PROLINE-CE

WORKPACKAGE T2, ACTIVITY T2.1

SET-UP OF PILOT-SPECIFIC MANAGEMENT PRACTICES

D.T2.1.2 TRANSNATIONAL CASE REVIEW OF BEST MANAGEMENT PRACTICES IN PILOT ACTIONS

February, 2018

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Date last release	February, 2018

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1. Introduction

In this report best management practices (hereinafter: BMPs) are presented on the level of Pilot Action Clusters.
Pilot actions and pilot sites respectively were classified into three clusters concerning the geographic specification and natural site characteristics (aquifer type) and main land use:

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

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

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

In this report, BMPs regarding potential conflicts of interest between land use management and water protection are presented.

The aim of this report is to provide the review of BMPs aiming at water protection and mitigating floods. BMPs are classified regarding types of land use, which are characteristic for particular pilot action cluster.

For reaching this aim, first of all human activities have to be identified, which are posing risk to water quality and quantity; flooding and consecutive to water management. Finally, review of best management practices in the Pilot Action is presented.

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

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

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

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

Both Pilot Actions are in mountainous area and the major land use is forest, grassland and pastures. The major conflict regarding drinking water protection is timber production, gaming and cattle grazing. In PA1.1 the focus of interest is grassland management and forest management is subordinate. In the PA there is a problem of succession of grasslands and abandoned pastures, which cause concentration of existing pastures. In contrary, in PA1.2 the focus of interest is forest management and grasslands management is subordinate. The main natural differences of both Pilot Actions are type of aquifer: PA1.1 is in karst aquifer, whereas PA1.2 is in fractured aquifer and elevation: PA1.1 spreads on elevation from 400 to 2277 m a.s.l. and PA1.2 from 300 to 969 m a.s.l. These differences in natural characteristics and land use conflicts will contribute to more comprehensive set of best management practices.

2.1. Land use

The dominating land use type within PA1.1 and PA1.2 is forest. There is also agriculture, pastures, stone quarries and gravel pits.

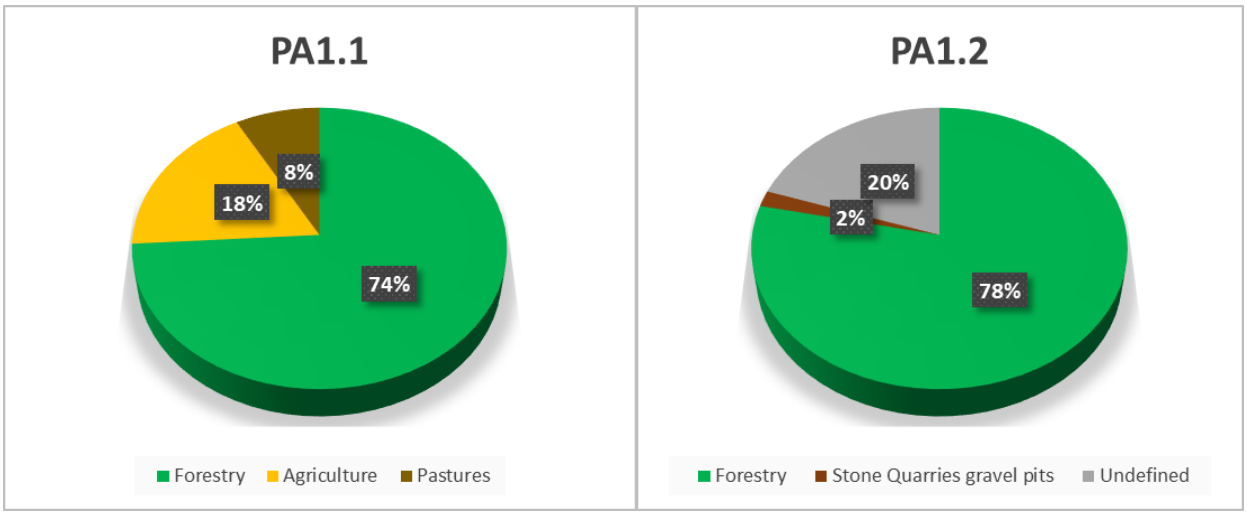


Figure 1: The land use types within PA1.1 and PA1.2.

Forestry exerts several pressures to drinking water quality. Within the PA1.1 clear-cuts are forbidden. Through the application of clear-cuts by some forest owners within the PA1.2 the mineralization processes within the soils are exaggerated. In PA1.1 on some areas the density of the ungulate species is already adapted towards a forest ecologically sustainable level. Despite that fact the wild ungulate densities have to be reduced within various areas of PA1.1. Within the PA1.2 the wild ungulate densities have to be reduced, as the whole area is affected by browsing damages. Forest road construction and operation is an essential challenge for drinking water protection within both PA1.1 and PA1.2.

The problem for the water supply is microbial contamination due to manure. Through ponors and sinkhole, the contaminants infiltrate into the aquifer. This problem can be solved by regulating the pasture and applying different technical measures. Within PA1.1 the situation is related to subalpine pasture areas, where also cow-dung and liquid manure exert pressure on water quality. Within PA1.2 the situation is clear.

Pressures resulting from urban areas can be identified in the field of potential contaminations caused by leaking sewage pipes or mineral oil contaminations stemming from heating systems or cars/trucks. Urban areas are relevant within PA1.2.

Industrial facilities are situated within the WPZ of Waidhofen/Ybbs. Potential pressures resulting from them could be caused by leaking sewage pipes, mineral oil contaminations stemming from heating systems or cars/trucks or by the leakages of chemicals used in the production processes. The industrial activities impact above all water quality, water quantity and flood prevention are not affected that much. Within PA1.1 there do not exist industrial facilities.

The potential impacts of active stone quarries on the aquifers are resulting from the applied detonations, from the trucks which can cause oil-spills and from further applied chemicals like e.g. explosive materials. Also, the handling of waste and waster waters may cause problems. Stone quarries impact water quality, water quantity and flood prevention, as surface flow is increased through the bare rocks and are found within PA1.2. Gravel pits comprise also the danger of contamination with mineral oil products used in the trucks and excavators. But the danger linked to explosive materials is not given in this case. Gravel Pits are found within PA1.1.

2.2. Drinking water protection

In Austria (country location of PA1.1 and PA1.2) DWPZs are protected by law (BGBl. 345/1973). This decree is based on the Austrian water Law, which is the national adaptation of the water Framework directive.

Table 2: Water Protection Zones in PAC 1.

Water Protection Zones in Austria (PA 1.1 and 1.2)	In Austria DWPZs are protected by law: Protection Zone I Protection Zone II

PA1.1-situation	Pfannbauernquelle: typical spring with a dolomitic recharge area. The discharge ratio (Q_{max}/Q_{min}) is 1.4 a value showing good buffering properties. The spring water has a relatively long residence time (21 years). Due to the long residence time there are very seldom contaminations detected. Nevertheless, some sites with high vulnerability have been located. Brunngrabenquellen: dolomite is dominant in the recharge area but some influence of limestone is evident. Also, a small contribution comes from a little porous aquifer in a valley south to the springs. The buffering properties are still quite good. The residence time of 10 years and the discharge ratio of 1.6 show also a well buffered reservoir. Höllbachquellen: Limestone dominates in the recharge area. The Höllbachquellen drain the western part of the Zeller Staritzen. There is also some influence from the partly porous aquifer of the so called "Hintere Höll". The residence time of 1.7 Years and the discharge ration of 4.0 show a difference to the Pfannbauern- and Brunngrabenspring. Detailed analyses show that there are different parts of the recharge area with distinctly different hydrological properties. Protection measures have to take this differences into account. Kläfferquelle: the Kläfferspring is the spring in the whole Hochschwab area (of which Zeller Staritzen is part) with the highest discharge (>5000 l/s). the catchment area is accordingly large. But in the whole Hochschwab area catchments are not strictly separated. Due to intensive tectonics hydraulic effective connections exist which allows for transportation of contaminants. Kläfferspring is a typical limestone karstspring with a discharge ratio of 40 and a residence time of 0.7 years. There are different discharge components which relate to the geological different properties. The reservoir is generally well mixed.
PA1.2-situation	There are 5 karstic springs which are currently used for drinking water supply within the DWPZ Waidhofen/Ybbs. The names are Kerschbaumer-Spring, Glashütten-Spring, Hieslwirt-Spring, Hinterlug-Spring and Mitterlug-Spring. The hugest spring, which is Kerschbaumer-Spring, has a mean daily discharge rate of 2,932 m3 and a mean monthly discharge rate of 89,255 m3. The second largest spring is Hinterlug-Spring with a mean daily discharge rate of 957 m3. The smallest spring is Mitterlug-Spring with a daily discharge rate of 329 m3. The whole area is DWPZ and is a legally decreed water sanctuary.

2.3. Other protection areas

There are no other protection areas within PA1.1. There are areas of Natura 2000 within PA1.2.

2.4. Best Management Practices

Best Management Practices are classified regarding types of land use and can be identified with a specific colour (see Table 3).

Table 3: Legend of Best Management Practices classification

	Forest
	Grassland
	Agriculture
	Urban Areas
	Industrial Areas
	Wetland, flood mitigation and Karst region
	Tourism
	Stone Quarries and Gravel Pits

2.4.1. Forest

▪ BP MF1 Avoidance of the clear-cut technique	
Description of the measure	The clear-cut technique (CCT) as silvicultural measure for timber yield and subsequent artificial recruitment techniques does not conform to water protection requirements, as it can cause contaminations of the aquifer or streams with nutrients and solid matter mobilized from plant, humus and soil compartments. Additionally, CCT creates top-soil drought conditions, what causes water repellency of the soil and humus layers. Water repellency of the top soils increases surface runoff processes and hence is in contradiction to flood mitigation and also decreases groundwater recharge.
Measure advantages	Avoidance of CCT opens the path for a consistent water protection strategy. It assures the avoidance of the most threatening processes caused by forestry in terms of drinking water protection and flood prevention.
Challenges	The resistance of foresters towards the avoidance of CCT may be very

	strong, as CCT can be regarded as the most important silvicultural system applied in timber-yield forestry in Austria. It will need a lot of knowledge transfer strategies to convince foresters in Austria about this step.
PA1.1-situation	Within the PAC1.1 the clear-cut technique is forbidden since 1985.
PA1.2-situation	Within the PAC1.2 the clear-cut technique is still applied by some forest owners. It will be part of the stakeholder-processes to change this situation.

▪ BP MF2 Establishment of a Continuous Cover Forest System	
Description of the measure	The actual given crown cover percentage of forest stands has to range between 70 % and 90 % in colline to mountain areas and between 60 % and 80 % in subalpine areas. This guarantees a high degree of stability towards disturbances like wind storms and additionally provides enough space and light for a continuous regeneration process. Mobilization processes in soil and humus layers are kept on a low level and it can be regarded as basic requirement for the establishment of CCF and for the sustained provision of the water protection functionality of forest ecosystems.
Measure advantages	The defined crown cover percentage for forest stands provides a clear frame for forestry in DWPZ. It is a very important BP and helps to secure the water protection functionality of forest ecosystems (together with others BP's).
Challenges	As timber production was and is the overall purpose for most of the Austrian forest regions, this BP can create discussions among foresters, as it requires a fundamental change in silvicultural concept and measure application.
PA1.1-situation	Within the PA1.1 the CCF is applied since the last decade. Hence it will need several decades until the whole forest area can be described as CCF. Despite this fact the aim of silviculture is the establishment of CCF.
PA1.2-situation	Within the PA1.2 the CCF is still far from being applied. Most of the forests actually are treated via the classical age-class-system, comprising clear-cuts and artificial regeneration.

▪ BP MF3 Defined Crown Cover Percentage of Forest Stands	
Description of the measure	The actual given crown cover percentage of forest stands has to range between 70 % and 90 % in colline to mountain areas and between 60 % and 80 % in subalpine areas. This guarantees a high degree of stability

	towards disturbances like wind storms and additionally provides enough space and light for a continuous regeneration process. Mobilization processes in soil and humus layers are kept on a low level and it can be regarded as basic requirement for the establishment of CCF and for the sustained provision of the water protection functionality of forest ecosystems.
Measure advantages	The defined crown cover percentage for forest stands provides a clear frame for forestry in DWPZ. It is a very important BP and helps to secure the water protection functionality of forest ecosystems (together with others BP's).
Challenges	As timber production was and is the overall purpose for most of the Austrian forest regions, this BP can create discussions among foresters, as it requires a fundamental change in silvicultural concept and measure application.
PA1.1-situation	In the course of silvicultural measures this BP is not applied. Communication efforts with the foresters could be a solution for this situation.
PA1.2-situation	Within the PA1.2 the implementation of this BP requires communication efforts with the forest owners. The incentives may be motivating enough to establish it.

▪ **BP MF4 Limitation of the Percentage of Timber Extraction**	
Description of the measure	The actual given crown cover percentage of forest stands has to range between 70 % and 90 % in colline to mountain areas and between 60 % and 80 % in subalpine areas. This guarantees a high degree of stability towards disturbances like wind storms and additionally provides enough space and light for a continuous regeneration process. Mobilization processes in soil and humus layers are kept on a low level and it can be regarded as basic requirement for the establishment of CCF and for the sustained provision of the water protection functionality of forest ecosystems.
Measure advantages	The limitation of the percentage of timber extraction has the great advantage that together with the application of BP MF 3 the sustained stability and resiliency of the forest stands and forest ecosystems can be facilitated. This is a basic condition for the protection of drinking water resources and from floods.
Challenges	Again, the habitual management procedures in Austrian forestry will be an obstacle for the application of this BP, as it requires from the foresters a fundamental shift of timber yield patterns. Drinking water protection as overall purpose is still rather new and unknown for most

	of the foresters in Austria.
PA1.1-situation	In the course of silvicultural measures this BP is also not applied. Communication efforts with regard to actual management procedures of the foresters could be a solution for this situation.
PA1.2-situation	Some farmers within PA1.2 act on small-scale level in terms of silvicultural operations, but most of the forest owners act like classical Austrian foresters hence the implementation of BP MF4 will require communication efforts.

▪ BP MF5 Continuous Regeneration Dynamics	
Description of the measure	Forest stands in DWPZ have to host a continuous regeneration phase on minimum 10-20 % of their spatial extension. This ensures the highest degree of resilience, as in case of disturbances the water protection functionality of the forest can be restored the fastest way. Continuous regeneration is a basis condition for CCF, as it provides the basis for uneven-aged forest stands. In case of natural forest stands it also ensures the natural regeneration of autochthonous genetic material, which is of crucial importance for stability and resilience, especially under climate change.
Measure advantages	Continuous regeneration dynamics provide a basic condition for forest ecosystem stability and resiliency. Only if young trees can grow without hindrances in all forest stands and ecosystems, the system stability and also the water protection functionality are given on a high level.
Challenges	In Austria the high wild ungulate densities are the greatest threat for a continuous regeneration dynamic. 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.
PA1.1-situation	Within the PA1.1 area the natural regeneration process of the forest ecosystems is a declared aim. Through the reduction of the wild ungulate densities within the PA1.1 some areas already show continuous regeneration dynamics. In some parts of the WPZ the reduction of the wild ungulates still needs some time, hence also natural regeneration is still hindered there. Those areas are declared management intervention zones.
PA1.2-situation	Within the PA1.2 the high wild ungulate densities exert a major hindrance for natural regeneration dynamics. Actually, the continuous regeneration dynamics of the forest ecosystems within the PA1.2 can be used as indicator for forest ecologically balanced wild ungulate

	densities. If natural regeneration of all tree species takes place on an optimal level, the challenge of elevated ungulate densities can be regarded as solved.

▪ BP MF6 Foster Stability, Vitality and Resilience of the Forest Ecosystems	
Description of the measure	In DWPZ stability, vitality and resilience of the forest ecosystems are the most important features. Stable forest ecosystems and forest stands can resist any given disturbance. In case of strong disturbances, resilient forest ecosystems can recover their water protection functionality rapidly. The vitality of the tree individuals and of the whole forest ecosystem is the basic condition for stability and resilience.
Measure advantages	Stability, vitality and resilience are the most important features of forest ecosystems in DWPZ. Hence any activities to foster those are important for drinking source water protection and flood prevention. The purpose in silviculture moves from high quality timber trees towards stable and vital trees, what makes a definite difference.
Challenges	This change in silviculture requires again a renunciation from habitual procedures in forest management. The foresters have to be trained towards perceiving the most stable and vital trees and also towards a consequent implementation of fostering stable and vital tree individuals.
PA1.1-situation	Within the PA1.1 the improvement of stability and resilience of the forest stands is part of the internal guidelines. The implementation of it will need further training for integrating new views. Despite this fact the actual silvicultural practices already focus on the improvement of stability.
PA1.2-situation	The focus of the stakeholder trainings will have to be put on the necessity to increase stability of the forest ecosystems.

▪ BP MF7 Tree Species Diversity According to the Natural Forest Community	
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 plantations with not-natural tree species

	should be transformed gradually to stands dominated by native species, depending on the local experience and legislation.
Measure advantages	In many Austrian forests tree species diversity according to the natural forest community is 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. Diversity has also positive side effects, like e.g. for conservation purposes.
Challenges	In some forest areas there can be expected resistance against tree species diversity according to the natural forest community, if the habitual forestry practices had a strong focus on conifer plantations or other homogeneous timber yield focused plantations.
PA1.1-situation	The Forest Hydrotope Model was elaborated within the PA1.1 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.
PA1.2-situation	Within the PA1.2 the forest hydrotope map is available for the definition of the silvicultural targets to be fulfilled in terms of tree species diversity. The current trend to plant conifer tree species has to be reversed through persuasive efforts, which may be supported by the incentives intended for adequate forestry in terms of water protection. BP MF7 is relevant for both drinking water protection and flood prevention.

▪ **BP MF8 Improve the structural diversity of the forest stands**	
Description of the measure	Forest stands in DWPZ should be structured vertically and horizontally. This involves tree species diversity as well as uneven-aged and multi-layered forest stands. Structural diverse forest stands are a basic requirement for continuous cover forest systems. Stability and resilience are improved in case of structural diverse forest stands.
Measure advantages	Structural diversity in forest ecosystems provides an improvement of forest stand stability and additionally is necessary for CCF (continuous cover forest systems). Hence it has to be followed as purpose in forest management within DWPZ to achieve structural diversity.
Challenges	As most of Austrian forest stands are based on the age-class system, structural diversity is actually not very common. Most of the forest stands are even-aged and only single-layered. The change of silvicultural practices towards structural diverse forest stands will have to involve both persuasive efforts and training of the foresters.

