>

	measures. River Waal now has more room around Nijmegen. As a result, the water level of the river has dropped by 34 centimetres. A unique urban river park has been created in Nijmegen: the Spiegelwaal and the Veur Lent island are part of a plan in which flood risk management and urban quality go hand in hand. In the 1995 flooding, Nijmegen residents were up to their neck in water. Now, the Waal can cope with a similar volume of water with no problem at all. Nijmegen is prepared for future high water levels caused by climate change.' River park The flood risk management measures have been carried out in a manner that ensures they can add value to the city in other ways. The new area has become a place where there is room for living, nature, recreation, education, hospitality venues, and small-scale events. A new quay forms the beating heart of the river park. Facts and figures: • Project area: 250 hectares • State budget: 358 million euros • Earthwork: 5.2 million cubic metres • 50 houses/business buildings demolished • 34 cm drop in the water level of the Waal • Special components of the Room for the Waal project: • Secondary channel: 4 kilometres long, 200 metres wide, 8 metres deep measured in respect of the ground level of the flood plain, 14 metres deep measured in respect of the height of the quay and the dyke • Waterproof cut-off wall to prevent the seepage situation in Lent from worsening, 1.6 km long, 20 metres deep, 80 cm wide • Unique island in the Waal with potential as an urban river park in the centre of Nijmegen with room for living, recreation, nature and culture • Existing railway bridge columns: a reinforcing wall around the three columns of the Spoorbrug (railway bridge dating from 1880); 23 metres deep and 1.5 metres wide • New dyke as well as a new quay of 1.2 kilometres in length • Three new bridges for access to and from the Veur Lent island • Archaeological and cultural-historical activities in the oldest city of the Netherlands with traces from Roman times, the Middle Ages, the Renaissance and World War II
Comments	

2.6. General

This chapter deals with gaps/measures which are related either to multiple types of land use (and therefore could not be fitted into specific land use type), general topics or combination.

Identified GAP provoking action		
GAP short name	**Public engagement in development of action plans**	
GAP short description	Little involvement of local (public) communities in the development of site-specific actions implemented in protection plans	
Measure		
Name of measure	**Implementation of site-specific solutions**	
Type of land use regarded	Mostly agriculture	
Pilot action cluster (if relevant)	All areas	
Location	Bavaria	
Description of the measure	Public engagement should take place already at early steps of the decision process. The development of action plans for the implementation of protection plans should be carried out in close cooperation with land owners that are directly affected by future regulations in the delineated protection zones. Possible actions and measures should be elaborated based on land owner's possibilities to use existing structures/facilities/machinery. Thus, site-specific solutions can be found which can reduce the trade-offs between decision makers and land owners.	
Measure advantages	Engaging local stakeholders and affected land owners in the process of finding adequate, site-specific solutions can increase the acceptance of the finally proposed measures and potentially decrease the costs for compensation measures. Due to their daily business, land owners know best about potentials of how to restructure or manage their field operations. Moreover, the proposed measure can significantly reduce the existing mistrust between authorities and land owners.	
Challenges	Little involvement generally leads to lower acceptance of planned measures that could be decreased if site specific actions would be planned in cooperation with the affected land users. In this context, the stakeholders noticed that when their interests are affected by the implementation of a measure, then local stakeholders show a higher acceptance than those who just operate their business in the respective region (and live somewhere else). Local stakeholders feel more the problematic issues about planned measures and recognize the advantage of a solution, while stakeholders which are not so much connected to the territory do not feel the related danger/problem.	
Relevance	Water protection functionality	High - difficult to quantify
	Cost of the measure	Low
	Duration of implementation	Short term
	Time interval of sustainability	Long term - if acceptance is high then

		the measure will last in time
Reference / source	Stakeholder interviews, Online stakeholder survey	
Limitations	Existing policies, intending public engagement once a plan and measures have been elaborated; Existing mistrust between decision makers, water suppliers and land owners and thus resulting hardened fronts and difficult discussions between the relevant stakeholders;	
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example		
Comments		

■ Identified GAP provoking action	
GAP short name	**Saltwater intrusions in coastal areas**
GAP short description	Saltwater intrusions can happen due to either natural processes or human activities. Increasing water demand (agriculture, households, increase of tourism activities) during summer months is causing saltwater intrusions into coastal aquifers. This problem is additionally enhanced by climate change, mainly due to decreased rainfall, when aquifer water intake is lower, allowing sea water to penetrate into it. This presents direct impact on available freshwater resources and could result in water shortage, endangering local population. Endangered aquifers can be seen in **Fig 2.**
■ Measure	
Name of measure	**Prevention of saltwater intrusions**
Type of land use regarded	Any
Pilot action cluster (if relevant)	PAC2: South Dalmatia
Location	Croatia Coastal areas
Description of the measure	Scientific monitoring and assessment provide basic characterization of the groundwater resources of an area, providing an understanding of the different pathways by which saltwater may intrude an aquifer, and a basis for sustainable management of water supplies. Main indicative parameters are chloride concentrations and electrical conductivity. Some common approaches for monitoring, often used in combination are: measuring groundwater levels and hydrograph analysis; water quality sampling; and, geophysical logging. Water-quality monitoring networks are particularly important to serve as early-warning systems of saltwater movement toward freshwater supply wells, as well as providing information on the rates of saltwater encroachment.