PA1.1-situation	Structural diversity is created through small-scale silvicultural measures. Those have to be implemented with continuity. The purpose of forestry within PA1.1 is the creation of structural diverse forest stands. The implementation of this guideline is a true challenge hence training sessions for foresters could solve this situation.
PA1.2-situation	Within PA1.2 the creation of structural diversity depends on the forest owner. Some farmers already create structural diverse forest stands by implementing small-scale measures. Huger forest owners implement the clear-cut technique and create homogeneous forest stands. The implementation of structural diversity will have to be part of training programs in connection with the project-goals.

▪ **BP MF9 Forest Ecologically Sustainable Wild Ungulate Densities**	
Description of the measure	High wild ungulate densities provoke severe browsing damages on tree seedlings and saplings, fraying damages and bark-peeling damages. Those inhibit the natural regeneration process of whole forest ecosystems or destabilize those. 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 wild ungulate densities are regulated to a forest ecologically sustainable level, hence providing vital regeneration of all tree species.
Measure advantages	Forest ecologically sustainable wild ungulate densities provide the huge advantage that the forest ecosystems can evolve naturally, can grow according to their natural inner dynamics. 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.
Challenges	In Austria the high level of wild ungulate densities is the greatest threat for a continuous regeneration dynamic. 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 wild ungulate densities can be regarded as the main challenge in the Austrian forest sector.
PA1.1-situation	Within PA1.1 some areas show already forest ecologically sustainable wild ungulate densities which is indicated by the vital development of natural regeneration of all relevant tree species. But some areas still need further efforts to establish forest ecologically sustainable wild

	ungulate densities. Hence the situation has to be seen differentiated.
PA1.2-situation	Within PA1.2 high wild ungulate densities form a major threat for forest ecosystem stability. This endangers both drinking water protection- and flood prevention functionality of the forest ecosystems.

▪ BP MF10 Protection of the Gene Pool of the Autochthonous Tree Species	
Description of the measure	Autochthonous tree species have evolved since thousands of years in their specific forest regions. They carry the genetic information, which allowed them the survival of the past climate changes in those areas. They are the basis for the establishment of the natural forest communities (BP MF 7). Tree species diversity is dependent on them.
Measure advantages	Autochthonous tree species are the basic requirement for forest ecosystem stability. They carry a lot of genetic diversity and are the best in coping with the local climatic conditions. In times of climate change their value becomes priceless.
Challenges	In Austria in some regions it could already become difficult to find autochthonous tree species, especially in such where only Norway spruce (*Picea abies*) was planted, always using only the varieties with the greatest increment levels. Again, persistence can be expected, if the change from high-timber-yield species towards more stable autochthonous species is envisaged.
PA1.1-situation	As the paradigm of natural regeneration is part of the silvicultural strategy within PA1.1, the gene pool of autochthonous tree species is still at a high level. There also exist wide spread forest areas, where the tree species composition of the natural forest community (forest hydrotope type) is still given. It is recommended to mark tree individuals which should provide their genetic material for longer periods (strong, huge and vital trees).
PA1.2-situation	The current situation provides a good starting point for the protection of autochthonous tree species, as there still was identified a high share of those within the forest area of PA1.2 in the course of the hydrotope mapping survey. Those individuals of each species just have to be identified and marked in order to protect their gene pool.

▪ BP MF11 Foster old, huge and vital tree individuals	
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. Thereby they provide

	a substantial contribution to forest stand stability. Therefore, 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 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.
Challenges	The old, huge and vital tree individuals have to be selected for remaining in a forest stand. In recent times huge trees in Austria are in general selected for being cut. This change of behaviour has to be achieved through information and persuasive efforts.
PA.1-situation	The selection of old, huge and vital tree individuals with the purpose to remain in the forest stand is envisaged by some foresters. In order to implement this Best Practice more consequently, information transfer to the foresters would be an adequate solution.
PA1.2-situation	Selection and marking of those stable and old tree individuals should be executed in order to become aware about the stability-network within the forest stands/forest ecosystems. Until now such an effort has not been undertaken within the PA1.2, but this could be a first step towards a target-oriented silviculture, which supports both drinking water protection and flood prevention.

▪ **BP MF12 Adequate Dead-Wood Content**	
Description of the measure	In DWPZ, coarse dead-wood has to be present in each forest area in adequate quantity and quality. Coarse dead-wood is a habitat and an ecological niche for many organisms with relevance for forest stability, especially insects. Also, owl species, which depend on standing dead-wood, can improve forest stand stability by controlling mouse populations. Lying coarse deadwood provides space for nurse-log regeneration.
Measure advantages	Deadwood is an important feature of biodiversity in forests as it improves the ecological conditions and hence is a pre-condition for the establishment of stable and vital forest ecosystems. Dead-wood keeps the forest ecosystems alive, as the multitude of organisms living in and on it can be explained as fundamental for the interdependencies within forests. The measure does not cost very much and the effect is strong. Besides, dead-wood also acts as water storage.

Challenges	To keep standing and lying dead-wood in forest stands is still a challenge for some foresters, as they have the tendency to yield each single tree. Again, in some cases the change of behaviour has to be achieved through information and persuasive efforts.
PA1.1-situation	Within the PA1.1 the awareness regarding adequate dead-wood content in the forest stands is elaborated. The foresters created "woodpecker-trees" (standing dead-wood) and have the declared aim to leave a certain amount of dead-wood within the forest stands.
PA1.2-situation	The dead-wood content within the forest ecosystems of PA1.2 in most of the cases can be described as satisfactory. Hence BP MF12 is not rated with priority for implementation within PA1.2.

▪ **BP MF13 Buffer Strips along Streams, Dolines and Sinkholes**	
Description of the measure	Streams are sensitive sectors in many DWPZ and hence have to be protected with highest priority. Buffer strips with dense and vital forest cover can protect the streams from direct infiltration of sediments or nutrient loads and from lateral erosion. Forest vegetation has to be stable in buffer strips and management operations have to be carried out extremely cautious. Dolines and sinkholes are karstic features and deserve the same attention as streams, buffer strips are also an adequate solution there.
Measure advantages	The protection of the stream-banks from lateral erosion processes through a vital forest cover can be regarded as the most crucial effect of buffer strips, as lateral erosion could mobilize huge amounts of soil-, gravel- and rock material, endangering both water supply facilities and human infrastructure in general. But also, the protection from nutrient loads and sediments is relevant. Buffer strips along streams are one of the classical Best Practices on global scale. Additionally, the shadowing effect of them on the stream is relevant for keeping the waters relatively cool.
Challenges	Actually, there can be identified a trend in Austria, where Buffer Strips along streams are clear-cut. This trend has to be reversed, as the protection from lateral erosion processes is more important. The balance between driftwood prevention and preservation of the forest cover along streams has to be found, what maybe could lead to multi-dimensional discussions in some cases. The most important purpose within this context has to be the most efficient flood mitigation/prevention/protection functionality of the system Streams/Forest Ecosystems. It will have to come to a trade-off between lateral erosion prevention and drift-wood prevention. The huge threat-potential of lateral erosion processes has to be taken into

	account. This situation is valid for both mountain and plain (flatland) stream systems.
PA1.1-situation	Buffer strips along streams are a vital means for erosion control within the PA1.1. The protection and adapted management of those can still be described as challenge. Some foresters keep the adequate forest cover along streams, others have cut it totally. Hence a guideline for the whole PA1.1 should be elaborated in order to keep the buffer strips with vital and stable forest cover.
PA1.2-situation	Within the PA1.2, buffer strips along streams are also forming a vital means for erosion control and hence have to be protected from being clear-cut. This is of essential interest for both drinking water protection and flood prevention.

▪ BP MF14 Adaptive Forest Management under Climate Change	
Description of the measure	Climate change can alter the growth conditions for forest ecosystems significantly. For ensuring the provision of the ecosystem service (ES) 'drinking water protection', adaptive forest management towards climate change has to be applied. This involves a strategic procedure, where the evaluation of both climate development regarding the climate change scenarios and of forest succession has to be carried before concept-design. The concept-design of adaptive management can demand various measures like e.g. the support of the migration of certain indigenous tree species.
Measure advantages	Adaptive forest management under climate change ensures the provision of the Ecosystem Service (ES) 'Drinking Water Protection' - over space and time. This is elementary for water protection issues.
Challenges	In Austria there actually can be identified various attempts to adapt forest ecosystems towards climate change. The most important fact in DWPZ is the use of indigenous tree species for reaching this goal, what could result in discussions in various cases, as there can be identified a tendency to use alien conifer or deciduous tree species for adaptation. This could be very dangerous as their stability in our climate is not proved. Hence the use of alien species for forestations or afforestations is not acceptable within DWPZ. Again, in some cases information transfer and persuasive efforts will have to be applied.
PA1.1-situation	The strategy to adapt the forest ecosystems to climate change were described in detail in the course of the CC-WaterS project. For each forest hydrotope type the strategy was elaborated. For the current time the establishment of the natural tree species diversity of each hydrotope type is the most crucial activity. This is the defined goal of silviculture within PA1.1. Further adaptations can first be

	implemented, if the climate evolves further towards the predicted situation.
PA1.2-situation	Some alien tree species were planted in the past. The strategy to adapt the forest ecosystems to climate change were described in detail in the course of the CC-WaterS project. For each forest hydrotope type the strategy was elaborated. For the current time the establishment of the natural tree species diversity of each hydrotope type is the most crucial activity. Further adaptations can first be implemented, if the climate evolves further towards the predicted situation.

▪ **BP MF15 Natural Forest Succession in Case of Stable Forest Ecosystems**	
Description of the measure	In some cases, forest ecosystems already fulfil all criteria of an adequate drinking water protection forest. Tree species diversity and distribution, uneven-aged and multi-layered structure of the forests are given and stability, vitality and resilience have to be given on an optimal level. Wild ungulate densities are forest-ecologically balanced and the self-regulating force of such forest ecosystems is given on a high level. If all these criteria are fulfilled, forest management measures within those forest ecosystems can be suspended and natural succession can take place, until an urgent need for management measures implementation should arise.
Measure advantages	This measure assures a low disturbance regime for the included forest areas. This is of crucial interest for water protection. Also, conservation targets can be achieved with this measure.
Challenges	It is not very common in Austria to let natural forest succession take place outside from national parks and natural forest reserves. Within DWPZ this measure could be a solution for achieving necessary goals, but again persuasive efforts will have to be applied.
PA1.1-situation	Within the DWPZ of the City of Vienna there already exist forest conservation reserves, which are protected from ongoing management interventions due to their close-to-nature status of forest stands and their stability.
PA1.2-situation	Within the PA1.2 there could be identified such stable forest ecosystems in future, actually the challenges like browsing damages on most of the tree species do not allow natural forest succession on a huger area. If the frame-conditions should be given in future, this could be an appropriate tool for some remote forest areas.

BP MF16 Small-Scale Regeneration Techniques	
Description of the measure	Within DWPZ the applied regeneration techniques have to be carried out on small-scale areas. This is an essential contrast to the clear-cut technique and supports forest stand stability during the mostly natural regeneration phase. The adequate techniques are e.g. group selection cuts, single tree cuts or small-scale gap cuts. There has to be given the balance between light-provision for the regeneration of the forest trees and the stability of the remaining forest stand.
Measure advantages	Small Scale regeneration techniques like single tree cutting, small gap cutting or group selection system assure a low disturbance regime within the context of forest management measures and give advantage of the natural seed regeneration. This allows and supports the overall purpose of drinking water protection. The remaining forest stands can be kept in stable conditions and the conditions for natural or artificial regeneration dynamics are created.
Challenges	Small scale regeneration techniques are in the clear-cut country Austria not very common, but in general well known. In some DWPZ they are common (City of Vienna) or have been tested (in Waidhofen/Ybbs during the project CC-WaterS). The need to apply them within DWPZ will have to encompass information transfer and persuasive efforts.
PA1.1-situation	As the clear-cut technique is forbidden within the PA1.1, small-scale regeneration techniques are already applied there.
PA1.2-situation	Some farmers apply small-scale regeneration techniques within the PA1.2. The challenge is to provide for the whole WPZ the implementation of BP MF16, what will require persuasive efforts in case of many forest owners within the PAC1.2, which still apply the clear-cut technique. Again, the incentives will be an important motivator.

BP MF17 Structural Thinning Operations	
Description of the measure	In order to create uneven-aged and multi-layered forest stands, structural thinning can be applied. The focus is on the improvement of forest stand stability. Stable trees remain and unstable ones are removed. The structure of the forests is improved in terms of the creation of uneven-aged and multi-layered stands with a wide diameter-distribution. The spatial distribution of the thinning measures is determined by the improvement of structure and stability within the forest stands. The structure of the forest stands should be given on a

	horizontal and vertical level. Also, the tree species diversity according to the forest hydrotope type (natural forest community) has to be given and hence is facilitated by structural thinning.
Measure advantages	Structural thinning can create more stable forest stands by widening the diameter-distribution, by the way increasing the age-distribution and structural diversity of them. This supports forest stand stability and resiliency and facilitates the establishment of the intended continuous cover forest system (CCF).
Challenges	Structural thinning is not very well known in Austria's forestry enterprises and hence will need to be taught to foresters.
PA1.1-situation	Structural thinning is applied within the PA1.1 in some cases, all times depending on the expertise of the forester.
PA1.2-situation	Structural thinning does not seem to be part of the silvicultural operations within the PA1.2, hence it will have to be communicated as alternative.

▪ **BP MF18 Artificial Recruitment Techniques**	
Description of the measure	Artificial recruitment techniques become necessary in cases, if the natural regeneration dynamics do not provide adequate results in terms of tree species composition and/or of quantity of tree seedlings and saplings. It is mandatory to use autochthonous plant material in order to maintain forest stand stability in a sustainable way. Artificial recruitment may also become necessary as measure under climate change, if migrating tree species have to be supported.
Measure advantages	Artificial recruitment techniques are in some cases the only way to establish regeneration phases within forest ecosystems. Hence, they are an indispensible factor for the facilitation of stable forest ecosystems. It never can be excluded that there arises the need for the application of artificial recruitment techniques. It is of crucial importance to use only indigenous tree species according to the forest hydrotope type (natural forest community) for planting.
Challenges	Artificial recruitment techniques are very well established in Austrian forestry hence their application should be easy. The use of indigenous tree species only will provoke in some cases discussions – these have to be lead with the purpose of transporting the cornerstones of source water protection through adaptive forest management.
PA1.1-situation	As natural regeneration is the paradigm within PA1.1, artificial recruitment techniques are only applied in exceptional situations. It is recommended to extend the application of artificial recruitment techniques under pending circumstances of forest stability.

PA1.2-situation	Artificial recruitment until now was performed with conifer species like Norway spruce, European larch or Douglas fir. Except European larch, the other species do not show high adaptability within the PA1.2. Hence the focus should be placed on the set of natural tree species defined for each forest hydrotope type.

▪ BP MF19 Forest Fire Prevention	
Description of the measure	Forest fire prevention is of vital interest for the integrity of forest ecosystems, especially if they are providing a continuous protection of drinking water supply. Climate change and other challenges threaten forests and their protection and production functionality. According climate change simulations forest fires could increase in future. For this reason, it is necessary that forest management practices address principles that ensure fire prevention. Fire prevention measures require attention from all authorities, especially from those responsible for forest management. Forest fire prevention does not only protect life, environment and natural heritage, but in most cases, is the most effective strategy to reduce damages.
Measure advantages	As the effects and impacts of forest fires are disastrous for the water protection functionality of forest ecosystems (both for drinking water protection and for flood prevention), forest fire prevention becomes crucial for DWPZ. Especially in countries with a high risk of forest fires this is of prior importance, but also other countries like Austria have to be aware about the threat of forest fires and should have prevention and mitigation concepts available.
Challenges	As Austria is a quite humid country, the forest fire prevention concepts are not that wide spread like e.g. in Mediterranean countries. Despite this fact the forest fire prevention concepts and strategies have to be elaborated for DWPZ.
PA1.1-situation	It is recommended to elaborate forest fire preventions concepts and strategies for the PA1.1 (DWPZ), as in Austria the tools for fighting forest fires should be improved.
PA1.2-situation	It is recommended to elaborate forest fire preventions concepts and strategies for the PA1.2 (DWPZ), as in Austria the tools for fighting forest fires should be improved.

▪ BP MF20 Limitation of Forest Roads	
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. 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.
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.
Challenges	In Austria forest roads and their construction is a cornerstone of "normal management situations". Foresters tend to construct forest roads. Hence it is very difficult to convince them about the need of abstaining from constructing them. Focused information transfer and persuasive efforts will have to be applied.
PA1.1-situation	Also in PA1.1 the construction of new forest roads should be limited or stopped. The potential negative impacts of forest roads on the aquifers require such a decision.
PA1.2-situation	The limitation of forest roads has to be implemented within the PA1.2. Forest owners have to be convinced that incentives are only possible if they confirm to abstain from further construction activities.

▪ **BP MF21 Adequate Timber Yield Techniques**	
Description of the measure	In DWPZ the applied timber yield techniques should prevent the disturbance of the soil- and humus layers. In the case of mountainous forest sites the application of the skyline-crane system or animal-traction systems is recommended. The tractor-skidding method should only be applied in exceptional cases and the soils must then be frozen or dry. With the cable-crane system the assortment-technique (cut to the length method) has to be applied and the whole-tree harvesting method has to be avoided. In flat areas the tractor-skidder method has to be applied in times when the soils are frozen.
Measure advantages	The application of adequate timber yield techniques has the advantage that the soil and humus layers are kept in desirable conditions, by the way providing the full level of forest ecosystem services "water protection". Also, the remaining forest stand can be kept stable.
Challenges	In many cases there will be a tendency to apply the cheaper tractor-skidding method, also in steep terrain. This will have to be opposed, as within DWPZ only the water protection functionality and the ways to protect this should be followed. Again, focused information transfer and persuasive efforts will have to be applied.
PA1.1-situation	Within the PA1.1 there can be identified a strong focus on the skyline-

	crane method, as the DWPZ is situated in a rather steep alpine landscape. Despite that fact the tractor-skidding method is still applied on less inclined forest sites. This should be subject of discussion, as this method should be avoided within DWPZ.
PA1.2-situation	Incentives for the forest owners have to be restricted to the application of the skyline-crane method, animal-traction systems or hand-craft traction. The tractor-skidding method has to be avoided due to negative effects on drinking water protection and flood prevention.

▪ BP MF22 Prohibition of the Use of Chemicals in Forestry Practices	
Description of the measure	Chemicals like fertilizers, pesticides or herbicides are substances which form a threat for water quality and hence should not be present in forested DWPA. In forests their use is generally only marginal. Despite this fact their use has to be prohibited within forested DWPA. The absence of the application of those chemicals is a crucial advantage of forested watersheds in contrast to agriculturally used ones.
Measure advantages	Pesticides and other agro-chemicals form a strong threat for source water quality in agriculturally used watersheds. The absence of the application of those chemicals is a crucial advantage of forested watersheds in contrast to agriculturally used ones. Hence this measure has to be applied with ultimate consequence.
Challenges	In Austria the application of chemicals in forestry is rare, but in some cases present. Within DWPZ the use of chemicals is in general prohibited. If this should not be the case, focused information transfer and persuasive efforts will have to be applied.
PA1.1-situation	The application of chemicals within the DWPZ of PA1.1 is restricted, and within the forest area of the city of Vienna chemicals are totally forbidden.
PA1.2-situation	The use of chemicals will be regulated with the decreed water protection zone. It has to be avoided strictly within the DWPZ.

▪ BP MF23 Source Water Protection Policy and Institutional Implications	
Description of the measure	In Austria, like in most of the CE partner countries substantial administrative deficits were identified in legislation within the context of the protection of DWPZ and source water quality and quantity. An integrated source water protection policy (SWPP) has to integrate all potential impact factors on water resources. The establishment of an adequate legislative and administrative frame would be a fitting outcome.

Measure advantages	Integrated source water protection policy takes all potential drivers, pressures and impacts on drinking water resources into account and defines routines for adequate response. This results in an encompassing drinking water protection and flood prevention/mitigation policy, which secures water resources.
Challenges	In Austria the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.
PA1.1-situation	For PA1.1 the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.
PA1.2-situation	Also for PA1.2 the PROLINE-CE output DriFlu Charta will form a step towards the elaboration and implementation of such an integrated source water protection policy.

▪ **BP MF24 Integrative Planning Strategy for Watersheds (Forest Ecosystems with drinking water protection as focus)**	
Description of the measure	The operative activities within watersheds (DWPZ) need a detailed planning process in order to be efficient. The water protection functionality (WPF) of the forest ecosystems has to be given over space and time. Deviations from an optimal WPF have to be detected by the screening of the current forest dynamics (monitoring). A GIS-based integrative planning strategy provides an efficient schedule for improving or maintaining the WPF of the forest ecosystems. Integration of all relevant impacts on source water protection into the planning strategy is required. The implementation of an adequate watershed classification according to the regional indicators, like e.g. vulnerability of the local ecosystems, tree species sets, etc. have to be set up for each DWPZ.
Measure advantages	The integrative planning strategy would establish a structured and operative tool for well-established management for DWPZ.
Challenges	The establishment of an integrative planning strategy in DWPZ would need the commitment of all involved stakeholders towards it. It would be a huge step for the Austrian drinking water protection sector.
PA1.1-situation	The establishment of an integrative planning strategy for watersheds within PA1.1 would be a huge step towards applied source water protection. Actually, there exist partial aspects of it, but the integration into one encompassing strategy would be an innovation.

PA1.2-situation	As the area of PA1.2 is owned by various different people and organisations, such an integrative planning strategy would be a huge step towards integral drinking source water protection. It could be based on the implementation of the incentive system.

2.4.2. Grassland

▪ BP MG1 Establishment or enhancement of grassland by regeneration process	
Description of the measure	Alpine ecosystems are characterised by unfavourable climatic conditions with limiting effects on growth and bio-mass production of plants that are increasing with altitude. At an altitude of 2000 m, the number of growing days (average daily temperatures > 5°C) is reduced to 67 days. In alpine environments, vegetation has therefore a growing season of two to three months to establish. Because of the limited growing period, restoration activities at high altitudes should be carried out the first weeks after snow melt. The results of investigations on climatic site conditions indicate that large scale interventions and thus restoration with seed mixtures generally should be avoided above altitudes of 2.400 m. Above timberline, more dense vegetation with a cover of about 80 % is recommended. Therefore, a sufficient combination of application technique and adapted seed mixture, reaching the minimum requirement of sustainable vegetation with 70 to 80 % cover within the first two vegetation periods has to be the goal behind restoration in high altitudes. Under average conditions of high altitudes, the necessary minimum demand on cover can be achieved in the second vegetation period at the earliest. This requires application techniques with sufficient protection of top soil for the first two vegetation periods. The best protection against erosion can only be reached by additional cover of the top soil with straw mulching, hay mulching, different mats, nets, three-dimensional mats etc. causing a clear decrease of superficial soil losses and water flow rate.

Measure advantages	One of the most severe problems within re-cultivation works in mountainous areas (with 30-45% slope gradient) is the increased surface run-off and soil erosion (B. Krautzer, AREC). Seeding procedures with adequate protection against erosion are important requirements for a successful revegetation. Without the adequate cover of the top soil indigenous and fast-growing species show a comparable bad erosion-behaviour within the first 4-8 weeks after seeding. In view of an economic evaluation, the set-up costs indicate that commercial seed mixtures would be much cheaper than seed mixtures including indigenous species. But when looking at the years following the set up the sites that use commercial seed mixtures have to calculate with follow up costs (reseeding and steady fertilisation). So, in the long term in order to reach a sustainable restoration the use of indigenous species is meaningful not only from an ecological but also from an economic standpoint.
Challenges	Within the whole alpine area, thousands of hectares are affected every year, e.g. by ski slopes, ski lifts, tourist infrastructure, improvement of alpine pastures and roads. After intervention, those areas are re-seeded and normally used as pastures. Such areas, mainly within the sub-alpine and alpine stage, are one of the most sensible parts of the Alps. Every intervention in such alpine living spaces leads to interference that requires different technical and ecological measurements to reach the goal of a sustainable restoration of those affected areas. This can only be reached with the help of indigenous plant material. For want of indigenous vegetation, seed mixtures have to be used in most cases. On 8 localities of the Alps, in different altitudes from 1.230 m to 2.340 m, the research project “Seed Propagation of Indigenous Species and their Use for Restoration of Eroded Areas in the Alps” (FAIR CT98-4024, short title “ALPEROS”), supported by the EC, was carried out in order to assess the possibilities to restore damaged areas using a combination of improved application techniques combined with seed mixtures of indigenous species.

	To get basic information about the effects of different application techniques on superficial soil losses and water flow rate, a mobile erosion facility with three chambers was built up at the location Hochwurzen (1,830 m ASL) in order to measure erosion in dependence on different application techniques after restoration.
PA1.1-situation	The use of autochthonous seeds for the grassland areas within PA1.1 is not of superior relevance, as cases of erosion which could be solved by sowing grassland seeds are not very common. Despite that fact artificial seed application is applied under rare circumstances especially after removal of krummholz.
PA1.2-situation	The use of autochthonous seeds for the grassland areas within PA1.2 is not of superior relevance. Despite that fact the use of autochthonous seeds for the grassland in case of eroded grassland sites should be state-of-the-art.

▪ BP M(P)G2 Establishment or enhancement of grassland by sowing or planting	
Description of the measure	Only autochthonous or regional seed from the natural surroundings of the respective construction project is optimally adjusted to the specific site conditions. As it usually origins from high-quality crops rich in species, it generates an especially dense, dynamic and powerful root system. The choice of the target vegetation must be based on the natural vegetation of the site to gain ecological stability and ensure a higher resistance to environmental stress and diseases and reducing therefore the maintenance demands and costs.
Measure advantages	Due to the especially dense, dynamic and powerful root system an optimal protection against soil erosion and the improvement of biodiversity can be guaranteed. Technical functions of primary importance in terms of the stabilisation properties of plants in the frame of soil and water bioengineering interventions are: 1. Covering of the ground using plant communities as protection against heavy precipitation, soil erosion by water and wind

	2. Mechanical anchoring and buttressing of the soil by the roots. 3. Cohesion and stabilisation of the soil trough the aggregation of soil particles by plant roots, humus, mycorrhizae and micro-fauna as well as interlocking or anchoring of topsoil and subsoil and prevention of the washout of fine material through their retention and filtering by the network of fine roots. 4. Slowing down and diverting air and water flow. Effects in the area of the root, in particular compression through the increase in root thickness, soil loosening due to movement of the root system induced by the movement of the stem and branches and soil compaction due to the weight of the vegetation. 5. Increase in overall soil cohesion through the extraction of water by evapotranspiration 6. Positive management of the local and regional water balance trough the evaporation of soil water, retention of precipitation water, retention of soil water and balanced water infiltration. But in areas with no or only little vegetation in gullies and other drainage channels intensive rainfall events may cause strong surface run-off causing intense erosion. That is why a dense vegetation cover is needed as associated with complementary measures to increase the roughness of the surface. A suitable coverage with vegetation such as wood, bushes and hedges can be used to regulate the water regime particular in extreme or very disturb sites like gullies, steep slopes or other erosion prone areas. The impact of these bioengineering measures can be especially important in catchments which are situated above an area of flood risk as well as a catchment belonging to hydro-dam and other constructions of water supply.
Challenges	Research on grassland farming in the alpine area exists in Austria since 1889. After successful breeding of cultivars of forage crops, a comprehensive programme for breeding of grasses and legumes for

	the use in seed mixtures for permanent grassland has been started. Additionally, also a programme for the propagation of seed of alpine and subalpine ecotypes for erosion protection and landscaping has been conducted. One result of these efforts is the launch of a special cultivar. A number of indigenous species have been selected during the last years, optimising the production and harvesting technique for successful seed production. The slow growing rate of the alpine grasses and forbs, their subsequently low competitive capacity and their susceptibility to fungal diseases make seed production difficult in context of organic farming. Therefore, 18 subalpine and alpine grasses, legumes and herbs have been selected by means of intensive research procedures, to be propagated and used for high zone restoration. In Austria indigenous seed mixtures for different altitudes and site conditions are available on the market.
PA1.1-situation	In case of erosion processes on the grassland areas sowing with indigenous seed mixtures would be an appropriate tool for re-establishment of the vegetation cover.
PA1.2-situation	In case of erosion processes on the grassland areas sowing with indigenous seed mixtures would be an appropriate tool for re-establishment of the vegetation cover.

▪ BP M(P)G3 Supporting guidance for creation of low-input grassland to convert arable land at risk of erosion or flooding	
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 per cent 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 is 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: 1. particularly long uninterrupted slopes 2. field valleys, low corners or other areas which tend to concentrate run-off 3. 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 4. areas which drain directly to a watercourse will be of greater risk of transferring eroded soil to the watercourse 5. areas with flooding risk (adjacent to watercourses)
Challenges	Only certain sustainable measures are provided from funding system for environmentally friendly management of agrarian land.
PA1.1-situation	There cannot be found any arable land within the PA1.1 at the moment, this situation will not be different in future, what is due to the alpine location of the DWPZ. Hence this BP is not relevant.
PA1.2-situation	There cannot be found any arable land within the PA1.2 at the moment. Grassland could be converted into arable land, but this management-step does not seem to be very probabilistic. In case of future conversions dialogues with the farmers will become necessary.

■ BP M(P)G4 Weed control in particular against invasive plant species	
Description of the measure	Invasive plant species are considered as one of the major threats to biodiversity. They can reduce yields from agriculture, forestry and fisheries, are known to decrease water availability and to cause land degradation. They suppress native plants that play an important role in binding soil with their roots and may thereby contribute to increased soil erosion. The main identified costs in Europe comprise eradication and control costs and damage to agriculture, forestry, commercial fisheries, infrastructure and human health. Comprehensive management measures against these invasive plant species have to be pursued continuously by all countries to minimize their expansion.
Measure advantages	Through intensive destruction of invasive species, especially plant species as they are most important concerning water resources protection and flood mitigation, native species can spread over their original range and provide again the necessary ecosystem services (e.g. minimizing soil erosion and land degradation, improvement of water quality).
Challenges	Main goal is the optimization of existing legal instruments and tools for implementation and monitoring together with voluntary measures, but clearing invasive alien species is an expensive business.
PA1.1-situation	BP not yet considered. If necessity will arise suggestions and BMP will be applied. At grassland sites there has not been identified the risk for the establishment of invasive plant species within the PA1.1. Invasive alien species can be found along the brooks and rivers.
PA1.2-situation	There has not been identified the risk for the establishment of invasive plant species at the grassland-sites within the PA1.2.

■ BP M(P)G5 Reduction of nutrient inputs into water resources	
Description of the measure	Due to land use management measures within

	grassland/agricultural areas concerning adequate fertilisation, especially adjacent to water courses and lakes, water pollution through nutrients can be mostly prevented. Following measures should be considered: optimum timing of application, reduction of fertiliser-amount, special techniques of application, avoidance of soil compaction, and maintenance/establishment of a dense grass sward. By means of indicator plants the specific site status can be identified (A. Bohner, AREC). Changes of site characteristics as well as wrong fertilisation and cultivation measures can be recognised at an early stage. Site specific improvement measures and the adequate demand for fertilisation can be estimated accordingly.
Measure advantages	Through suitable cultivation measures within arable and grassland areas losses of nutrients (e.g. phosphorus) to the groundwater and surface water can be reduced and the respective water quality will be improved.
Challenges	To reach this target, phosphorus inputs from agricultural used areas have to be reduced.
PA1.1-situation	No fertilizers are applied in PA1.1. Already accomplished studies show that the nitrogen balance is negative due to grazing. The problems within PA1.1 are stemming from cow-dung in the areas of the subalpine and alpine pastures.
PA1.2-situation	Within the PA1.2 all substances stemming from manure and liquid manure constitute a problem for source water quality hence microbes, nitrate, phosphorus and all other critical substances have to be prevented from leaching into the aquifer. The application of fertilizers should be restricted within the DWPZ so that source water quality can be maintained on a high level.

▪ BP MG6 Site-appropriate extensive management of mountain pasture land	
Description of the measure	Through the abandonment of pastures or inadequate intensive management measures in mountainous areas the adequate ecosystem service “protection of surface and soil” gets lost. Mudslides and erosion

	processes increase and important areas and soils are destroyed as the former vegetation and its root-system changes. After intensive fertilisation or abandonment of pastures the rooting decreases and thus the potential risk of erosion processes increases. Fallow lands of 15 up to 20 years are the most unstable areas (TASSER et al. 2004). Within sensible sites (e.g. steep gullies, sensitive wetland areas, DWPZ) also erosion processes and soil losses can occur by trampling damages through livestock. Grazing should be accordingly limited or totally abandoned within these areas. On already destroyed sites the improvement of the sward through site-specific seeds should be conducted supplemented with adequate fertilisation. Important in this connection is the diversity of the vegetation to provide different root-lengths, so that the interlocking with the underground and the stabilisation of the topsoil get improved.
Measure advantages	Site-appropriate management of pastures cause a positive effect on water storage capacity and run-off behaviour during rainfall. The risk of dangerous torrent-flows or erosion processes throughout heavy rainfalls decreases.
Challenges	The adequate extensive management of mountain pastures is very labour-intensive, difficult and uneconomic. Therefore, in some areas of Austria the danger of abandoned pastures in the mountains increases. Nevertheless, some positive examples exist.
PA1.1-situation	No negative impacts on the water resources due to pasture abandonment have been detected. Within the DWPZ of the City of Vienna (PA1.1), cattle-grazing is regulated in a way, that dolines and sink-holes are fenced so that cattle cannot approach these highly vulnerable sites. Through these measures the critical dung of cattle is intended to be kept in distance to the areas, which have direct connection to the aquifer. In order to avoid the direct entrance of precipitation water also technical constructions were used, like e.g. dams which prevent precipitation water from directly flowing into dolines or sinkholes. The water can subsequently infiltrate slowly via the

	soil matrix, so that the potential contaminants are reduced (soils are acting like a filter). Additionally. for avoiding erosion processes and consequently threat for source water quality by trampling damages through livestock (above all cattle), fencing of erosive sites was done for keeping livestock away from there.
PA1.2-situation	A classical mountain-pasture area is situated at Mount Schnabelberg. Any measures to reduce the intensity of use of this pasture area would be of interest for securing water quality. The afforestation of this area would be the best solution with regard to drinking water protection.

2.4.3. Agriculture

Within both PA1.1 and PA1.2 currently there do not exist agricultural areas, all farmland areas can be associated with grassland or subalpine pastures.

2.4.3.1. Urban areas (settlements)

▪ BP U1 Utmost care with mineral oil products	
Description of the measure	All mineral oil products (MPR) used in settlement areas have to be handled with utmost care. It has to be avoided that MPR enter the soils and could be transferred to the aquifers. Hence all MPR have to be kept within their intended courses of application. Oil tanks and all oil lines have to be kept sealed. Oil tanks need special level of quality and containments. Oil tanks within areas endangered by flood events have to be prohibited.
Measure advantages	The measure ensures that no MPR are entering the aquifer. This is of crucial importance for drinking water security.
Challenges	The sustainable implementation of the measure needs communication with people living in the settlements within the DWPZ. They might show resistance against the implementation of the measures, but have to be convinced about the urgent dimension of integral drinking source water protection.
PA1.1-situation	There are no urban areas within the PA1.1.
PA1.2-situation	The settlements within the DWPZ in PA1.2 have certain restrictions. The usage of oil-tanks is restricted within the DWPZ. Also, the intrusion

	into the soil in the course of new constructions or drilling boreholes for thermal pumps is restricted. Sewers are subject to approval in terms of the Water-Act. All houses except 4 are actually connected with the public sewage system, which was set up during the years 2012-2015, applying the technical state-of-the-art. All five years the sewage system and also the seeping pits are checked for tightness.