	Furthermore, early warning system could be useful for water suppliers and distributers as they could adjust the extraction quantities and provide immediate response in case of saltwater intrusion. This is particularly important for dry summer periods, as the water demand for population (including tourism) and agriculture is on the rise, causing imbalance between extraction and aquifer recharge. Other successful mitigation methods include deep recharge wells, barrier wells, aquifer research (potentiometric surface mapping, plotting of water levels, climate change modelling). Another successful method include maintenance of coastal wetlands - which can provide natural barrier to saltwater intrusions as they are capable of undergoing "autonomous" adaptation to increase sea levels, through increased accumulation of sediments to allow the elevation of the wetland to keep pace with changes in sea level (Nicholls & Klein, 2005) - in contrast to hard defences.	
Measure advantages	Main advantage of this measure is protection of freshwater resources (groundwater) in vulnerable coastal areas – such as Dalmatia.	
Challenges	Effects of climate change (sea level rise, decreased rainfall, increased drought periods) are not fully taken into consideration while making long term strategies and plans. Also, socio-economic aspects also should be addressed in more appropriate manner – such as increase of population and tourism activities and increase of agricultural water demand. Additional problem is relatively high costs of "hard" mitigation infrastructure and monitoring network, supplemented by medium to long term implementation periods and long periods of investigation and research.	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Medium to long term
	Time interval of sustainability	Long term
Reference / source	Best Practices for Prevention of Saltwater Intrusion https://www2.gov.bc.ca/assets/gov/environment/air-land-water/water/water-wells/saltwaterintrusion_factsheet_flnro_web.pdf USGS Seawater Intrusion https://ca.water.usgs.gov/sustainable-groundwater-management/seawater-intrusion-california.html Schlumberger Coastal Zone Aquifer Management Solutions http://www.slb.com/services/additional/water/resources/coastalzone.aspx	
Limitations	Relatively high costs, lack of awareness, climate change effects are not taken seriously, lack of adaptation strategies for vulnerable areas	
Implemented in	☐AT ☐BAV ☒CRO ☐HU ☐IT ☐POL ☐SLO Croatia – in the pilot action South Dalmatia, there was a successful salinity prevention project that constructed a submerged step that prevents salt water intrusion into the Baćina lakes.	
Implementation	World examples: California, British Columbia, China	

example	
Comments	 **Figure 2.** Endangered aquifers due to saltwater intrusions in Croatia (University of Zagreb, Department of Geotechnics; 2009)

▪ Identified GAP provoking action	
GAP short name	**Pressure on water resources quantity**
GAP short description	Climate change in form of droughts, floods, shorter winter season with reduced snow cover, in general change of the timing of seasonal events etc., will drastically affect freshwater resources. Water scarcity could not only lead to serious economic losses but also have severe impact on the environment, agriculture and food production and consequently human welfare. This problem is enhanced by high losses in water supply in Croatia – 42% national average, while some networks in Dalmatia have up to 80% losses.
▪ Measure	
Name of measure	**Climate change adaptation and resilience**
Type of land use regarded	All
Pilot action cluster (if relevant)	PAC2: South Dalmatia
Location	Croatia CC mitigation measures are necessary for all areas, especially those with

	prominent dry periods (e.g. South Dalmatia, where summer season is very dry with low amount of precipitation).	
Description of the measure	Croatia has recently developed drafts for CC Adaptation Strategy 2040-2070 and Action Plan 2019-2023 which serve as a basis for future mitigation action against CC. Roughly speaking, measures be divided into 2 categories (Rubinić, 2017): • Initial measure – to minimize the presence of negative anthropogenic pressures • Administrative measures: rationalization of water consumption and water re-use wherever possible; promoting alternative sources of water; spatial planning measures for mitigation of flood effects in flood prone areas; monitoring and modelling projections; improvements in legal regulations • Structural measures: reduction of losses from water supply network; construction and revitalization of accumulation structures; construction of thresholds in the basin to stabilize the water level in river/lake bed and the surrounding aquifer; construction of retention objects in flood prone areas; control of surface runoff in urban environment (construction of separate systems for meteoric water and sewage); construction of green retention and infiltration zones, green roofs, urban retention and accumulation	
Measure advantages	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.	
Challenges	Raising awareness on the climate change and adaptive management practices among relevant stakeholders Financial support in form of subsidies for adaptation	
Relevance	Water protection functionality	High
	Cost of the measure	High
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Drinkadria - http://www.drinkadria.eu/ CC Waters - http://www.ccwaters.eu/ Ministry of Environment and Energy project - http://prilagodba-klimi.hr/	
Limitations	Lack of funds, long implementation periods, low awareness of key stakeholders	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – in the process of implementation	
Implementation example		
Comments		

Identified GAP provoking action	
GAP short name	**Community use of inner and outer zone of groundwater protection area**
GAP short description	Bank-filtered groundwater resources along the Danube can be found within the most beautiful areas, so there is the need for utilization of this area as bike roads, and boat harbours. This question has more importance on the area of groundwater reserves of Szentendre-island, where the wellheads occur along the complete river bank. Accordingly the appropriate legal act, in inner groundwater protection zone these types of activities are not allowed, and in case of utilization of inner districts, it is impossible to ensure the integrity of inner protection zones.
Measure	
Name of measure	**Community use of partitioned groundwater in inner and outer protection zones**
Type of land use regarded	River banks, outer settlement districts
Pilot action cluster (if relevant)	
Location	Hungary All partitioned groundwater reserves, for example Szentendre Island
Description of the measure	The wellheads are along the complete river bank on Szentendre Island. They are in the operation of Budapest Waterworks in the inner and almost in the whole outer protection zone, so these are guarded and isolated areas. Local inhabitants and those who are looking for recreation may reach the river banks on very short sections. The operational roads of the Waterworks are running along on both sides of the island and they reach at some points the inner protection zones of the wellheads. Considering the number of the wellheads and their different size of protection zones, they are not isolated with fence but only with bush hedges. It is not possible to move away the road or isolate the inner protection zone by fence. Although there is a high need for opening or some parts of the areas of the Waterworks. Bike roads, touristic paths and boat harbours are rising from time to time as development directions. The wells are technically secured and the possibility of surface water intakes is minimal even in case of flooding, the superstructures can be locked and an alarm system is in operation. With appropriate technical protection, a specific regulation would be able to resolve the requirement for the internal protection area of the bank-filtered wells. Even so because in Margaret Island and on other banks of Budapest there are also bank filtered water wells with qualitatively good water, but there is no space for protection area. There is a park, a playground around the wells, as well as a road stretching across the wells protection area. In practice, therefore, it has been shown that community use does not necessarily endanger the water quality of wells. Certainly it is necessary to set up adequate rest areas, waste collection and removal, mobile toilet use. Treatment should be performed by an organization.