▪ BP U2	Avoidance of pesticide application in settlement areas
Description of the measure	Pesticide application within settlement areas in the DWPZ has to be avoided. Many products are already wide-spread in current days, like e.g. 'RoundUp' (Glyphosat) or others. People have to be informed about the threat they are creating also to them-selves if they use those products within their gardens or on their paved areas. Information about alternatives could be part of the strategy.
Measure advantages	The measure ensures that the application of pesticides is limited and avoided within the DWPZ. This contributes to the drinking water security.
Challenges	People might show resistance against the application of the measure if they are used to the application of pesticides. This creates the need of an information campaign.
PA1.1-situation	Within the DWPZ the application of pesticides is strictly limited.
PA1.2-situation	Within the DWPZ the application of pesticides is restricted. The application and also the storage of pesticides have to be declared and have to be approved. Until now there were not detected any pesticides or metabolites within the source water.

2.4.4. Industrial areas

▪ BP I1	Avoidance of the construction of new industrial areas within the DWPZ
Description of the measure	The construction of new industrial areas within the DWPZ is avoided, instead there are provided more adequate sites for the facilities, which are not connected with aquifers used for water supply.
Measure advantages	The measure ensures that no potentially hazardous substances used within industrial facilities could enter the aquifers, simply by avoiding those activities within the DWPZ. This contributes to drinking water security.
Challenges	It might be difficult to prevent industries to settle within DWPZ, but if

	there exists a decreed WPZ, this restriction might be easier being implemented.
PA1.1-situation	Within the DWPZ of PA1.1 there do not exist industrial facilities. Also, the construction of new facilities is not realistic what is due to the remote location of the DWPZ.
PA1.2-situation	Within the DWPZ of PA1.2 the construction of any new industrial facility will not be allowed. Actually, there are two industrial plants operating within the DWPZ.

▪ **BP I2** **Industrial Activities within the DWPZ carried out with utmost care**	
Description of the measure	Clear guidelines within the context of the use of potentially hazardous materials (PHM) make sure that those remain in the intended containments. The whole chain of PHM usage is under surveillance and the industrial use follows the technical state-of-the-art. Hence the risk that PHM enters the aquifer is minimized.
Measure advantages	The measure ensures that the risk is minimized that potentially hazardous materials (PHM) used within industrial facilities could enter the aquifers. This contributes to drinking water security.
Challenges	It might be difficult to convince the owner of such industrial facilities to apply the state-of-the-art technique, as it might be more expensive than the business-as-usual.
PA1.1-situation	Within the DWPZ of PA1.1 there do not exist industrial facilities. Also, the construction of new facilities is not realistic what is due to the remote location of the DWPZ.
PA1.2-situation	Within the DWPZ of PA1.2 two industrial facilities are in operation. The inspection of the two facilities showed that potentially hazardous materials (PHM) for human health and drinking water are used and stored there. But the quantities of those PHM are so little that also in case of an accident the water could be contaminated, but the threshold values never could be exceeded. For providing a high level of drinking water security the restrictions for the industry are as follows: Sewage channels have to be inspected regarding impermeability every 5 years. The construction of traffic areas, water mains, drillings or other activities which encompass the soil are subject to approval in terms of the Water Act. Also, unpaved parking areas and the infiltration of surface water are forbidden. The storage and application of PHM is officially strictly restricted. Additionally, the enterprises have to elaborate emergency plans how to act in case of accidents.

2.4.5. Stone Quarries and Gravel Pits

▪ BP S1	Abandonment of stone quarries within DWPZ
Description of the measure	Stone quarries are abandoned within DWPZ. This is the only measure which excludes any potential danger stemming from active stone quarries. Areas which are prone to be vegetated are planted with autochthonous seeds of soil plants and trees.
Measure advantages	All potentially harming activities within stone quarries are stopped. This contributes to drinking water security.
Challenges	It might be difficult to convince the owner of stone quarries to stop the mining activities, what might be due to the profitable running of the quarry.
PA1.1-situation	Within the DWPZ of PA1.1 there do not exist huge stone quarries for industrial use. Only small quarries (gravel pits) for the construction of forest roads are in operation, their spatial extension is rather small.
PA1.2-situation	Within the DWPZ of PA1.2 two stone quarries are actually in operation, but the level of operation is already focused on the abandonment of the quarries. Two stone quarries are actually already abandoned.

▪ BP S2	Utmost care in the course of working-processes in stone quarries
Description of the measure	Stone quarries are run with utmost care within DWPZ. All given restrictions are met. The works within the stone quarry are executed according to the technical state-of-the-art. The stone quarry is intended to be abandoned soon. The embankment has to be adapted towards a 45° angle for being re-vegetated. For being within limits also rock-faces may be present, hence the spatial demand of the adaptation can be minimized.
Measure advantages	All activities within stone quarries are carried out with utmost care for the water resources. The overall purpose of the measures is the abandonment of the quarry.
Challenges	It might be difficult to convince the owner of stone quarries to carry out the mining activities with utmost care, as this may involve higher costs.
PA1.1-situation	Within the DWPZ of PA1.1 there do not exist huge stone quarries for industrial use. Only small quarries (gravel pits) for the construction of forest roads are in operation, their spatial extension is rather small.
PA1.2-situation	Yearly the stone quarries are examined by the authorities, including geological, water level and water quality investigations in groundwater

	and surface waters. Additionally, it is examined whether the restrictions regarding waste, waste waters, storage and refuelling with gasoline and oil are met. For potential accidents it is necessary to store oil binding agents. The devices like trucks and excavators have to be checked with regard to drip losses. If the devices are not in operation they have to be parked at sealed and roofed surfaces. Between the yearly controls unexpected examinations are carried out through the water works and the authorities. A potential extension of the stone quarry was forbidden through the authorities.

2.4.6. Tourism

▪ BP T1 Financial support and contributions of and to other stakeholders	
Description of the measure	The installation of waste water and sewage treatment is supported, especially within the context of mountain huts within the DWPZ. The transport of waste water and sewage out of the DWPZ is being paid. Farmers are supported building stables, build drinking places for animals, fencing in vulnerable spots, etc.
Measure advantages	The financial support enables effective protection measures. Long lasting negotiations or even law suits are not necessary.
Challenges	High costs.
PA1.1-situation	Vienna Water has already supported larger projects (stables and touristic mountain huts). For smaller operations a yearly budget is planned. The financial contribution is based on contracts which state conditions for sustainable water protection.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP T2 Installation of compost toilets in small mountain huts	
Description of the measure	Approximately 22.000 mountain huts and refuges currently exist in the Alps. Most of them are situated in extreme locations where they are hard to access. Nevertheless, they generate relevant amounts of sewage and wastewater. In order to protect the Alpine environment and to preserve drinking water resources, the wastewater generated by mountain huts and refuges must be properly treated and/or disposed to minimize adverse impacts. For adapted sanitation systems, composting toilets are a possible system component, especially in the case of water shortage. Composting toilets can be applied as component of the sanitation system at remote objects in the alpine region. Due to the extreme

	climatic conditions, the degradation efficiency of the composting process for the reduction of hygienic parameters is low or does not work at all. The not continuous delivering of compost material is an additional challenge. Vienna water has in close cooperation with the University of Live Sciences in Vienna developed the toilet design and the composting (degradation) process in order to implement sanitation systems in the DWPZ.
Measure advantages	The composted sewage and wastewater may be disposed in the protection area with (almost) no hazard to the aquifer.
Challenges	The composting period takes for years. The investment is medium price. The handling needs training.
PA1.1-situation	After the development and testing the implementation is ongoing.
PA1.2-situation	There is no such situation within the PA1.2.

2.4.7. Alpine karst regions

▪ BP AK1 Geological mapping	
Description of the measure	Geology is part of the natural system. The distribution of the different rocks is mapped, and profiles are constructed to achieve a 3-dimensonal picture of the underground. The hydrologic properties of the rocks are described.
Measure advantages	It is indispensable for assessing impacts of land use activities on water resources and for designing measures and management plans. A geological map is the basis for other investigations.
Challenges	Depending on the extent and the topographic characteristic of the catchment area geological mapping is elaborate, costly and time consuming.
PA1.1-situation	The total catchment area of the DWPZ is geologically mapped.
PA1.2-situation	The total catchment area of the DWPZ is geologically mapped.

▪ BP AK2 Investigation of the geological structure	
Description of the measure	Based on the geological map the structure of the underground is mapped, described and assessed. The geological structure is characterised by faults and other geological lineaments. The hydrological properties of faults have to be studied and described (faults can be more or less permeable and drain the water in special

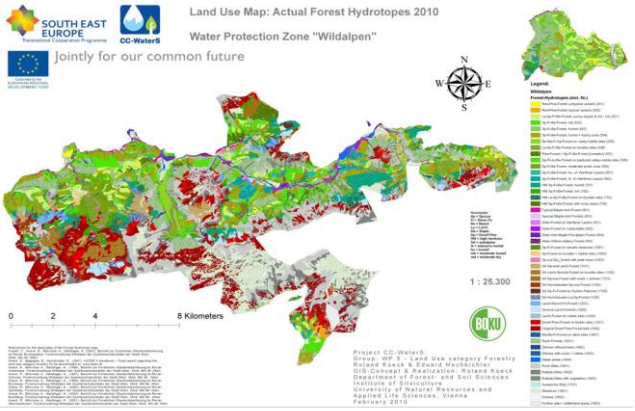
	directions).
Measure advantages	Basically, structural mapping is detailing geological mapping especially for hydrological and water supply reasons. It is essential for hydrological modelling and allows for a better understanding of the processes in the aquifer.
Challenges	The measure is elaborate.
PA1.1-situation	Just parts of the catchment area of PA1.1 are mapped and investigated. Additional parts will be studied in course of PROLINE-CE.
PA1.2-situation	There is no such situation within the PA1.2.

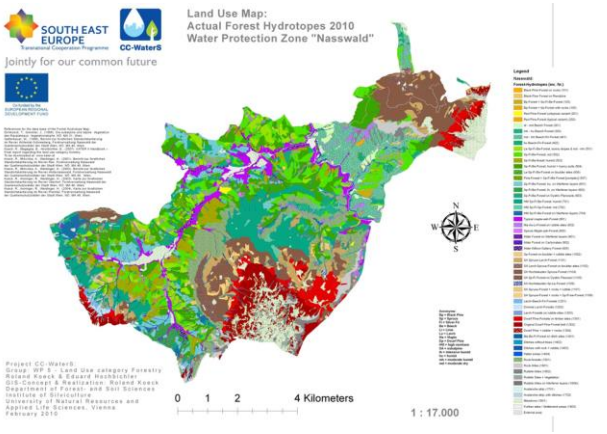
▪ BP AK3 Investigation of the karst-morphological features and properties	
Description of the measure	Carbonate rocks especially limestones are prone to solution by hydro-carbon-acid which is dissolved in water. This solution forms ways of easy and rapid water infiltration and transport. To map these karst features on the surface (polje, dolines, ponors, sink-holes, …) are mapped and characterised. Secondly caves are explored and their influence on the water cycle described.
Measure advantages	Karst-morphological mapping helps to locate vulnerable zones and points.
Challenges	The measure is elaborate.
PA1.1-situation	Just parts of the catchment area of PA1.1 are mapped and investigated. Additional parts will be studied in course of PROLINE-CE.
PA1.2-situation	There is no such situation within the PA1.2.

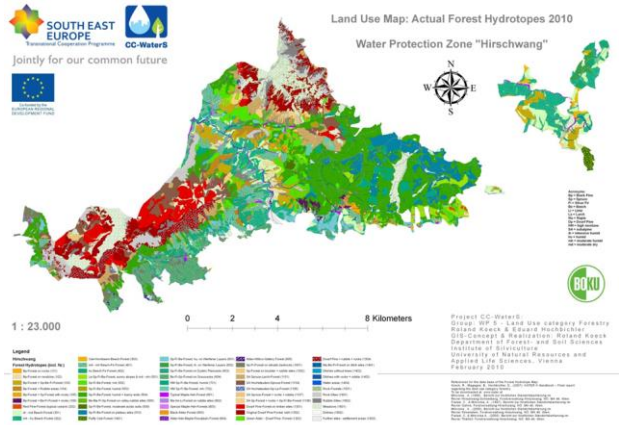
▪ BP AK4 Mapping and investigation of soils	
Description of the measure	The spatial distribution of soils is mapped. The thickness and other features of soils are described.
Measure advantages	Soils are important for filtering, buffering and retaining precipitation water. To assess the vulnerability of the system the knowledge of soils – their spatial distribution and their specific properties – is important.
Challenges	The measure is elaborate.
PA1.1-situation	The area owned by the city of Vienna is totally mapped. This concerns mainly the forested areas. Areas above the timberline are just partially mapped. In this area the distribution of the soils can be concluded from vegetation and karst-morphologic maps. Some of the soils will be mapped during inspection tours.

PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK5 Mapping and investigation of forests (see Best management practices 2.3.1)
The forest hydrotope model, which was created out of the forest site mapping survey of the water protection forests of the city of Vienna:







▪ BP AK6 Mapping and investigation of vegetation above the timberline	
Description of the measure	The spatial distribution of plants is mapped. Their properties regarding erosion prevention and influence on the water cycle is described.
Measure advantages	The knowledge of plant cover and plant type helps to design water protection measures. Soils are important for filtering, buffering and retaining precipitation water. To assess the vulnerability of the system the knowledge of soils – their spatial distribution and their specific properties – is important.
Challenges	The measure is elaborate.
PA1.1-situation	Except for small areas the total catchment is mapped. The rest will not be mapped.

PA1.2-situation	There is no such situation within the PAC1.2.

▪ BP AK7 Studies of Microbial situation	
Description of the measure	Springs are probed and the amount, of microbes is determined. The abundance of microbes is put in relation with hydrological events. Samples of faeces are collected in the catchment area and that allows for a so called microbial source tracking (MST).
Measure advantages	Origin of microbial contamination can be determined and appropriate measures can be designed.
Challenges	The measure is elaborate, costly and time-consuming.
PA1.1-situation	Relevant studies are already accomplished. Their results will be included in other projects.
PA1.2-situation	There is no such situation within the PAC1.2.

▪ BP AK8 Evaluation of pastures	
Description of the measure	Pastures are mapped regarding their quality and yield. Additionally, the intensity of their use is mapped.
Measure advantages	Such maps give a good impression, where cattle prefer to stay. Protection measures can be designed adequately. A further advantage is that such studies are also informative for farmers and it facilitates the discussion.
Challenges	The measure is elaborate.
PA1.1-situation	Investigations in this realm have started and will be extended regarding the need.
PA1.2-situation	There is no such situation within the PAC1.2.

▪ BP AK9 Determination of spatial patterns of surface runoff and its influence on spring dynamics	
Description of the measure	This best practice combines classical hydro-geological mapping methods and hydrological modelling for representing spatially distributed information of the interplay of infiltration and surface runoff processes in a karstic catchment. Aim is the identification of surface runoff patterns at different hydrological conditions, e.g., during summer storms. Classical hydrogeological mapping is extended

	by the "process-oriented" view, i.e. a detailed description of dominant runoff generation mechanisms at an area. The procedure provides two results: (a) A static "surface runoff propensity index" is provided by the mapping which contains a specification of typical flow lengths. It is a quick measure of the frequency of surface runoff occurrence. (b) Transient modelling provides dynamic surface runoff patterns at different events. Also, from the continuous simulation patterns of frequency of surface runoff occurrence are produced.
Measure advantages	In karstic catchments, occurrence of surface runoff and corresponding erosion processes can lead to input of solutes/contaminants into the system that may affect spring quality, particularly during aestival thundershowers. During these events, the generation and flow paths of surface runoff play an important role for material mobilization and transport. The main advantage of the procedure compared with traditional vulnerability mapping is the incorporation of hydrological processes in mapping ("process-oriented") and the combination with transient modelling, which allows for an illustration of dynamic surface runoff patterns. These can be analysed at different event types and different hydrological conditions whereas vulnerability maps are static. In the highly vulnerable catchments of karst springs of the Vienna drinking water supply the model is used for optimizing land management and formulating water safety plans in a risk based procedure by overlaying the surface propensity with solute loads.
Challenges	The view on hydrological processes is not common in hydrogeological mapping which traditionally regionalises lithological/soil properties from a limited number of mapping points. The challenge is to map a large number of points and polygons with less detail rather than few points with a lot of detail. Strictly applying (hydro)geological mapping principles implies that only those items are included which are possible to categorize in the field. These principles are extended by the "process-oriented" view. This provides a pre-defined mapping catalogue and enables to map a large remote region without using a regionalisation model. Cooperation between the hydrogeologist (mapping) and hydrologist (modelling) is an essential part of this method. Comprehensive discussions are particularly important for defining the mapping catalogue in a systematic, process-oriented way as well as for specifying dominant processes. On the other hand, selection of model parameters requires a high degree of hydrological understanding and modelling knowledge. This significantly reduces uncertainties introduced by the parameter upscaling procedure. Model calibration is limited in a karstic catchment, when catchment boundaries are not known. Furthermore, the generally coarse spatial rainfall distribution in high alpine areas increases uncertainties in

	parameter identification.
PA1.1-situation	A pilot study has been accomplished already. In PROLINE-CE the continuation of this investigation is the central part of the thematic work.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK10 Climatological and hydrological monitoring	
Description of the measure	State-of-the-art climatological monitoring is performed at stations in the catchments recording parameters such as precipitation, temperature, air humidity, global radiation, as well as snow depths. At the springs discharge (water quantity) is recorded as well as other parameters such as electric conductivity, SAC254 and turbidity, which indicate water quality measures.
Measure advantages	Comprehensive monitoring is necessary for drinking water supply management and early warning (based on water quality thresholds). Archiving and documentation allows for analysing hydrological behaviour and tracing activities in the system.
Challenges	In the high alpine region station maintenance is very time consuming and expensive. Particularly precipitation data in winter are often of critical quality and need a comprehensive check or correction. Due to the high number of spring gauges, data have to be well organised (data bases) and data screening and checking is time consuming. Building measurement infrastructure is costly.
PA1.1-situation	The number and location of meteorological and hydrological stations was designed in cooperation with agencies and is regarded as sufficient. Also, the data handling is organised and operated in cooperation with public meteorological and hydrological agencies.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP 11 Development of a GIS (Geographical Information System)	
Description of the measure	In order to use all the information described in the previous BP examples a GIS-based tool is most appropriate to assess the information. It includes all spatial information and is connected to the measurements from the monitoring systems.
Measure advantages	Information can be used optimal, can be merged and visualized. The connection to the data from the monitoring systems allows for an integration of all information.
Challenges	The development of such a system is elaborate, costly and time

	consuming. Also, the maintenance is challenging.
PA1.1-situation	Vienna Water has developed such a system and it is regarded as a valuable tool and it is updated according to the progress of other operations.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK12 Catchment inspection tours	
Description of the measure	In regular intervals the catchment area is monitored by staff of Vienna Water, who report their observations and problems encountered. Changes in nature can be observed, described and assessed. But even more important are contacts with other stakeholders met during the tour. That enables the exchange of information and the stating of problems which are to be solved.
Measure advantages	The regular contact with other stakeholders is of great importance for both sides. Changes which cannot be measured are also described and can be evaluated.
Challenges	Own staff in the catchment area is necessary.
PA1.1-situation	Vienna Water implemented this practice since decades and regards it as indispensable.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK13 Financial support and contributions of and to other stakeholders	
Description of the measure	The installation of waste water and sewage treatment is supported. The transport of waste water and sewage out of the DWPZ is being paid. Farmers are supported building stables, build drinking places for animals, fencing in vulnerable spots, etc.
Measure advantages	The financial support enables effective protection measures. Long lasting negotiations or even law suits are not necessary.
Challenges	High costs.
PA1.1-situation	Vienna Water has already supported larger projects (stables and touristic mountain huts). For smaller operations a yearly budget is planned. The financial contribution is based on contracts which state conditions for sustainable water protection.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK14 Paddock management of mountain pastures