	Supervision of the usage is required on a regular and frequent way throughout the entire coast. Auditors are required to have appropriate knowledge to act effectively against the perpetrators.	
Measure advantages	It would meet a long-standing and growing social need.	
Challenges	Legislative modification is required. The design and operation of the open and freely used waterworks area - internal and external protection area - is more complicated and costly than the current system.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Medium (results savings)
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Bank-filtered groundwater resources	
Limitations	Legislative amendment, taking care of the operator's tasks and costs	
Implemented in	☐AT ☐BAV ☒CRO ☒HU ☐IT ☐POL ☐SLO Croatia – various land uses exist within DWPZ and there are specific ordinances that prescribe restrictions for the specific land-use types, additionally the first DWPZ is fenced	
Implementation example		
Comments		

■ Identified GAP provoking action	
GAP short name	**Design of infrastructure under steady-state weather conditions**
GAP short description	Not accounting for potential effects of climate change (CC) for design of new infrastructures could strongly affect their performances and safeguarding
■ Measure	
Name of measure	**Adaptation of building standards for design, maintenance and operation of infrastructures**
Type of land use regarded	All, according the type of infrastructure of interest
Pilot action cluster (if relevant)	All
Location	Italy Example: urban drainage systems generally more vulnerable to pluvial flooding as designed using IDF curves not accounting for CC
Description of the measure	Buildings and infrastructures designed for coping with the effects of flooding events (e.g. riverbanks) or potentially affected by such events (e.g. urban drainage systems) are currently built assuming steady-state weather

	conditions. Under the effect of climate change, such assumption could err not on safe side inducing an improper design and realization; for these reasons, the findings made available by climate projections should be explicitly considered for the definition of reference "design events" (e.g. storms). In this perspective, in last years, several literature approaches have been proposed and, in some cases, transposed also through "qualitative methods" in regulations, guidelines and design of key critical infrastructures. Moreover, it should be integrated in building regulations.	
Measure advantages	The measure is aimed to: - increase the resilience of infrastructures (in special way, newly built); - attempt to enhance coherence between climate change adaptation (CCA) and disaster risk reduction (DRR) approaches and tools; - reduce the costs associated to failure or outages of infrastructures	
Challenges	Climate projections are currently characterized by significant uncertainties. As well known, they are due to natural variability of weather conditions, limited knowledge about future socio-economic development and/or technological progress and current constraints in modelling. In order to manage such uncertainties are often adopted ensemble of climate simulations; adequate procedures and relevant expertise are then required to properly handle with such results; nevertheless, constraints and limitations associated to adoption of expeditious approaches should be made clear to practitioners. Moreover, the significant and constant improvements in climate modelling should periodically entail the update of adopted design values.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Short term
	Time interval of sustainability	Long term
Reference / source	Climate-ADAPT platform; coordination unit of Italian Government "Italia Sicura"	
Limitations	Up to now, current uncertainties associated to climate projections prevented accounting for potential effects of climate change for design of new infrastructure; in this regard, only in some areas, policymakers and administrators have properly evaluated the threats represented by them; nevertheless, potential current higher costs against potential future profits often limit the appealing of such approaches.	
Implemented in	☒AT ☒BAV ☐CRO ☐HU ☐IT ☐POL ☐SLO	
Implementation example	Two examples of implementation for the proposed measure are retrieved by Climate-ADAPT platform; they relate to design of metro in Copenhagen and "Adaptation of French standards for design, maintenance and operation of transport infrastructures". In the first case, in attempting to take into account the potential effects of climate change on storm surges and heavy rainfall events, "the elevation level of critical elements of the Copenhagen metro stations (entrance, stairs, tunnel ventilation, ramps, technique room, shaft, elevator, and control and maintenance centre) increased from approximately 2.25 m on the existing metro to approximately 2.50 m on the City ring, which is currently under construction, considering the various IPCC projections	

	available and their evolution in time". Moreover, several precautions have been implemented to deal with potential future events characterized by intensities and durations higher than the current ones. In the second case, a deep interdisciplinary study has been carried out in order to detect standards and regulations requiring an update to take into account climate change and to provide ways to adequately consider them.
Comments	The coordination unit established by Italian Government "Italia Sicura" proposed a comprehensive set of guidelines for programming activities and intervention planning against geological, hydrological and hydraulic risk (http://italiasicura.governo.it/site/home/dissesto/linee-guida.html; in Italian); among these ones, "Linea 11" proposes "Considerations about the resilience of the intervention, including climate change scenarios" in which accounting for climate projections in design of infrastructures also through qualitative approaches is explicitly reported.