Description of the measure	In most pastures in karstic areas there are sink holes, creeks and dolines. Those are sensible locations where potentially contaminated surface water may infiltrate into the aquifer. Paddock management allows to steer and direct farm animals away from sensible area but still allowing for sufficient grazing. The pasture can be used more efficient because the grazing is distributed optimal over the total pasture area.
Measure advantages	The infiltration of contaminated water can be minimised. The advantage for farmers is that the whole area of the pasture can be grazed. On the long run this method helps to improve the quality of animal feed and limits the spreading of weed which is not grazed by animals.
Challenges	The fencing and the maintenance of the fences is time consuming. Water places are scarce in karstic areas and watering places or drinking troughs have to be provided.
PA1.1-situation	In the PA1.1 paddock management is implemented step by step where appropriate.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP AK15 fencing of sensible spots	
Description of the measure	Instead of dividing a pasture in several paddocks the fencing out of sensible spots can achieve the same protection results.
Measure advantages	The infiltration of contaminated water can be minimised. Animals can go to existing watering places.
Challenges	The fencing and the maintenance of the fences is time consuming. Fencing out is often not possible since sensible spots are often drinking places for the animals.
PA1.1-situation	It is long lasting practice in PA1.1 and implemented when regarded as necessary.
P1.2-situation	There is no such situation within the PA1.2.

▪ BP AK 16 Growing of vegetation around or along sensible spots	
Description of the measure	Growing of local vegetation (mostly dwarf pine in Austrian alpine areas) around or along sensible spots.
Measure advantages	The growing may happen as a natural process. For planting the effort is low. No maintenance is necessary.
Challenges	The natural growing is very slow and may take decades and cannot be

	influenced. Planting shows often that growing and spreading does not succeed.
PA1.1-situation	It is long lasting practice in PCV and implemented when regarded necessary.
PA1.2-situation	There is no such situation within the PA1.2.

▪ BP 17 Installation of compost toilets in small mountain huts	
Description of the measure	Approximately 22.000 mountain huts and refuges currently exist in the Alps. Most of them are situated in extreme locations where they are hard to access. Nevertheless, they generate relevant amounts of sewage and wastewater. In order to protect the Alpine environment and to preserve drinking water resources, the wastewater generated by mountain huts and refuges must be properly treated and/or disposed to minimize adverse impacts. For adapted sanitation systems, composting toilets are a possible system component, especially in the case of water shortage. Composting toilets can be applied as component of the sanitation system at remote objects in the alpine region. Due to the extreme climatic conditions, the degradation efficiency of the composting process for the reduction of hygienic parameters is low or does not work at all. The not continuous delivering of compost material is an additional challenge. Vienna water has in close cooperation with the University of Live Sciences in Vienna developed the toilet design and the composting (degradation) process in order to implement sanitation systems in the DWPZ.
Measure advantages	The composted sewage and wastewater may be disposed in the protection area with (almost) no hazard to the aquifer.
Challenges	The composting period takes for years. The investment is medium price. The handling needs training.
PA1.1-situation	The composting period takes for years. The investment is medium price. The handling needs training.

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

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

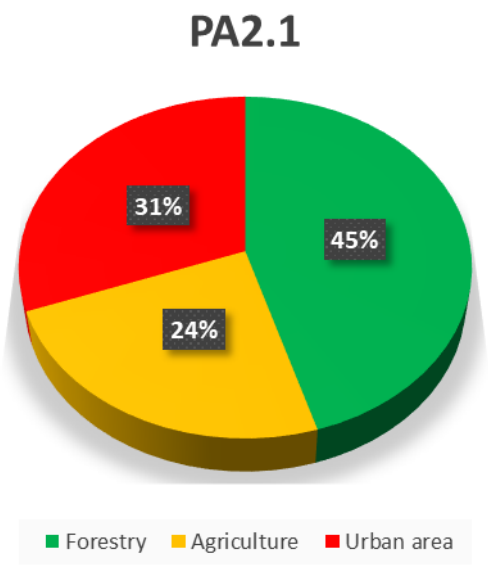
Into the Pilot Action Cluster 2 (PAC2) five Pilot Actions were assigned:

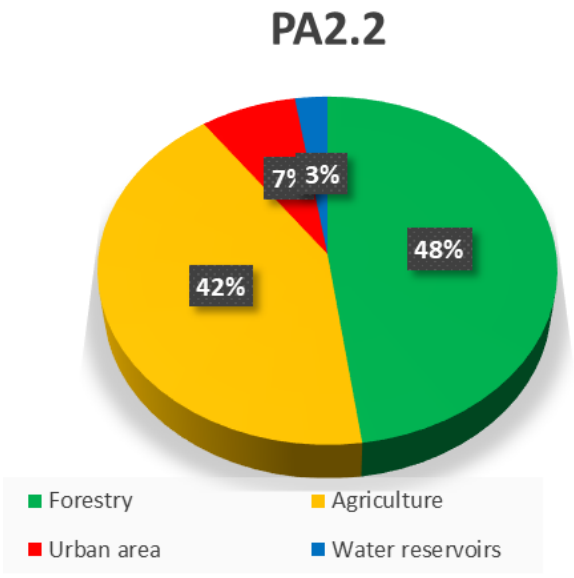
- PA2.1: Well field Dravlje valley in Ljubljana, Slovenia,
- PA2.2: Water reservoir Kozłowa Góra, Poland,
- PA2.3: Tisza catchment area, Hungary,
- PA2.4: Groundwater protection in karst areas in Croatia (PA2.4.1: South Dalmatia: Prud, Klokun and Mandina spring; and PA2.4.2: Imotsko polje springs);
- PA2.5: Neufahrn bei Freising, Germany.

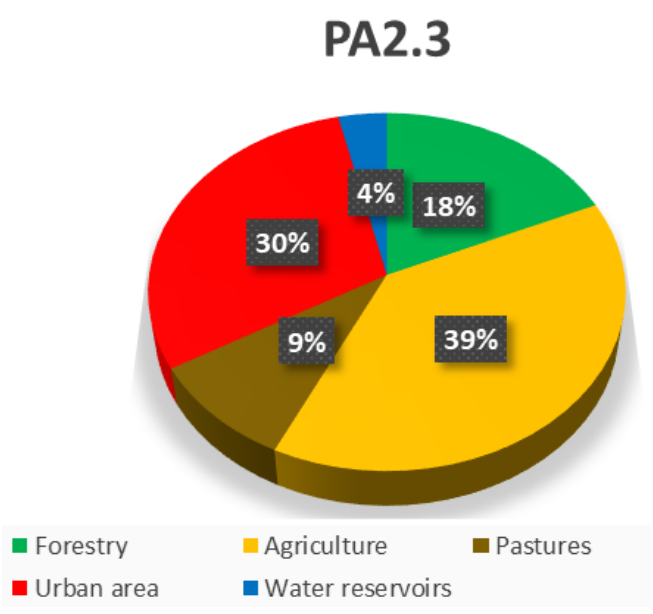
All Pilot Actions are in plain areas and the major land use is agriculture (with grasslands) and also urbanization. PA2.2 and PA2.3 present surface waters as drinking water sources, whereas PA2.1, PA2.4 and PA2.5 present groundwater as drinking water sources in different types of aquifers: PA2.1 and PA2.5 in porous aquifer and PA2.4 in karst aquifer.

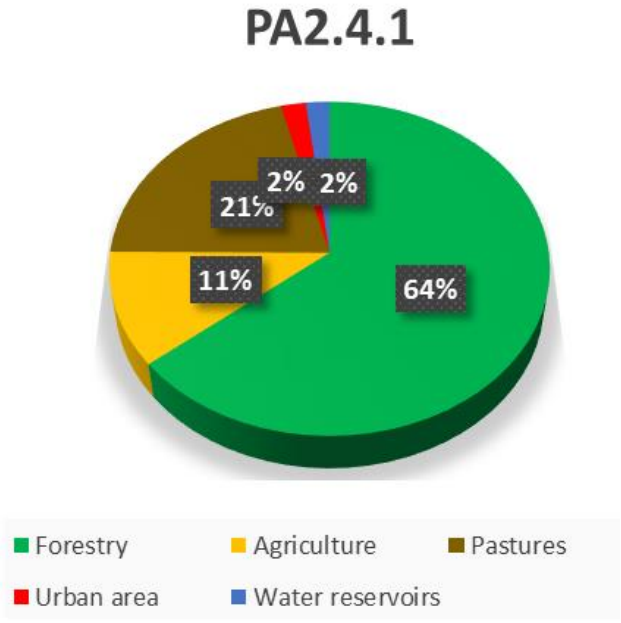
3.1. Land use

The dominating land use types within PA2.1, PA2.2, PA2.3, PA2.4.1, PA2.4.2 and PA2.5 are forest and agriculture. There are also pastures, urban areas and water reservoirs.


PA2.1
31%
45%
24%
Forestry
Agriculture
Urban area


PA2.2
7%
3%
48%
42%
Forestry
Agriculture
Urban area
Water reservoirs


PA2.3
4%
18%
30%
9%
39%
Forestry
Agriculture
Pastures
Urban area
Water reservoirs


PA2.4.1
2%
2%
21%
11%
64%
Forestry
Agriculture
Pastures
Urban area
Water reservoirs

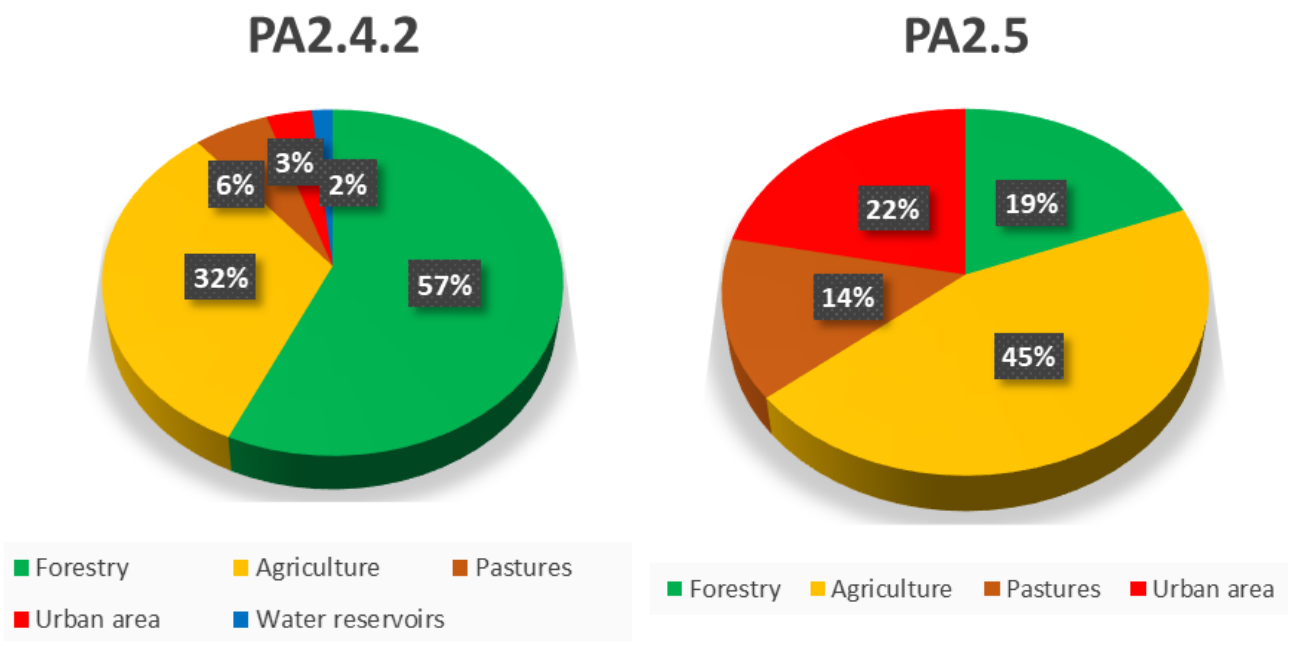


Figure 2: The land use types within PA2.1, PA2.2, PA2.3, PA2.4 (2.4.1 and 2.4.2) and PA2.5.

The largest percentage of surface in **Slovenia** is covered with forest and semi natural areas (45.3 %), following with artificial surfaces (30.6 %); the least of the surface belongs to agricultural areas (24.1%).

The largest part of the **Polish** sub-basin is covered by forest areas – 47.8% of the land area. Most of the remaining surface is covered by agricultural lands (42.3%).

The largest part of the **Hungarian** PA is covered by non-irrigated arable lands (35,42%), discontinuous urban fabric (14,06%) and broad-leaved forest (17,36%).

Croatian, Prud-Klokun-Mandina spring area covers Broad-leaved forests (37919 ha) along with the transitional woodland-shrub areas (12125 ha) at least the majority of Pilot Action area. Agriculture: Valuable agricultural soil is concentrated in the Neretvadelta, near Baćinska lakes, karst fields, sinkholes and karstic plains.

Pilot Actions **Imotsko polje springs (Croatia)** land is mostly Broad-leaved forests (6652 ha) along with land principally occupied by agriculture, with significant areas of natural vegetation (3715 ha) which covers the majority of Pilot Action area.

The **German** pilot areas Neufahrn bei Freising land use in the pilot area is dominated by (non-irrigated) arable land (44.86 %).

3.2. Drinking water protection

Drinking water protection zones (DWPZ) are established for the purpose of the protection of groundwater and surface water sources.

Table 4: Drinking water protection zones (DWPZ) within PAC 2.

PA2.1 Slovenia	DWPZs are divided into inner areas due to different levels of protection: a) wider area with the moderate protection regime (III) b) subzone with milder protection regime (IIIA) c) subzone with mild protection regime (IIIB) d) narrow area with the rigorous (strict) protection of the water protection regime (II) e) subzone with strict protection regime (IIA) f) subzone with less strict protection regime (IIB) g) the narrowest area with the most rigorous protection regime (I) Pilot Action Dravlje valley lies at the border of two groundwater bodies: the Ljubljansko polje aquifer and the Ljubljansko barje aquifer and is a location for potential water well filed, which is for now only a reserved area in the Spatial plan of the Municipality of Ljubljana.
PA2.2 Poland	There are no drinking water protections zones concerning surface water on the Pilot Action area.
PA2.3 Hungary	The protective measures set forth in the regulation serve the following purposes: a) The inner protective block, zone: protection of the abstraction works and the water supplies from direct pollution and damage, b) The outer protective block, zone: protection against refractory, further bacterial and other decomposable pollutants, c) The hydrology or hydrogeological block, zone: Protection against refractory pollutants by measures prescribed for the entire, or part of the catchment (recharge) area of the abstraction. The hydrogeological protective block or area is subdivided to "A", "B" and "C" protective zones. There are total 165 drinking water resources (155 working, 6 perspectives and 2 reserve resources) on the Pilot Area. From these there are 4 bank-filtered resources, 151 groundwater, 4 shallow groundwater and 2 surface drinking water resources.
PA2.4.1 Croatia Prud-Klokun-Mandina	Sanitary protection zones in aquifers with fracture and fracture-cavernous porosity are divided into: a) zone of limitation (IV. zone), b) zone of limitation and surveillance (III. zone), c) zone of strict limitation and surveillance (II. zone),

spring	d) zone of strict protection regime and surveillance (I. zone).
PA2.4.2 Croatia Imotsko polje springs	Sanitary protection zones in aquifers with fracture and fracture-cavernous porosity are divided into: a) zone of limitation (IV. zone), b) zone of limitation and surveillance (III. zone), c) zone of strict limitation and surveillance (II. zone),
PA2.5 Germany	The pilot area Neufahrn bei Freising includes only one drinking water protection zone. The well field comprises 3 shallow wells and 6 deep wells, whereof only the deep wells are used for the local drinking water supply due to the high nitrate concentrations registered in the upper aquifer.

3.3. Other protection areas

Table 5: other protection areas within PAC 2.