▪ Identified GAP provoking action	
GAP short name	**Pressure on water resources management**
GAP short description	Qualitative and quantitative over exploitation of water system and unbalanced exploitation rate between surface and ground water bodies
▪ Measure	
Name of measure	**Integrated Water Management for implementing efficient voluntary agreements**
Type of land use regarded	Agriculture, industry, urban areas
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin (P-RB)
Description of the measure	The P-RB is rich in water resources, but the increase of water consumption and climate change are affecting them. Especially during drought events, the conflicts among the users reach an extreme level, and as pointed out in D.T2.1.2, only on a river basin level the optimal area for soil, subsoil and water protection actions can overcome institutional fragmentation and competences through unitary plans; besides an Authority with decision-making power able to manage water crisis conditions.
Measure advantages	Overcoming of actual weaknesses of voluntary agreements connected with the lack of implementation, implementation efficacy, and efficacy indicators of implemented measures foreseen in norms and plans. Establishment of a permanent network of "Observatories on water uses" among all public and private stakeholders of national relevance included in Po river basin. Transferring and tailoring experiences and practices to the P-RB suggested and currently implemented with valuable results in other countries, coping with

	water scarcity shortage and crisis.	
Challenges	Practicable, measurable and effective overcoming of institutional fragmentation through an Authority with more decision-making power and more structured decision processes based on flow charts. Business continuity guarantee to maintain the operational system on water resources management (DEWS-Po) in Po river basin to support planning and integrated management processes. Integrated Water Resources Management supports Institutional change. Following a widely shared approach to transform good BMP in regulation and legislation norms (i.e. ERA directive)	
Relevance	Water protection functionality	Medium
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	WFD 2000/60/CE, Enhance FP7 project, Italian D. Lgs. 152/2006, Po river basin Water Balance Plan	
Limitations	Factors to consider are: lack of implementation of political will, scarce awareness of population, conflicts of land use vs water management vs flood management, lack of supervising/implementation mechanisms	
Implemented in	☐AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – prevention measures are a part of the existing legislation, but it is not implemented	
Implementation example	Documentation from National Committee of River basin Authorities Directors and from the Italian Operational Hydrology Group. International comparison among Sava River, Israeli and Australia taking into account difficulties of implementation and instruments to overcome them. Hydrological monitoring and modelling, water data sharing, capacity building, education and training of stakeholders and general public.	
Comments	-	

▪ Identified GAP provoking action	
GAP short name	**Soil degradation and consumption**
GAP short description	Qualitative and quantitative over exploitation of soils, soil consumption, loss of soil biodiversity and lack of legislation for soil planning produces negative impacts on water cycle.
▪ Measure	
Name of measure	**Evaluating effects of Soil Protection Plans on water bodies**
Type of land use regarded	Agriculture, urban areas, industrial areas, transport networks

Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)	
Location	Italy Po river basin	
Description of the measure	Soil, land use solid waste planning, including contaminated sites, contributes to overcome the actual reductionist implementation of WFD.	
Measure advantages	Water quality and quantity aspects, including ecosystem services, are strongly affected by uncontrolled and excessive land use and soil exploitation in Po river basin. Without a wise governance of this issue, all water policies, actions and measures may be less effective; moreover fixed environmental targets on water bodies can be reached with more costs acting only on water aspects, disregarding soil management. The transition to a green and circular economy supported by institutions, organization and private sector will strongly affect soil and land use management inducing a better use of water and reducing water ecosystem stressors.	
Challenges	Upgrade of European and National policies taking into account soil management and planning into water management plan and measures. Acting on the coupled land use and water use can improve social and economic resilience including water scarcity and flood events. Supporting crosscut policies and leverage of different lobbies. Reducing ecosystems fragmentation and loss of connectivity. Fostering the ability of ecosystems to provide services among which natural health capital increases and water resources are more available. Reducing the conflicts of interests between land use management and water protection.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	European Environmental Action Programme, EU Communication on Biodiversity, EU Landscape and Soil Thematic strategies	
Limitations	Factors to consider are: expertise coupling soil degradation aspects and their effects on water, lack of legislation, conflicts of land use vs water management vs flood management, lack of soil availability, social costs to support soil transformation and social acceptance of soil recovery.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO Croatia has no Soil Act, but there are laws for nature protection, Environment protection Act, Agricultural soil law and laws regarding waste management that include soil protection.	
Implementation example		

Comments	

■ Identified GAP provoking action	
GAP short name	**Flood impact**
GAP short description	Impacts of floods on water quality, especially on drinking water supply system and the whole environment is not yet fully considered in the flood risk management cycle
■ Measure	
Name of measure	**Assessing flood impacts on drinking water supply systems and on water bodies**
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the measure	Implementation of monitoring and modelling system in order to evaluate and reduce negative impacts of floods on water quality and water supply systems and focus on positive contribution to ecosystem services. Planning at river basin scale.
Measure advantages	Evaluating flood impacts on water bodies at environmental level is useful to plan and manage water supply systems Evaluating flood impacts may be useful in preserving the access to satisfactory quality water, which may be damaged by the adverse consequences of floods for human health and economic activity To permit a better allocation of funds devoted to demolition and removal of building included in flooding areas in order to fulfil the objective of ensuring more space for river flows, the increase of concentration times, and giving them back the natural retention and recharge rules
Challenges	Comprehensive and objective (not emotional nor political) comparing of costs and benefits of floods including the impact of the infrastructures The big effort for reconstruction and recovery after flood events and their impacts may be reduced The increasing trend of unbalance between proactive (prevention/preparation) measures and reactive measures should be inverted. Considering the effects of recovery of natural role of flood plains and increase concentration times can be useful for ground water recharge, landscape enhancement, natural processes development (sedimentation/transformation of pollutants) Reducing the conflicts of interests between agriculture, urban and natural areas and between land use and water protection and management