PA2.1 Slovenia	Two nature parks and several natural heritages locations (caves, trees, marshes, karst area…).
PA2.2 Poland	No further protection zones are located within the considered pilot area.
PA2.3 Hungary	Many nature reserve areas are situated in the PA, which are protected on national and international levels. There are large areas of Natura 2000 in the central and northern parts of the Pilot Area. Protected areas are designated for: the abstraction of water intended for human consumption, the protection of economically significant aquatic species; bodies of water designated as recreational waters, including areas designated as bathing waters; nutrient-sensitive areas, including areas designated as vulnerable zones, areas designated for the protection of habitats or species where the maintenance or improvement of the status of water is an important factor in their protection, including relevant Natura 2000 sites.
PA2.4.1 Croatia-Prud-Klokun-Mandina spring	In the pilot action South Dalmatia Prud-Klokun-Mandina springs, are four areas protected with Nature Protection Act: Nature park Biokovo, special reserves: Prud, Pod Gredom, Orepak and significant landcape: Modro oko I jezero Desne and Predolac-Šibenica. The Republic of Croatia contributes to the ecological network Natura 2000 by designating most important areas for each individual species and habitat type listed in the annexes to the directives. Natura 2000 areas that are within the pilot

	action South Dalmatia Prud-Klokun-Mandina springs: Delta Neretve, Biokovo, Rastok field, Matica-Vrgorac field, Krotuša, Izvor Vir, Izvor Dropulića vrilo, Podbiokovlje, Jasena ponor, Betina velika jama, Čoćina jama, Velika špilja kod Antunovića and Biokovo i Rilić.
PA2.4.2 Croatia-Imotsko polje springs	In the pilot action area Imotsko polje springs, areas protected with Nature Protection Act are: Special reserve (Vrljika izvor), Nature monument (Crveno jezero and Modro jezero), Significant landscape (Prološko blato and Imotska jezera – Gaj). Natura 2000 areas within the pilot action Imotsko polje springs are: Prološko blato, Izvor Krčevac, Vrljika, Modro jezero, Kanjon Badnjevica, Crveno jezero and Bočni kanal uz Vrljiku.
PA2.5 Germany	No further protection zones are located within the considered pilot area.

3.4. Best Management Practices

Best Management Practices are classified regarding types of land use and can be identified with a specific colour (see Table 5).

Table 6: Legend of Management Practices classification

	Forest
	Grassland
	Agriculture
	Urban Areas
	Industrial Areas
	Wetland, flood mitigation and Karst region
	Tourism
	Stone Quarries and Gravel Pits

3.4.1. Forest

▪ BP MF 1 Protective forest management and afforestation of DWPA	
Description of the measure	Protective forests are especially important for the protection of the bank filtered systems. These forests mitigate or prevent the impact of

	a natural hazard, including soil erosion, landslide or flooding. The protective effect consists in maintaining the 'natural' flow regime. With regard to floods forests reduce stormflow peaks and delay. Protecting stream and river banks from undue horizontal erosion is function of a buffer zone of trees along both sides of a watercourse. The buffer area also acts as a filter and depository for sediment, pesticides and fertilizers from upslope land use, thus preventing them entering to the DWPAs. The significance and necessity of afforestation can be characterized by favourable impacts on the soil, water, air and biodiversity, in short on the environmental state, in addition to the economic benefits.
Measure advantages	▫ Protective forests form forest belts, which protect forests and land from wind, water, snowfall. ▫ Establishing protective forests at banks of waters prevents leaching of agricultural pollution to waters. Planting trees can be effective in increasing water infiltration, and reducing and slowing runoff. ▫ The main aims of the measure are to increase the forest cover of the PA's plain sites; by developing the forestry sector, to enable the agricultural restructuring, by the help of alternative use of areas. Objectives of forestry also include the establishment of high biodiversity natural forests. ▫ The whole area of afforestation contributes to protection against erosion and combating climate change mitigation.
Challenges	In Hungary the management of forests depends on the owners. The good practices in forest management ensured if waterworks can treat the protective areas of drinking water sources.
PA2.1-situation	In the PA area forests are divided into mixed forest (64.6%), coniferous forest (30.6%) and broad-leaved forests (4.9%). Because the forests are within the city, they are called the urban forests, where the importance of two main production functions of the forest, timber production and hunting management, are not present. The main functions of the urban forests are environmental function (climatic, biological, hydrological), since they preserve biodiversity and protect valuable natural features (Smrekar et al., 2011). The social functions are also very important, such as hygienic health function and recreational function. Fertilization is not allowed due to DWPZ. Due to urban forest no clear cuts or timber productions are present.
PA2.3-situation	The forest cover (nearly 19%) of the Pilot Area is improving but at international level it is still low when compared to the average of the EU (34.2%). The problem is that the forests disappeared after the

	deforestation of the plains for agricultural reasons in the previous century.

▪ BP MF2 Protective forest management on floodplain	
Description of the measure	Man-made flood defenses – engineered embankments, flood walls and temporary structures – are an essential part of the fight against flooding. However, forests/trees can provide a sustainable and low maintenance solution to lessening the risk of flooding as well as delivering other environmental and economic benefits when combined with other flood defenses on floodplain.
Measure advantages	Establishing protective forests at banks of waters or in DWPAs prevents leaching of agricultural pollution to waters. Planting trees can be effective in increasing water infiltration, and reducing and slowing runoff. Woodland located on floodplains can mitigate large flood events by absorbing and delaying their progress downstream. Trees and green space could play a critical role in adaptation to climate change in addition to reducing flood risk.
Challenges	Maintainance of healthy wood and regularly cleaned embankments.
PA2.3-situation	Riverine forests (mainly alders, willows and poplars) have been heavily transformed but important areas remain along the large rivers, like the Danube. The most of them show rather pristine state and they are Natura 2000 sites. Only a few “relicts” show the original natural vegetation because of the spread of invasive species of non-native plants and of weeds (IUCN, 1993).
▪ BP MF3 Prohibition or restriction of grazing in forests	
Description of the measure	The reasons of prohibition grazing in forests were to protect soil from degradation, increase game production and biodiversity as well. Compaction of soil can reduce plant growth, inhibit root penetration, restrict water and air movement in the soil and, ultimately, reduce yields. Overgrazing can occur when undergrowth is exposed to intensive grazing for extended periods of time, or without sufficient recovery periods. The only thing to stop overgrazing is to limit the animal’s space to roam around. Overgrazing reduces the usefulness, productivity, and biodiversity of the land and is one cause of desertification and erosion. Overgrazing is also seen as a cause of the spread of invasive species of non-native plants and of weeds.
Measure advantages	Negative impacts of overgrazing can be prevented and/or reversed by proper forest management.

Challenges	Undergrowth management has to solve by forestry. The quality of forest management depends on the owners of the forest.
PA2.3-situation	According to the Hungarian actually Forest Law grazing in the forests has been prohibited for the last decades. The grazing in forests was maintained until the middle of the 20th Century, but it had been regulated by laws since the early times. After the date of 01.09.2017 the law will cancel the prohibition of the grazing in forests, it will be allowed with restrictions. Only horses, cattles and sheeps are allowed to be grazed or rested in forest.

▪ **BP MF4 Establishment of agro-forestry systems (grazing) and wood-pastures**	
Description of the measure	The agro-forestry systems are extensive land use systems where trees are attended and agricultural activities are pursued simultaneously, thus a mosaic of agricultural and forestry systems is created. They combine extensive agricultural and forestry systems aimed at the production of excellent quality wood and other forestry products.
Measure advantages	▫ The agro-forestry systems have major importance in reintroducing sustainable landscape management and the strengthening of the mosaic character on plain areas. ▫ The measure aids the protection of rural natural resources and improves their state. ▫ The measure provides a good opportunity for integrated and ecological farming, decreasing the conflict of interest between agriculture and drinking water protection. ▫ For farmers on the DWPAs and upstream area of the surface drinking water abstractions the agro-forestry systems are perfect for making the rural area more attractive, for maintaining jobs and creating new ones, and for improving the living conditions.
Challenges	▫ The traditional use of woodlands and its essential influence on the land's structure and dynamics have become commonly known among the Hungarian ecologists only in the past few years. The abandoned wood-pasturing occurred in all types of forests. In all cases the decrease of pasturing livestock was the reason for the abandonment of the areas. ▫ Although, wood pasturing which is based on the traditional knowledge has a great importance in conserving nature and landscape but for re-establishment of agro-forestry systems a lot of obstacles have to defeat, for example: intensive

	husbandry has replaced grazing. ▫ It would be necessary evolving a consciously controlled and sustained wood pasturing system again.
PA2.3-situation	Introducing agro forestry system in special regions of PA (floodplains) is expected to achieve major positive environmental effects.

■ **BP MF5 Protection of forests and forest land**	
Description of the measure	In the Pilot Action area forest can be divided into privately owned forests and forest land and forests and forest land owned by State. Also, forests are divided into protective, economic and special purpose forests. Protective forests mitigate or prevent negative, anthropogenic impacts or natural hazard effects on land, soil, water, settlements, people and their assets. The most significant protective functions of forests are reduction of foods effects (maintaining the "natural" flow regime by reducing and delaying the stormflow peaks) and reduction of soil erosion caused by water (reduction of sedimentation of deposits incurred due to soil erosion in water stream channels and stagnant water bodies). On the PA in terms of forest management, it can be distinguished between state-owned and non-state-owned forests, mostly private ones. The non-state-owned areas are managed mostly by private management companies. These must be recorded by the forestry authorities. The management of the state forests is mainly carried out by the state forest management companies. However, there are also other state organizations – e.g. Water Management Authorities, National Parks – managing state forest areas. The share of community ownership on forests is low, usually municipal, town and city councils are the forest managers.
Measure advantages	▫ the sustainable forest management and forest conservation, ▫ protection of forests as part of valuable ecological systems and landscapes, ▫ achieving the development of forest land and forests planted for non-industrial purposes in order to support ecological acceptable afforestation programs of new and already afforested areas, ▫ improve the forest protection against fire, disease and parasites, ▫ stimulate the activities of greening the public space. ▫ The control on Forestiers ensures to reach sustainable forest management objective.

	▫ Clear legislative background system
Challenges	Not managed forests also exist in Hungary most of them being in private property. At these areas there is no forest manager recorded in the register of the forestry authority. It is a key objective of forest policy in Hungary to further reduce the size of unmanaged forests.
PA2.1-situation	Similar acts are within TRŠ Nature Park.
PA2.3-situation	Pro Silva Hungaria was established in 1999 as a non-governmental organization, it's made for stakeholders of the forest sector for forestry practice. It promotes sustainable and profitable forest management strategies. As a result of the discussions silviculture includes not only wood production but an emphasis on maintaining forest biodiversity, recreational, landscape, soil, air and water protective functionalities as well as socio-economic and cultural functions. It ensures the soil and water protection functionality of forest ecosystems, ensures up-to-date knowledge transfer. The Directorate of Forestry of the National Food Chain Safety Office (NFCSO FD) carries out tasks in general of forestry administration. The main activity is to ensure, through its administrative functions, the sustainable forest management in the country. It must be stressed again that forestry authority organizations do not carry out any forest management activities in Hungary, independently of the ownership type.
PA2.4.1-situation	According to the Spatial plan of Dubrovnik-Neretva County, forestry development must be based on the principles of sustainable management, therefore all activities on forest land or near water bodies must be conducted in order to protect or preserve relative stable ecosystems by controlled use of natural resources.

▪ **BP MF6 Environment and significant landscape protection**	
Description of the measure	When planning the development projects by which forest land conversion is planned, cross-sectoral and institutional cooperation on a vertical and horizontal basis level is needed. Forest land conversion must be planned on areas with minimal negative erosion impact.
Measure advantages	▫ afforestation of forest land damaged due to natural hazards (e.g. forest fires and floods) offers a chance to expand the existing biodiversity and helps to secure the water protection functionality of forest ecosystems,

	▫ afforestation can decrease soil erosion. ▫ strengthening human and organizational capacities for fire protection, ▫ establishing monitoring system of initiatives, plans and proposals for forest land, conversion and other plans and activities for the integral environment protection, ▫ remediation of forest land damaged due to natural hazards, ▫ organizational and personnel capacity improvement of county institutions in the forest protection system
Challenges	▫ erosion due to forest loss that influences the water quality of the area, ▫ confusing ownership issues, ▫ dominance of tourism over forest protection.
PA2.4.1-situation	Part of the Pilot Action South Dalmatia: Prud-Klokun-Mandina spring is protected by Nature Protection Act (Official Gazette 80/13). Modro oko and lake near Desne settlement are protected in category of significant landscape.
PA2.4.2-situation	Strategic Environmental Impact Assessment of the Development Strategy of Dubrovnik-Neretva County 2016-2020 prescribes measures for environment protection (water protection).

▪ **BP MF11 Consideration of restoring the forest areas destroyed by fire with proper species**	
Description of the measure	Of particular interest is the protection of the forest areas and the restoration of forests destroyed by fire, as well as the creation of preconditions for afforestation of new forest areas, especially since the area is prone to fire hazard.
Measure advantages	▫ continuous afforestation that offers a chance to expand the existing biodiversity; great forest cover (47.5%) with dominantly productive forest land provides a clear frame for forestry that helps secure the water protection functionality of forest ecosystems
Challenges	▫ erosion due to forest loss that influences the water quality of the area; confusing ownership issues; dominance of tourism over forest protection
PA2.4.2-situation	When restoring the forest areas destroyed by fire, it is important to note that instead of Aleppo pine, it is afforested with seedlings of

	indigenous herbs that are less susceptible to fire (evergreen oak, European hornbeam, strawberry tree, etc.).

3.4.2. Grassland

▪ BP MG1 Establishment or enhancement of grassland by regeneration process	
Description of the measure	According to the CLC, grassland covers less than 15% of the PA area and is mostly presented as pastures; some parts are areas of natural vegetation. Around half of the grassland is within DWPZ, where ploughing of permanent grassland is prohibited. From harvesting period in autumn until 1st March it is forbidden to use mineral fertilizers containing nitrogen and similar period starting one month later it is forbidden to use manure and slurry. Outside the time ban mineral fertilizers containing nitrogen can be used for permanent grassland where the maximum permitted amount of nitrogen must not exceed 50 kg N/ha for each mowing.
Measure advantages	Enhancing and preserving drinking water sources.
Challenges	▫ diminishing applications of fertilizers in the period, when it is not allowed ▫ establishing control over the purchased and used quantity of fertilizers
PA2.1-situation	Within DWPZ ploughing of permanent grassland is prohibited.
PA2.4.1 & PA2.4.2-situation	Croatian Ministry of agriculture issued conversion prohibition (in agricultural purpose) of permanent grassland and pastures in specific NATURA 2000 areas.

▪ BP MG2 Levelled terrain to prevent surface runoff	
Description of the measure	Within the inner protective zone, the terrain shall be levelled to prevent surface runoff from accumulating in stagnant pools. The terrain should be planted as continuously as practicable with grass. No fertilisers, manure and pesticides must be spread. The surfaces on which no grass can be planted shall be paved with durable, non-polluting material.
Measure advantages	▫ Clear legislative background system

	▫ Grassland may reduce quantitative and qualitative vulnerability of groundwater and surface water resources by retaining water, filtering and attenuating pollutants, reducing erosion.
Challenges	/
PA2.3-situation	The Government Regulation 123/1997 prescribes this.

▪ BP MG3 Special good practices of grazing in protected areas	
Description of the measure	A significant portion of grasslands are over utilized by livestock. Although a parcel of land is not overgrazed there are some parts where signs of degradation can be found. These special areas are attractive for ungulates because there is water, added by salt sources, shelters. Overgrazing has detrimental effects on soil and vegetation but changes are reversible. High grazing pressure negative influences the ecosystems. Moreover, overgrazing increases area covered by no vegetation, reduces infiltration, soil moisture and fertility, accelerates runoff increases soil ammonia and nitrate content and changes soil microbial activity. If this befalls on DWPAs the drinking water aquifer can polluted. Nevertheless, all these negative impacts can be prevented and/or reversed by proper grassland management practices.
Measure advantages	▫ The measure preserves retention capacity, consequently ESSs, in the frame of general grassland management without considerable additional cost or loss of production: which increases cost efficiency. ▫ Appropriate grazing can efficiently contribute to weed control.
Challenges	▫ the correct information of farmers ▫ need increased awareness of the farmers
PA2.3-situation	According to the Government Regulation 123/1997 within the inner protective zone is prohibited grazing, but in particular instances (e.g. groundwater table deeper than 2 m) grazing may also be allowed inside

	the outer protective zone, only watering and noontime rest of the animals shall be outside the protective zone.

▪ BP MG4 Ecological network protection	
Description of the measure	Spatial plan of Dubrovnik-Neretva County prescribes the guidelines for the measures of ecological network protection: ▫ restoration of wet grasslands, ▫ maintaining the pastures, ▫ restoration of steppe grasslands and reintroduce steppe species, ▫ prevent grasslands succession, ▫ ensure the subsidies for mowing the grasslands in a way that does not endanger *Crex crex*, providing the subsidies for the conservation of biological diversity. Furthermore, Spatial plan of Dubrovnik-Neretva County prescribes the guidelines for the measurements of grassland protection in accordance with the Ordinance on list of habitat types, habitat map and threatened and rare habitat types in Croatia (OG 88/14): ▫ manage the grassland through pasture and mowing regime that is adapted to the habitat type and use mineral fertilizers and soil improvers sustainably, ▫ preserve biological species that are significant for the habitat type; prevent the introduction of foreign (allochthone) and genetically modified species, ▫ maintain a favorable ratio between grasslands and bush, prevent the succession processes of grasslands, ▫ preserve a favorable low level of mineral substances in the soils of dry and wet grasslands, ▫ maintain a favorable water regime, including high groundwater levels in wetland areas, ▫ encourage the revival of extensive livestock farming in mountainous grassland areas.
Measure advantages	▫ measures of ecological network protection will

	have positive impacts on ecosystem and biological diversity, ▫ by revegetation of degraded grassland areas surface run-off and soil erosion (by water and wind) will be decreased and soil will be improved (organic and mineral elements).
Challenges	▫ implementation and control of grazing activities and control of invasive species introduction are main challenges. According to the "Agriculture that protects nature, Protection of nature through measures of Rural Development Programme of the Republic of Croatia 2014.-2020.", decreasing number of grazing animals in the last decade is leading to the disappearance of grasslands rich in plant and animal species. Also, cattle is kept indoors in longer period through the year. The problem is particularly serious in the karst and mountainous areas where shrubs have suppressed the valuable grassland species adapted to survive in the poor soil or in holes between rocks with very little water, ▫ due to significants deruralization process (which is present in whole country) i.e. abandonment of villages and rural areas, meadows and pastures are neglected.
PA2.4.1 & PA2.4.2-situation	Croatian Ministry of agriculture issued conversion prohibition (in agricultural purpose) of permanent grassland and pastures in specific NATURA 2000 areas. According to the Ordinance on the amendment of the Ordinance on agricultural land use records (35/15, 118/16, 26/17) "The edge buffers along water streams" are grassy belts that are at least 3 m wide and are at the interface of arable land that is at least 10 meters away from the edge of the water stream.