Relevance	Water protection functionality	Medium
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	Regional studies, environmental associations, Flood Directive, Italian D.lgs 49/2010, Po river flood risk management plan	
Limitations	Factors to consider are: lack of skills, knowledge and experience, lack of political and communities awareness, resistance of population, potential conflicts of land use vs water management vs flood management, lack of supervising/implementation mechanisms	
Implemented in	☒AT ☐BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example	Case studies, from scientific publications, examples of pilot implementation by EEA and some EU member states, research projects	
Comments		

▪ Identified GAP provoking action	
GAP short name	**Qualitative/Quantitative unbalance of law/plans/measures implementation**
GAP short description	Effectiveness, motivation and efficacy of resources allocation for environmental issues faces with the heavy weight of environmental drivers (pollution, water stress, climate change, geological and hydrological risks, soil degradation, floods and droughts)
▪ Measure	
Name of measure	**Identification of priorities and measurable effects of responses to environmental drivers and pressures on water quality/quantity**
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the measure	In Italy, activities are mainly concentrated during the emergency phases and efforts are often not integrated. Nevertheless, in some sectors (agriculture, public health, civil protection) is rapidly rising the need of a wider approach, and sometimes the implementation is ongoing. A participative process including all stakeholders will be helpful in focusing and addressing local weaknesses (salt intrusion and soil salinization in Po delta area, population and land management decrease in the Apennines, intensive livestock and farming in plain areas).

Measure advantages	Implementation should ensure that water management will be based on a better understanding of the main risks and pressures in a river basin founded on proper monitoring and assessment The "green revolution" acting in Italy will shift resources, efforts, social awareness and political consensus to circular economy and sustainable use of natural capital. A proper monitoring and application will permit the institutions to be tuned with these changes.	
Challenges	Pragmatic approach to identification of priority drivers and pressures on water quality/quantity and possible responses Decomposition of governance process in sub processes in order to find weaknesses, opportunities and gaps including all economic, social environmental and political aspects (administrators, job opportunities, social acceptance, zero option, education and training)	
Relevance	Water protection functionality	Medium
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source		
Limitations		
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☐IT ☐POL ☒SLO	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Climate Change**
GAP short description	Potential conflicts among users and impacts on drinking water systems derived from climate change are not fully identified and faced
▪ Measure	
Name of measure	**Implementation of practical responses to mitigate climate change and to adapt to its effects**
Type of land use regarded	Infrastructures, industrial soil and contaminated sites, agriculture, urban areas.
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy Po river basin
Description of the measure	Processes including climate change studies, downscaling of their effects, considering main impacts in river basin planning, and following the

	implementation of measures for mitigation and adaptation	
Measure advantages	To avoid redundancy of measures and specific resources for implementation, considering effects on climate change deriving from applied measures to other sectors (agriculture, forestry, transport) To reduce lack of information and communication to population connected with water shortage problems To measure the effective reduction of impacts due to climate change on water shortage, floods and salt intrusion.	
Challenges	To combine hydrological, environmental, water and soil knowledge with economic and political programmes for adaptation and mitigation of climate change Overexploitation of water, soil degradation and over consumption, drought and flood extremes are not yet fully implemented global governance combines with shadows projected by climate change generating potential conflicts and impacts for drinking water systems.	
Relevance	Water protection functionality	High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source		
Limitations		
Implemented in	☐AT ☒BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO Bavaria - implemented in specific case studies Croatia – there is a draft of the National Climate Change Adaptation Strategy as well as an Action Plan draft that are implemented in specific case studies	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Analysis of links between employment/education policies and the water sector**
GAP short description	Water shortage and scarcity and difficulties of access to water resources and water treatment may limit economic growth and employment
▪ Measure	
Name of measure	**Social, employment and education policies in water resources sector**
Type of land use regarded	All
Pilot action cluster	PAC 3: Special sites (dry areas, riparian strips)

(if relevant)		
Location	Italy Po river basin	
Description of the measure	Water scarcity, access, quality, lack of water cycle knowledge and its integration with environmental, economic and institutional background may hinder the territory governance, management, and social progress. The sectors of integrated water planning and management with a skilled and large work force will foster a progress in actions regarding sustainable water and societal benefits together with effective education and training of people involved.	
Measure advantages	Sustainable water management creates employment opportunities and economic growth. Education and training of administrators, experts, technical and the private sectors will also contribute to a more effective and efficient processes.	
Challenges	There is a link between unemployment and environmental degradation growth and the growing trend should be stopped. Links between the above mentioned problems and the lack of governance and management and protections of water, land and soil. Capturing social benefits of ecosystem services may generate economic and social growth. Strategic efforts in employment, education and training of water management sector, may foster the fulfilment of water quality, availability and access targets.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	UNESCO, 2016	
Limitations		
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☐IT ☐POL ☐SLO	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Lack of information regarding groundwater salinity while designing and operating unconfined coastal aquifers**
GAP short description	Current unconfined aquifer plans do not take into account properly the impacts of climate change (CC) and sea level rise (SLR) in the future causing autonomous salinization via seepage of saline/hypersaline groundwater;

	seawater intrusion, and lateral mixing between brackish/saline coastal lagoons and the unconfined aquifers. Therefore, there is a need to quantify the foreseeable impacts of climate change on the unconfined aquifers to establish adaptation initiatives in the future plans.
▪ Measure	
Name of measure	**Assessment of salinization of groundwater and surface waters**
Type of land use regarded	All, according the type of infrastructure of interest The reclamation drainage network
Pilot action cluster (if relevant)	PAC 3: Special sites (dry areas, riparian strips)
Location	Italy The coastal floodplain of the Po River
Description of the measure	First, we need to quantify the increase in salinization of groundwater, the salt loads export towards surface waters and the changing volumes of freshwater due to climate change and socio-economic dynamic. Then, adaptation initiatives need to be established to cope with these impacts corresponding with different climate and socio-economic scenarios. These initiatives are expected to enhance the sustainability of freshwater and groundwater resources in the future in term of quality and capacity.
Measure advantages	The measure is aimed to: - contribute our understanding of groundwater dynamics and salinization processes to lowland coastal aquifer plans in the future; - enhance climate change adaptation in coastal aquifer infrastructure; - improve freshwater resources in term of both quantity and quality
Challenges	There are many uncertainties in quantifying the evolution of salinity process and the impacts of CC and human intervention on this process. First, groundwater salinity processes are quite complex, including evaporation, evaporate leaching, mobilization of salts stored in the unsaturated zone, infiltration of non-marine polluted surface waters, slow-moving saline/salt waters of marine origin (Giambastiani, Colombani, Mastrocicco, & Fidelibus, 2013). Second, the impacts of CC vary in time and space, depending on geographical and climatic condition. Finally, human intervention and socio-economic dynamic is highly heterogeneous. All these factors lead to the difficulty to assess the dynamic of salinization of groundwater and surface waters as well as the establishment of adaptation plans.
Relevance	Water protection functionality: Medium Cost of the measure: Medium Duration of implementation: Long term Time interval of sustainability: Long term
Reference / source	Climate ADAPT Platform, Trust Project. Colombani, N., Osti, A., Volta, G., & Mastrocicco, M. (2016). Impact of Climate Change on Salinization of Coastal Water Resources. Water Resources Management, 30(7), 2483–2496. https://doi.org/10.1007/s11269-016-1292-z

	Giambastiani, B. M. S., Colombani, N., Mastrocicco, M., & Fidelibus, M. D. (2013). Characterization of the lowland coastal aquifer of comacchio (ferrara, italy): Hydrology, hydrochemistry and evolution of the system. Journal of Hydrology, 501, 35–44. https://doi.org/10.1016/j.jhydrol.2013.07.037
Limitations	First, there are lacks of monitoring data on groundwater in some regions for calibration and validation of models. Secondly, regional climate scenarios are not available for public users. Finally, there are political constraints in implementing these initiatives.
Implemented in	☐AT ☐BAV ☒CRO ☐HU ☐IT ☐POL ☐SLO Applied in Germany, but not in Bavaria Croatia – Water Salinity Monitoring
Implementation example	Few studies have quantified the impacts of CC of groundwater salinity. For instance, SEAWAT 4.0 model allowed identifying the zones of influence of RSLR and to quantify the increase in salinization of groundwater, the salt loads export towards surface waters and the changing volumes of freshwater by 2050 (Colombani et al., 2016). Giambastiani et al., 2013 invested groundwater dynamics and salinization processes in this lowland coastal aquifer. TRUST Project (Tool for regional-scale of groundwater storage improvement in adaption to climate change), has tested the implementation of water banking/Managed Artificial Recharge measures for groundwater management.
Comments	A step forward is to establish adaptation initiatives based on the projections of salinity dynamic, taking into account climate scenarios and socio-economic development. The implementation of these initiatives needs to consider local conditions and political constraints.

▪ Identified GAP provoking action	
GAP short name	**Legalization of illegal construction on flood areas**
GAP short description	Despite prohibition of constructing buildings on flood areas, construction takes place and with time gets legalized. Ineffectiveness or lack of penalties from state authority on illegal construction (legislation implementation problem).
▪ Measure	
Name of measure	**To prevent legalization of construction on flood areas**
Type of land use regarded	Riparian strips
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland Riparian strips
Location	Slovenia
Description of the measure	Despite the fact that construction of buildings on flood areas is prohibited and is not safe, people insist on constructing on such areas in belief, the flood won't reach them. Institute for Water of the Republic of Slovenia has evaluated parcels with flood risk. Unfortunately many take this document only for a recommendation and not for a regulation, although it is a mandatory

	requirement for building permit. Therefore construction on such areas is illegal. Municipalities legalize such constructions due to tendency of keeping the spatial register up to date. If not sooner, constructions get legalized after flood when owners of parcels want compensation from insurance companies, for which real estate has to be legal. Municipalities should not agree on such acts. With legalization of illegal construction on flood areas municipalities undertake responsibilities and must provide flood protection and included costs	
Measure advantages	Strict implementation of construction inhibition on floodplains considering flood hazard map.	
Challenges	Usually corruption at municipalities or at planning companies makes such acts possible and to avoid such cases is a big challenge.	
Relevance	Water protection functionality	Medium
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from past projects. Reports on flooding of constructions in floodplains due to noncompliance of the legislation and large material damage.	
Limitations	Expected limitations are lack of common sense of people which construct illegal buildings on flood area. Another limitation is corruption problem.	
Implemented in	☒AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example		
Comments		

▪ Identified GAP provoking action	
GAP short name	**Surface water intrusion in the well**
GAP short description	Exposure of wells during flood events
▪ Measure	
Name of measure	**Sealed wells heads**
Type of land use regarded	Flood prone areas
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia in cases of wells in flood prone zones.
Description of the measure	Many water supply wells are on flood-prone plains, so the wells heads should be constructed as sealed in a way to prevent the surface water intrusion in the well during the flood event.