▪ BP MG5 The edge buffers along water streams	
Description of the measure	The edge buffers along water streams are grassy belts that are at least 3 m wide and are at the interface of arable land that is at least 10 meters away from the edge of the water stream.
Measure advantages	▫ positive impact on the ecosystem water

	provision and regulation; protection from soil stress and erosion
Challenges	/
PA2.2-situation	Permanent grasslands, located in the immediate vicinity of surface waters, in addition to their production functions must also protect these waters, forming buffer zones between arable land and waters. Particular care is needed in case of grasslands on muck and organic soils, which can easily degrade.
PA2.4.2-situation	According to the Ordinance on the amendment of the Ordinance on agricultural land use records (35/15, 118/16, 26/17).

▪ BP MG6 Harvesting with the respective machinery.	
Description of the measure	Due to the general decrease of livestock in the pilot area, we assume that grazing activities decreased in parallel. So, the existing grasslands are mostly harvested with the respective machinery. Generally, grasslands are less tilled with heavy machinery as compared to arable lands which avoids an intensive degradation of the site conditions.
Measure advantages	Grassland soils mostly have a more loosened soil structure which improves the infiltration capacity. Those processes can be further enhanced through the root zone of the turf. The enriched content of soil organic matter of the topsoil of grasslands favors the water storage capacity and the process of water purification. Bioturbation further 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. A dense turf on grasslands provides a protection function against erosion processes, soil aggregate destabilization and evaporation losses. The turf decreases the susceptibility to surface sealing and

	lowers the probability of breaching the infiltration capacity and the resulting Hortonian Overland Flow and ponding, respectively. (DWA, 2015).
Challenges	It is important to note that a plowing up of grasslands can signifcantly increase the leaching of nitrate since on the one hand, huge amounts of organic matter can be decomposed by soil organisms and on the other hand, the natural nutrient uptake by vegetation is interrupted (WHITMORE et al., 1992). The decomposition process is also enhanced by a high solar radiation acting on the unprotected surface. We assume those described interdependencies to be the causing factors for the sudden increase in the nitrate concentrations measured in the shallow wells during the early 1990's.
PA2.1-situation	According to the CLC, grassland covers less than 15% of the PA area and is mostly presented as pastures; some parts are areas of natural vegetation. Around half of the grassland is within DWPZ, where ploughing of permanent grassland is prohibited.
PA2.2-situation	Permanent grasslands with degraded sward should be renewed. The main way of renewal is reseeding, possibly with partial destruction of the old turf and the improvement or change of use and fertilisation methods.
PAC2.4.2-situation	Grassland areas (meadows and pastures) are neglected due to centralization and village abandonment; low grassland utilization even though they occupy a large part of the total agricultural area. Croatian Ministry of agriculture issued conversion prohibition (in agricultural purpose) of permanent grassland and pastures in specific NATURA 2000 areas.
PA2.5-situation	Thus, the conservation of grasslands which are not intensively used, neither for livestock farming nor for fodder production, can be considered as a Best Management Practice in the Neufahrn bei Freising pilot area.

3.4.3. Agriculture

▪ BP MA1 Application of fertilization plan	
Description of the measure	Agriculture covers around 10% of the PA area and all is inside the DWPZ III (wider area with the moderate protection regime). On such areas it is forbidden to fertilize without a fertilization plan, which has to be written and must be available to the competent inspector at the time of inspection, if requested. The fertilization plan must contain information on the type and amount of mineral or organic fertilizer used for each crop. The manure and slurry storage must be large enough to storage manure and slurry for at least six months and must contain up to 170 kg/ha of nitrogen according to the fertilization plan.
Measure advantages	▫ regular inspections and supervision carried out by the Inspectorate of the RS for Agriculture, Forestry, Food and the Environment ▫ subsidies for limitations for use of fertilizers
Challenges	▫ establishing control on use of fertilizers in the time ban ▫ establishing control of the purchased and used quantity of fertilizers ▫ establishing control of storages of manure and slurry (sealing, quantities, etc.)
PA2.1-situation	The use of fertilizers is limited as written above.
PA2.2-situation	Animals should not be grazed when the soil is excessively wet and after mid-October, as fertiliser components from faeces may seep into groundwater. In sheep grazing loose herding should be used, allocating 2-3 m2 of surface for 1 animal per day. Sheep should not be grazed in water intake areas, near watercourses and steep slopes.

▪ BP MA2 Construction of new and expansion of existing sites for the storage of solid and liquid natural fertilisers

Description of the measure	All liquid and solid natural fertilisers and waste produced on the farm should be stored in special tight containers or on plates located at appropriate distance from buildings and farm borders in line with the requirements of construction law, in particular away from a well that is a source of water for people and animals. Containers for liquid manure and no-outflow containers should have an impermeable bottom and walls and a sealed lid with an entrance opening and a ventilation opening.
Measure advantages	▫ Enhance and preserve water supply ESS
Challenges	Educating / persuading the society to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	The program is aiming to be implemented.

▪ **BP MA3 Good agricultural specialist consultations and control of the agricultural sources of pollution**	
Description of the measure	To educate agricultural professionals on good agricultural practices and providing them with specialist consultations and also to control the agricultural sources of pollution and implementation of duties of agricultural professionals. Implementation of a program aimed at limiting of nitrogen outflow from agricultural sources.
Measure advantages	▫ Enhance and preserve water supply ESS
Challenges	Educating / persuading the society to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	Implementation of a program is aiming at limiting of nitrogen outflow from agricultural sources.

▪ **BP MA4 Fertilisation limitations**	
Description of the measure	Fertilisers may not be used on flooded, snow covered, or frozen soil. Observing the storage conditions for natural fertilisers

	and handling of leachates - Manure may be collected, fermented, and stored in animal houses or on dung plates with side walls. Floors of animal houses and dung plates should be protected against leakage to the ground and equipped with systems draining leakage to septic containers for dung and manure water. Manure may not be stored in field vents. Mineral fertilisers should be stored in their original packaging in closed storage or at least under a roof. The height of the stacks of fertiliser packages containing ammonium nitrate and ammonium fertilisers may not exceed 4 bags. Fertilisers supplied without package should be stored in storage or under a roof. Liquid fertilisers should be stored in original packaging or in tightly sealed containers intended for this role. Containers should be situated on a sealed plate with a capacity corresponding to the container capacity. Natural and mineral fertilisers should be used in such a way and at such times so as to limit the risk of dislocation of the contained components (nitrogen and phosphorus in particular) into surface water and groundwater. Use of fertilisers may not cause a risk to human and animal health. Natural fertilisers should not be used within a distance of 20 m from water protection zones, reservoir edges and watercourses, swimming zones in surface waters, and coastal zones. Natural fertilisers in liquid form may be use if the groundwater level is below 1.2 m.
Measure advantages	▫ Enhance and preserve water supply ESS
Challenges	Educating / persuading the society to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.1-situation	From harvesting period in autumn until 1st March it is forbidden to use mineral fertilizers containing nitrogen and similar period starting one month later it is forbidden to use manure and slurry. Outside the time ban mineral fertilizers containing nitrogen can be used for permanent grassland where the maximum permitted amount of nitrogen must not exceed 50 kg

	N/ha for each mowing.
PA2.2-situation	The program is aiming to be implemented.

▪ **BP MA5 Groundwater intakes used for agricultural irrigation and treatment plants**	
Description of the measure	Creation of a database of wells used for agricultural irrigation, preparation of an annual report from measurements of each intake with a transfer to a proper authority to issue a water permit and Regional Water Management Board in order to account for the data in water and economic balance. Farms with individual water intakes should have a sealed container for temporary collection of liquid waste. The container should be equipped with a sealed lid with a lockable opening for waste removal. No-outflow containers should be emptied by slurry spreaders, and the contents delivered to the nearest sewage treatment plant. Farms equipped with a water supply line use much more water than farms using their own wells, which results in the increasing amount of waste water. These farms should be connected to a collective sewage network or have a household sewage treatment plant. Sewage should not be discharged directly in the surface waters or spilled into the fields. Machine and agricultural equipment washers should be constructed in a manner that prevents the penetration of harmful substances into the groundwater. The optimal solution is to construct a washer on a biological substrate with thickness of at least 50 cm, consisting of 50% of cut straw, 25% of high peat, and 25% of soil; with a 10 cm thick gravel drainage layer underneath. The surface of the substrate where the structure (ramp) protecting from damage from other equipment is located, should be planted with grass. The decision to use chemical plant protection products and the choice of the most appropriate one should be taken very carefully. Before use of the product, the instructions should be read carefully and understood. Products without original label -

	instructions of use – should never be used. Chemical plant protection products may be used with ground equipment, in the fields located at least 5 m from public roads and at least 20 m from buildings, allotments, apiaries, herbal plantations, nature reserves and parks, surface water coastal lines, and water protection zones.
Measure advantages	▫ Enhance and preserve water supply ESS
Challenges	▫ Obligation to collect sewage in sealed containers in areas without sewage network. ▫ Obligation to connect to a collective sewage network or to have a household waste treatment plant in areas with sewage network. ▫ Proper cleaning of agricultural machinery and equipment. ▫ Educating / persuading the society to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations. ▫ Compliance with the rules governing the use of chemical plant protection products in order to protect water resources from pollution.
PA2.2-situation	The program is aiming to be implemented.

▪ **BP MA6 Storage of liquid manure, mineral fertilisers and silage**	
Description of the measure	Efforts should be made to reduce the amount of liquid manure produced on the farm by minimising as much as possible the amount of water used to clean animal houses and limiting leakage from drinking water dispensers. Waste from domestic sanitation facilities should not be disposed in the liquid manure storage. Mineral fertilisers should be stored in their original packaging in closed storage or at least under a roof. The height of the stacks of fertiliser packages containing ammonium nitrate and ammonium fertilisers may not exceed 4 bags. Fertilisers supplied without package should be stored in storage or under

	a roof. Liquid fertilisers should be stored in original packaging or in tightly sealed containers intended for this role. Containers should be situated on a sealed plate with a capacity corresponding to the container capacity. Silage juices contain significant amounts of minerals, including nitrogen compounds. The outflow of juice to the surface waters results in their pollution and depletes the water of oxygen. Juices collected in wells should be poured in the fields or meadows from which the vegetative mass for silage came from.
Measure advantages	▫ Limiting the amount of liquid manure produced on the farm. ▫ Enhance and preserve water supply ESS
Challenges	▫ Limiting the amount of liquid manure produced on the farm. ▫ Obligation to dispose of dead animals at special disposal sites. ▫ Proper disposal of silage juices. ▫ Educating / persuading the society to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	The program is aiming to be implemented.

▪ **BP MA7 Obligation to dispose of dead animals at special disposal sites.**	
Description of the measure	Dead animals left on the farm may cause water pollution. With the exception of individual poultry and small domestic animals, they may not be buried or stored with manure or compost pit. Dead animals must be immediately delivered to special disposal sites, preferably with a specialist transport vehicle.
Measure advantages	▫ Enhance and preserve water supply ESS
Challenges	▫ Obligation to dispose of dead animals at special disposal sites. ▫ Educating / persuading the society to apply the activity/ making them interested in

	implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	The program is aiming to be implemented.

▪ **BP MA8 implementation of subsidies for sustainable agriculture development**	
Description of the measure	States financial support for the further development of agricultural production is anticipated: ▫ Construction of accumulations in agriculture (support for the construction of simple accumulations in agriculture) ▫ Infrastructure refurbishment (organization of the existing neglected field roads in Dalmatinska Zagora) ▫ Support to the agricultural associations ▫ Encouraging the development of competitive agricultural production (support for the development of competitive agricultural production) ▫ Subsidies for the agricultural production (support for the co-financing planting material); ▫ remediation of agricultural land damaged due to natural hazards, ▫ implementation of soil monitoring system, ▫ remediation of soil damaged due to erosion and floods. ▫ within the irrigation and hydromelioration projects envision the conditions of water regime so that the natural regimes of surface waters and groundwater would not be disturbed. ▫ reduce the use of valuable agricultural land for other purposes, ▫ encourage the production of organic food, ▫ traditional agricultural production should have

	the priority (vineyards, olive groves etc.), ▫ the fundament of agricultural production should be homestead farms.
Measure advantages	▫ education of farmers on sustainable use of pesticides on their agricultural land, can have positive impacts on soil and water quality due to decreased amounts of applied pesticides, ▫ positive impacts on soil and water quality can be expected due to increased organic agricultural production, implemented soil monitoring system and remediation of soil damaged due to erosion and floods.
Challenges	Pollution of groundwater with nitrates and pesticides related to excessive use in agriculture production is one of the main problems, especially in karst fields (e.g. Vrgorsko field) with intensive agriculture production. Estimation of the pressures on agricultural land due to applied nitrogen and phosphorus was carried out by determining the spatial distribution of nitrogen and phosphorus deposited on agricultural land via mineral and organic fertilizers. According to the River Basin Management Plan (2016.-2020.), the organic nutrients pressure is also related to cattle keeping and grazing and application of manure on agricultural land. Since the Pilot Action is located in Dubrovnik-neretva County and Split-dalmatia County, the data for these counties is applicable to this area. The amount of applied nitrogen and phosphorous on agricultural land in Dubrovnik-neretva County is around 34 kg/ha for N and 5 kg/ha for P. The amount of applied nitrogen and phosphorous on agricultural land in Split-dalmatia County is 29 kg/ha for N and 5 kg/ha for P. Intensive irrigation can cause decrease in water table height and increase of water salinity due to sea water.
PA2.4.1 & PA2.4.2-situation	According to the State of the Environment Report of Split-dalmatia County, traditional measures of agricultural soil protection, so-called terracing and

	construction and maintenance of supporting dry stone walls is being abandoned which has the repercussions such as erosion of soil due to torrents, soil loss and contamination of surrounding water bodies.

▪ BP MA9 Implementation of catch crop plantations	
Description of the measure	Exposed and uncovered surfaces represent unprotected areas which are susceptible to negative environmental influences. Splash effects of rainfall can destroy soil aggregates and lower the water storage capacity. More detached, fine-textured soil particles can favor surface sealing processes and lower the infiltration capacity. Moreover, harvest residues on temporally unused lands are likely to foster the mineralisation of nitrogen and lead to increasing amounts of nitrate in the topsoil which can enhance the diffused discharge into the groundwater (SCHEFFER et al., 2010). In order to lower these negative effects on the water purification and water regulation functions of the soils, the implementation of catch crops plantations is becoming more and more frequent. Basically, catch crops are mostly fast-growing species which overlast the intermediate phase between two main crops and at best remove excess nutrients. Moreover, catch crops are also cultivated simultaneously with species that require a wider row spacing (e.g. maize fields or vineyards) to cover the bare soil between the crop rows. These catch crop species have to be adapted to the main crop since both should not be in nourishment competition for nutrients and at best benefit from each other.
Measure advantages	The cultivation of catch crops can significantly decrease the nitrate leaching (e.g. greening in winter). Depending on the species, catch crops can store a certain amount of nitrate which is mineralised after the harvest and thus available for the following main crops (THORUP-CHRISTENSEN et al., 2003; SCHEFFER et al., 2010). Moreover, catch crops cover the bare soil and increase the content of organic matter in the topsoil. Thus, these plantings protect the soil from soil aggregate destabilization and

	erosion processes. The increased content of organic matter also hinders surface sealing and the related probability to increased surface runoff (MEISINGER et al, 1991; GLAB et al., 2008). Catch crops also increase interception and transpiration losses and may thus counteract the ecosystem service water provision.
Challenges	To propose and to achieve the exposed surfaces susceptible to negative environmental influences to be covered.
PA2.5-situation	In the Landkreis Freising, farmers become more and more aware of the advantages of catch crop cultivations, also regarding their increasing profitability. (Boden-staendig.de, 2016)

▪ **BP MA10 Non-turning soil tillage**	
Description of the measure	Traditional tillage, or more precisely conventional tillage is usually based on soil-turning methods, such as plowing. Thereby the topsoil is loosened and turned so that the organic residues are extensively and equally distributed folded in the topsoil. Primarily, this measure is used to prepare the agricultural land for the following sowing. The plowing also provides a mechanical weed control and enhances the aeration of the topsoil (SCHEFFER et al., 2010). However, this technique can adversely affect the ecosystem services water provision, water regulation and water quality regulation.
Measure advantages	This technique destroys the aggregate structure of the topsoil due to the mechanical impact of the plow. The increased aeration in the topsoil fosters the decomposition (mineralisation) process of the organic matter and thus reduces the humus content (SCHEFFER et al., 2010). Both, the destroyed aggregate structure as well as the reduction of the humus content reduce the water storage capacity as well as the purification and filtering function of the topsoil. For example, KANWAR (1985) described higher nitrate leaching from conventional tillage sites than from no-till sites. A transition from conventional soil tillage to non-

	turning alternatives (conservation tillage) counteracts these negative impacts of soil-turning methods. Conservation tillage fosters the preservation of the soil structure and its pore system so that the soil maintains its water transferability and storage capacity. Especially the preservation of the vertical pores is of vital importance for water infiltration at the soil surface (SHIPITALO et al., 2000). Moreover, the humus content of the topsoil increases compared to conventional tillage favoring the water storage capacity and the process of water purification. Since the topsoil is not turned in conservation tillage the acitivity of soil organisms does not decrease 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 (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.
Challenges	We assume that the application of non-turning soil tillage increased during the last decades.
PA2.2-situation	Properly developed crop rotation limits the amount of mineral nitrogen leached from the soil during autumn and winter periods. On plains, ca. 60% of arable land, and on in areas with erosion risk at least 75% of arable land should be kept under plant cover throughout the year - Use of proper crop rotation is among other BMPs.
PA2.5-situation	This method has been proposed in the hydrogeological baseline studies for the delimitation of the drinking water protection zone (Geotechnisches Büro, 1992).