Measure advantages	Surface water cannot be mixed with groundwater, which is used for drinking water supply source, during floods. Water supply is not interrupted during the flood event.	
Challenges	No specific challenges are foreseen.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Short term
	Time interval of sustainability	Long term
Reference / source	Flood event in Celje in 1990 and flood event in Ljubljansko barje (Brest - lški vršaj) in 2010.	
Limitations	No limitations are foreseen.	
Implemented in	☒AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example	During the flood events in 1990 (Celje, Slovenia) the wells were flooded, but their heads were constructed as sealed so their operation was not interrupted.	
Comments	The information on the type of the well (sealed) should be emended to the data specification according to INSPIRE directive. Recommendations on the level of strategic guidelines resulting from the PROLINE-CE project, implementation on the level of national legislation requesting obligatory sealed well heads for the water supply wells on flood prone areas. Awareness rising and education process on this risk and potential measure.	

■ Identified GAP provoking action	
GAP short name	**Pollution sources in flood prone areas are not known / identified**
GAP short description	Identification of the potential pollution sources locations in flood areas is a challenging task.
■ Measure	
Name of measure	**Register of potential point pollution sources**
Type of land use regarded	Flood prone areas
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia
Description of the measure	Aggregated list of all potential point pollution sources (industry, heating oil tanks in households, etc.) is needed for efficient incident management in case of flood event. 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.

Measure advantages	It is very important to know all the potential pollution locations to implement prevention measures in the case of floods (i.e. flood proofing) and improve response of intervention forces during the flood events.	
Challenges	Data collection, data validation and maintenance, legal framework for the data collection.	
Relevance	Water protection functionality	High
	Cost of the measure	Low
	Duration of implementation	Mid term
	Time interval of sustainability	Long term
Reference / source	Flood event in Ljubljana in 2010.	
Limitations	Household inventory and data privacy.	
Implemented in	☐AT ☒BAV ☒CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example	Some of the potential pollution sources are known (especially industrial establishments under Seveso Directive), but there is among others no list of heating oil tanks in households, which are still quite common in Slovenia. 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.	
Comments	Challenge is how to adopt and enforce legislation enabling access to data and reporting on the amount of stored pollution substances on flood prone areas. Maintenance of the dataset. After the identification it is important to raise awareness and provide measures leading to improvements.	

▪ Identified GAP provoking action	
GAP short name	**Individualistic (Non-Sectoral) approach to common problematics regarding protection of drinking water resources**
GAP short description	Ministries, agencies and experts do not jointly develop measures for drinking water protection, but each "fight their own battle" and for interests, which are not necessarily in favour of protection of drinking water resources. Lack of co-operation and willingness to negotiate in favour of protection of drinking water resources.
▪ Measure	
Name of measure	**Joined and integrated management of drinking water resources (horizontal and vertical co-operation)**
Type of land use regarded	Agriculture, Grassland, Wetland - all
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland
Location	Slovenia

Description of the measure	Ministries, experts and public independently approach to common problematics, such as drinking water resources protection, instead of combining their knowledge and experiences to find unified and optimal solutions. Therefore more communication and cooperation is needed horizontally (inside ministries, among ministries, among experts, etc.) and vertically (panel discussions/round tables with experts and governmental bodies). More interactions (discussions, negotiations), finding solutions for sectors on which drinking water protection measures (trying to find win-win situations) are needed for achieving the main goal – drinking water protection.	
Measure advantages	In brief this is a general problem and not only specifically for this problematic.	
Challenges	A challenge is to change organisation strategy of drinking water sources management, among all within governmental institutions.	
Relevance	Water protection functionality	Very high
	Cost of the measure	Low
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	The BMP derives from experiences.	
Limitations	Expected limitations are lack of political will and also resistance to adaptation of many institutions.	
Implemented in	☐AT ☐BAV ☐CRO ☒HU ☒IT ☐POL ☐SLO	
Implementation example		
Comments		

▪ **Identified GAP provoking action**	
GAP short name	**Lack and not effective control over implementation of DWPZ restrictions**
GAP short description	There is lack of control over implementation of DWPZ restrictions, which is mostly not effective due to lack of co-operation among sectors (Environment, Health, etc) and due to low penalties (in case they are issued at all)
▪ **Measure**	
Name of measure	**Strict implementation and inspection of DWPZ restrictions**
Type of land use regarded	All
Pilot action cluster (if relevant)	Plain areas: Agriculture, Grassland, Wetland - all
Location	Slovenia, central part, PA area Dravlje valley in Ljubljana
Description of the measure	In the narrowest area of water protection zones regulations governing the construction of buildings is prohibited, with the exception of construction intended for the public supply of drinking water. 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. Implementation should be supervised by inspectors of the Ministry of Agriculture, Forestry and Food.	
Measure advantages	With restrictions truly implemented, quality of drinking water supply would not be endangered. In the DWPZs Agricultural Advisory Services encourage farmers to organic farming without pesticides and fertilizers. Because of smaller harvest, farmers get money compensations.	
Challenges	Ministry of the environment and spatial planning should assign supervisors to control locals and local farmers and their acts in DWPZs.	
Relevance	Water protection functionality	Very High
	Cost of the measure	Medium
	Duration of implementation	Long term
	Time interval of sustainability	Long term
Reference / source	BMP derives from bad practice. Decree on the water protection area for particular aquifer in Slovenia, which is based on Rules on criteria for the designation of a water protection zone.	
Limitations	This limitation is a lack of supervising of implemented mechanisms.	
Implemented in	☒AT ☒BAV ☒CRO ☐HU ☒IT ☐POL ☐SLO	
Implementation example		
Comments		

3. Conclusions

The starting point of this catalogue were the gaps and issues recognized during panel discussions with stakeholders at Start-up stakeholder workshops (Activity A.T1.3 "Identification of strategies and measures to be integrated into existing policy guidelines"). The workshop participants included local, regional and national public authorities, infrastructure and service providers, higher education and research facilities, interest groups and NGOs and also general public – hence their experience and knowledge of sectoral gaps and issues as well as proposed measures (as seen in D.T1.3.3 "Lessons learnt: synthesis report about start-up stakeholder workshops") were the basis for this catalogue. During the Start-up stakeholder workshops, in order to facilitate more efficient practices, stakeholders were introduced to existing best management practice (as seen in D.T1.2.2 "Transnational best management practice report"), fostering transnational transferability of results and using past knowledge and experience of other countries/partners with specific gaps and measures.

This catalogue provides a list of identified gaps and measures which could provide a major step in improvement of water resources management, flood and drought mitigation, reducing the effects of climate change and reducing the anthropogenic impact on water quality and quantity. This catalogue is also presented in a way which could be useful to planners, decision and policy makers, highlighting how specific gap could be resolved in an effective manner. Project partner countries had the liberty of freely selecting the measures which they thought were most important and should be prioritized.

Majority of the provided measures has high water protection functionality and long term time intervals of sustainability, demonstrating how sustainable, non-structural and long term approach with adequate planning and research has drastically higher effect over reactionary (most often structural/construction) measures.

In total, this document contains 38 recognized gaps and measures. According to land use, measures related to **general** (all) land uses, **agriculture** and **forest** dominate, which is expected due to the fact that those types of land use are most widely present in European countries (and also most problematic, especially agriculture and urban). The least amount of measures was provided for wetlands, grasslands and riparian strips. To conclude, further efforts must be put into:

- More effective implementation of existing measures and protection mechanisms (e.g. DWPZ) as well as more efficient financial stimulus for good practices (e.g. organic agriculture, subsidies for prevention of negative land use change)
- Climate change adaptation, research and inclusiveness into planning processes
- Sustainable and long term approach towards common problematics in water, flood and land use management (e.g. avoid reactionary measures)
- Target population consciousness through education, awareness raising activities and active participation of all social groups.

This document presents valuable input and a basis for PROLINE-CE Output O.T1.2 "Strategy for the improvement of policy guidelines"

A summary of all provided gaps and measures can be seen in **Table 1.**

Table 1. Summary of provided gaps and measures

Gap	Measure
Application of the clear-cut technique in drinking water protection zones (DWPZ)	Avoidance of the clear-cut technique
Elevated densities of unnaturally high stock of ungulate game as result of trophy-hunting activities and resulting browsing and bark-stripping damages.	Creation of forest-ecologically sustainable stocks of ungulate game
Extensive forest road construction within the DWPZ	Limitation of Forest Roads within DWPZ
Plantation of conifer species on all forest sites	Tree Species Diversity According to the Natural Forest Community
Cutting of huge, old and stable tree individuals	Foster old, huge and vital tree individuals
Forest deployment and cultivation, forestry practice in drinking water resources protection areas	Forest installation rules in floodplain of drinking water resources protection area
Inadequate management of forests. The conservation and appropriate enhancement of biodiversity	Establishment of an adequate deadwood management
Funding for land use actions for water protection	Linking land use measure funds to water resources protection
Deterioration of water quality due to agricultural pollution	Establishment of buffer strips
Application of intensive crop production technology and its impact on water resource protection	Intensive crop production possibilities in water protection areas
Obsolete conduction of agricultural practices	Increasing the efficient use of water in agriculture and adapting to climate change and crop irrigation to achieve optimum yields
Pollution of watercourses	Encouraging organic farming
Inflexible time ban of fertilizers and manure application	Redefinition of time ban of fertilizers and manure application
Pollution caused by inappropriate sludge management	Effective sludge management
Domestic gardens for small-scale cultivation in the drinking water protection areas	Controlling cultivation - awareness of domestic and small gardens within the drinking water protection area
Discharge of rainwater from the inner road network in soil	Impact assessment and pollution prevention of rainwater from the inter-urban road network to groundwater
Not arranged road rainwater discharge	Collection and treatment of road rainwater discharge, particularly within drinking water protection areas

Pollution of watercourses	Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding
Continuous conversion of (permanent) grasslands	Preservation of existing (permanent) grasslands
Pollution of watercourses	Wetland restoration
Flood risk reduction, Erosion / sediment control	Preservation and revitalization of wetlands on floodplains
Public engagement in development of action plans	Implementation of site-specific solutions
Saltwater intrusions in coastal areas	Prevention of saltwater intrusions
Pressure on water resources quantity	Climate change adaptation and resilience
Community use of inner and outer zone of groundwater protection area	Community use of partitioned groundwater in inner and outer protection zones
Design of infrastructure under steady-state weather conditions	Adaptation of building standards for design, maintenance and operation of infrastructures
Pressure on water resources management	Integrated Water Management for implementing efficient voluntary agreements
Soil degradation and consumption	Evaluating effects of Soil Protection Plans on water bodies
Flood impact	Assessing flood impacts on drinking water supply systems and on water bodies
Qualitative/Quantitative unbalance of law/plans/measures implementation	Identification of priorities and measurable effects of responses to environmental drivers and pressures on water quality/quantity
Climate Change	Implementation of practical responses to mitigate climate change and to adapt to its effects
Analysis of links between employment/education policies and the water sector	Social, employment and education policies in water resources sector
Lack of information regarding groundwater salinity while designing and operating unconfined coastal aquifers	Assessment of salinization of groundwater and surface waters
Legalization of illegal construction on flood areas	To prevent legalization of construction on flood areas
Surface water intrusion in the well	Sealed wells heads
Pollution sources in flood prone areas are not known / identified	Register of potential point pollution sources
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)
Lack and not effective control over implementation of DWPZ restrictions	Strict implementation and inspection of DWPZ restrictions