3.4.4. Urban areas (settlements)

▪ BP U1 Supervision of sewage network	
Description of the measure	Sewage system and individual small wastewater treatment plants (WWTP) are present in the PA area, but some septic tanks can still be found. The sewage network must be regularly supervised because a

	leaking network may cause environmental pollution (VOKA, 2017a). Construction of new or modernisation of already present sewage treatment plant and sewage network is important on this area. In case of heavy rainfall, the wastewater treatment plants are overloaded, so it would be necessary separate the rainwater form the sewage systems.
Measure advantages	▫ existing local sewage system ▫ Increase the level of human health ▫ Decrease the emission of microbiological pollutants, nutrient N&P compounds and priority substances ▫ Decrease the contamination of surface waters in case of overflowing sewers ▫ Prevent the deterioration of groundwater quality
Challenges	▫ establishing of control of local sewage condition ▫ establishing of control of septic tanks (quantities, cleaning etc.) ▫ Increase the connection to the sewage network ▫ Improve the waste water treatment technology ▫ Need of professional knowledge ▫ Increase the environmental awareness of residents ▫ Prevent incoming rainwater to the sewage system – needs of separated systems
PA2.1-situation	Within Dravlje PA area is one small WWTP, called Smodinovec, with capacity 70 PE and secondary treatment - biological treatment with activated sludge (VOKA, 2017b).
PA2.3-situation	In case of the Szolnok surface drinking water extraction of the waterwork is situated on the upper part of the city, and on the upstream there is no direct waste water discharges on the next 65 km. The nearest indirect waste water discharge is 16 km from the waterwork. This urban sewage load (significant effect) arrives to the Tisza by an affluent after taking 10 km. This river mouth is situated more than 5 km upstream from the waterwork. This sewage pressure doesn´t endangers the secure of the drinking water supply. In case of low water level this 10 km length affluent is adequate buffer to keeping the sustainable drinking water supply without the deterioration of water quality. In case of the Balmazújváros surface drinking water extraction is situated on the middle part of the Keleti Main Channel. This linear channel is artificial bordered by dykes. The waste water discharge is not allowed. The nearest urban and bath waste water discharge is 25 km from the waterwork, but this discharge is loads to a parallel

	channel, so there is not connected with each other. Only the settlements higher than 2000 PE (population equivalent) are involved to the national sewage program to set up of individual waste water treatment plants for individual houses, the others need to find individual solutions for waste water treatment. There are many known technologies, but actually their applications are on low level in Hungary because of the higher prices. At the households without connection to the sewage network there are usually septic tanks and the waste water is transported to the sewage plants.
PA2.4.1-situation	Sewage systems are planned for all larger settlements, settlements near lakes, water courses and drinking water protection zones. According to the Spatial plan of Dubrovnik-Neretva County the priority of construction of sewage systems have following settlements: ▫ Otrić seoca, Kobiljača and Staševice located in pilot area, ▫ Ploče, Metković and Opuzen located near pilot area. As a solution for the wastewater drainage, construction of local drainage systems is planned. Among planned systems are wastewater drainage system Vrgorac (located in the II. sanitary protection zone of Butina spring).

▪ BP **U2** **Optimisation of water consumption by limiting intake or construction of small retention reservoirs**	
Description of the measure	Optimisation of water consumption by limiting intake or construction of small retention reservoirs.
Measure advantages	▫ Limiting groundwater intake in areas of possible ascension and ingress of saline waters to a level enabling preservation of designated chemical composition of drinking water. ▫ Enhance and preserve water supply ESS
Challenges	Educating / persuading the society/ professionals to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	Optimisation of water consumption is aiming to be implemented.

▪ BP **U3** **Rainwater/Waste water management along roads**	
Description of the measure	Waste water from roads should be managed according to measures to reduce emissions due to discharge of meteoric waste water from public roads, limits of emissions into water and public sewer system for

	meteoric waste water from public roads and evaluation and measurement of emissions. In winter freezing of road surfaces is prevented with solvents (salt) and sands. Environmentally unfriendly solvents are allowed to use only in the minimum necessary quantities. For solvents only such device should be used, that enables accurate dosing quantities. The dosing quantities of solvent should take into account the amount of solvent that it is already on the road. Negative impact on water quality can have also the use of pesticides on the roadsides.
Measure advantages	▫ Decreased pollution deposition from air ▫ Increased water quantity and recharge, increased infiltration and drainage capacity ▫ arranged road rainwater discharge on motorway main roads and on majority of side roads
Challenges	▫ Increase the amount of green surfaces ▫ to prevent excessive use of solvents in winter ▫ to prevent application of fertilizers on the roadsides ▫ to collect and to control road rainwater discharge, particularly in the area of planned Koseze Waterworks
PA2.1-situation	Motorways and roads are present in the Dravlje valley PA area. Through the entire PA area runs the Western part of Ljubljana's ring road, which is one of the busiest roads in Slovenia due to the strategically important position and the concentrated economic life in the capital city.
PA2.3-situation	In case of the Szolnok surface drinking water extraction the waterwork is situated on the north border of Szolnok urban area. The city is on the downstream; still the importance of the urban rainwater management is not negligible (e.g. deposition from air). It needs decreasing sealed artificial surfaces to prevent the further quality and quantity degradation of groundwater and surface water. In case of the Balmazújváros surface drinking water extraction is situated on the middle part of the Keleti Main Channel, discharge is not allowed.
PA2.5-situation	Modern engineering plannings basically include recommendations how to implement decentralized rainwater infiltration systems to ensure an extensive surface infiltration as well as water retention. In this context, different measures are suggested depending of the type

	of the structural planning. One example is represented by the closed industrial area of AVON cosmetics. For a renovation and a new use of the area and its buildings as an industrial or commercial area, the following measures have been recommended by the engaged planning office (Dragomir Stadtplanung, 2016): due to the existence of flat roofs, those roofs should be equipped with extensive roof greenings to support the water retention; as far as possible, rainwater should be seeped extensively, therefore implementing water permeable surfaces for pathways, access roads and other open spaces in order to reduce the degree of sealing; rainwater seepage from sealed surfaces should further be seeped through extensive infiltration ditches; Those described measures can be considered as state-of-the art Best Management Practices to improve the water retention as well as the extensive seepage of rainwater in sealed urban and industrial areas.

▪ BP U4 Adoption of the Investment Program for the preparation, design, reconstruction, rehabilitation and construction of the transport infrastructure	
Description of the measure	Decision on the adoption of the Investment Program for the preparation, design, reconstruction, rehabilitation and construction of the transport infrastructure in the area of Split-Dalmatia County and allocation of funds for the County Budget to cities and municipalities for these purposes in 2017 (including the municipalities/cities of Runovići, Gradac, Imotski, Lokvičići, Lovreč, Donji Prologac, Zagvozd, Zmijavci). Ethno zones on the national and county levels of significance are regulated by the creation of a network of settlements where revision of local traditions is carried out by a planning approach. As the preservation of ethnological values is directly related to the preservation of the vitality of the settlement, it is necessary to promote the elements of spirituality in the cultural creativity of the inhabitants of the ethno zone and the development of economic activities related to working practices of the inhabitants (agricultural production, handicrafts, rural tourism) through the action of institutions and foundations.
Measure advantages	▫ reconstruction of waterworks, pumping stations of Banja and Butina in the area of the town of Vrgorac as the most important drinking water springs of the area ▫ reconstruction and construction of sewerage network and drainage facilities in the county

Challenges	▫ great drinking water losses due to outdated urban infrastructure; poor waste water management and purification
PA2.1-situation	Within the DWPZ the application of pesticides is strictly limited.
PA2.2-situation	Within the DWPZ the application of pesticides is restricted. The application and also the storage of pesticides have to be declared and have to be approved. Until now there were not detected any pesticides or metabolites within the source water.

3.4.5. Industrial areas

▪ BP I1 More stringent persecution of contaminated site remediation	
Description of the measure	On the PA there are some well-known industrial contaminated areas which impact some groundwater drinking water resources without effecting the surface drinking water sources. These contaminations provide from industrial locations nearby the Szolnok waterwork: Szolnok, Szajol, Törökszentmiklós. These contaminations are mainly TPH, TPX. The remediation has been going on. It needs significant material cost, high level skills and know-how and stringent authority controlling. After the remediation the areas can be used newly for other activities.
Measure advantages	▫ The areas can be used newly for other activities. ▫ Increase the human health quality. ▫ Increase the value of real estate.
Challenges	▫ Implementation of the remediation and recultivation ▫ Increase the level of controlling by authorities ▫ Increase the level of know-how
PA2.3-situation	On the PA there are Seveso and e-PRTR plants, but not on the upstream of the Tisza in case of Szolnok waterwork.

▪ BP I2 Waste management planning	
Description of the measure	Mandatory monitoring and implementation of protective measures against the potential negative impacts of landfills on surface water and groundwater should be precribed. All wastewater generated in county waste management center must be collected and treated. Rainwater must be collected in rainwater pool before it is discharge into the recipient. Sanitary wastewater must be collected in a leak-proof pool, form where it is periodically transported in tanks to the water

	treatment facility. Landfill leachate must be collected through drainage system that is laid on waterproof base and disposed into a retaining reservoir. Also implementation of recycling measures and measure of separate waste collecting should take place: ▫ recycling islands for separate waste collecting of paper, glass, PET packaging, metal packaging; ▫ collecting cardboard packaging from shops in cities and smaller settlements ▫ separate bulk waste collecting (Vrgorac in pilot action area), ▫ separate green waste collecting from public areas, compost of green waste from households and tourism objects (Vrgorac in pilot action area), ▫ measures that ensure the installation of construction waste recycling equipment (Vrgorac in the pilot action area) ▫ measures that ensure the collecting of waste in the recycling yards (Vrgorac in the pilot action area).
Measure advantages	▫ The areas can be used newly for other activities. ▫ Increase the human health quality ▫ Increase the value of real estate ▫ by implementing above mentioned measures the potential negative impacts of industrial wastewater and landfills on surface water and groundwater will be decreased, ▫ by educating citizens and economic subjects on the waste management (i.e. separate waste collecting, adequate waste disposal) the awearness of this significant environmental issue will be enhaced.
Challenges	▫ Implementation of the remediation and recultivation ▫ Increase the level of controlling by authorities ▫ Increase the level of know-how ▫ due to inappropriate waste management (unsanitary waste disposal or illegal disposal of construction waste) surface waters and groundwater are endangered, ▫ lack of clear allocation of tasks and lack of co-ordination between the different administrative levels, ▫ insufficient (door-to-door) separate collection of waste, ▫ insufficient inicentives to manage waste according to the waste

	hierarchy,
PA2.2-situation	Implementation of system tasks of waste management included in the waste management plans. Modernisation/closure of municipal waste landfill /landfill monitoring.
PA2.3-situation	On the PA there are some well-known industrial contaminated areas which impact some groundwater drinking water resources without effecting the surface drinking water sources. These contaminations provide from industrial locations nearby the Szolnok waterwork: Szolnok, Szajol, Törökszentmiklós. These contaminations are mainly TPH, TPX. The remediation has been going on. It needs significant material cost, high level skills and know-how and stringent authority controlling. After the remediation the areas can be used newly for other activities. On the PA there are Seveso and e-PRTR plants, but not on the upstream of the Tisza in case of Szolnok waterwork.
PA2.4.1-situation	Investment program for the remediation of illegal landfills and the allocation of funds of the County Budget to cities and municipalities in 2017. According to the Development Strategy of Dubrovnik-Neretva County 2016.-2020. a continuous education of citizens and economic subjects on the waste management is being implemented.
PA2.4.2-situation	There is a program of investments in the repair of illegal waste landfills and the allocation of funds of the County Budget to cities and municipalities for these purposes in 2017. Ministry of Environment and Energy plans rehabilitation and closing of landfill Kozjačić which is located in the area of Imotski is a natural karst sinkhole that will be, according to the Environmental Impact Study, filled with waste until the Regional centre for waste management in Lećevica starts operating. Disposal of waste is carried out in accordance with the planned remediation method, and when the landfill is used, the landfill will cover a watertight dump site. The waste disposal site will be completed by the Topana d.o.o. from Imotski.

▪ **BP I3**	**Monitoring and quality analysing of surface water and groundwater on mining areas**
Description of the measure	Development of an analysis concerning proper use of good quality water, e.g. water from mining drainage for municipal purposes. Preparation of an annual report concerning the amount of drainage,

	quality of drained water, manner of its use/monitoring of groundwater from reclaimed open mine and abandoned mining plant. Preparation of a report concerning the size of inflows to the excavation and the range of depression crater along with impact assessment. Prohibition of reclamation with materials posing a risk to surface water and groundwater.
Measure advantages	▫ Reclamation of open mines in a manner limiting the risk towards the quality of groundwater. ▫ Optimisation of water consumption by national management of water intended for consumption. ▫ Enhance and preserve water supply ESS
Challenges	Optimisation of water consumption by national management of water intended for consumption. Annual transfer of data on the status of excavation no longer exploited (conducted drainage, reclamation status, monitoring) by the mining plant director. Annual transfer of data on the scale of drainage and the range of depression crater by people who manage the plants conducting drainages on regional and local scale (deep and open mines). Educating / persuading the society/ professionals to apply the activity/ making them interested in implementation of the activity, monitoring of activity application process, enforcement of the policy or regulations.
PA2.2-situation	Monitoring and quality analysing of surface water and groundwater on mining areas is triing to be implented.

3.4.6. Tourism

Best management practices on tourism are not defined.

3.4.7. Wetland and Flood mitigation

▪ BP WM1 Management of natural and constructed wetlands	
Description of the measure	Wetlands are complex ecosystems of paramount importance, not only because they have become so rare and are so threatened, but because they perform important environmental and economic functions. Naturally functioning wetlands reduce flooding events, improve water quality, store carbon, and represent a valuable cultural and natural heritage. Due to their complex composition and structure, they generate unique vegetal, wildlife, fisheries, forestry and recreational resources. The combination of these functions and products makes these ecosystems invaluable to us. Thus, adequate management of wetlands. Numerous diverse and preserved natural and semi-natural habitat types with the abundance of species exist within wetland. Pursuant to the Birds Directive, Special Protection Areas (SPA) for bird species are proclaimed, while in accordance to the Habitats Directive Special Areas of Conservation (SAC) are proclaimed.
Measure advantages	▫ Wetlands are very efficient at removing excess nutrients from water. ▫ High water retention capacity with cost efficiency. ▫ Appropriate management can help in protection of drinking water sources. ▫ wetlands have important role from biodiversity and landscape aspect, ▫ wetlands are important factors in water storage, groundwater recharge and reduction of down-stream runoff, ▫ high protection degree in selected locations and designed sites, ▫ evaluation of potential cumulative impacts on water regime and ecological network.
Challenges	▫ several anthropogenic threats to wetlands cause degradation of them ▫ need increased awareness for the protection of relicts ▫ the Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia (OG No. 143/08) states that water courses, grasslands and wetlands are endangered due to degradation and reduction of biological and landscape diversity, excessive exploitation of natural resources, introduction of invasive species, construction of infrastructure (construction of roads, water management structures leads to

	habitat loss and fragmentation), agricultural activity (melioration, land consolidation, abandoning of agricultural lands) pollution, urbanization and global climate change, ▫ lack of and/or non-alignment of spatial plans of protected areas with spatial plans of local self-government units, ▫ input of allochthon (e.g. mouflon) and invasive (e.g. Caulerpa) species, ▫ the disappearance of domestic taxa and breeds; Insufficient expertise of the researchers.
PA2.3-situation	In the Hungarian Great Plain salt steppes and marshes were common areas before river regulation. Large areas of the plain are alkaline-saline "puszta", predominantly dry but containing many shallow waterbodies, as extensive marshes and soda lakes. The Kisköre reservoir or Lake Tisza is one of the most important sites for preservation of biodiversity on Hungary. Kisköre reservoir is a constructed wetland and managed for ensuring drinking water resource of Szolnok city.
PA2.4.1-situation	In the Pilot Action South Dalmatia: Prud-Klokun-Mandina spring valuable wetland area that is included in the List of Wetlands of International Importance is Neretva Delta, protected in 1993. Other protected areas in the PA: Prud-Klokun-Mandina spring: Betina velika jama, Čoćina jama, Velika špilja kod Antunovića, Krotuša Matica-Vrgorac field, Izvor Vir, Rastočko field, Jasena ponor, Podbiokovlje, Izvor Dropulića vrilo, Biokovo, Delta Neretve
PA2.4.2-situation	Protected areas in the Pilot Action Imotsko field springs: Prološko blato, Vrljika, Crveno jezero, Modro jezero, Bočni kanal uz Vrljiku, Kanjon Badnjevica, Izvor Krčevac.

▪ BP WM2 Designation of wetlands	
Description of the measure	One of the most important parts of the duties deriving from the basic obligations is the nature conservation management of the sites of international importance. Hungary is well positioned in this field, since the elaboration of the management plan of each site has already begun, and many of them are being implemented. The management plans are in line with the basic principles of the Convention, and are characterised by a clear, logical structure that enlists the given site's characteristics and assets and also determines the short-term objectives. The continuous monitoring of the ecological character and the regular review are very important parts of the plans.
Measure advantages	▫ Common and joint activities to protect wetlands promoted

	by international actions.
Challenges	▫ several anthropogenic threats to wetlands cause degradation of them ▫ need increased awareness for the protection of relicts
PA2.3-situation	The mainly part of the Hungarian PA is protected through the Natura 2000 network and there are four sites also adopted the Ramsar Convention too.
PA2.4.1-situation	In the Pilot Action South Dalmatia: Prud-Klokun-Mandina spring valuable wetland area that is included in the List of Wetlands of International Importance is Neretva Delta, protected in 1993. Other protected areas in the PA: Prud-Klokun-Mandina spring: Betina velika jama, Čoćina jama, Velika špilja kod Antunovića, Krotuša Matica-Vrgorac field, Izvor Vir, Rastočko field, Jasena ponor, Podbiokovlje, Izvor Dropulića vrilo, Biokovo, Delta Neretve
PA2.4.2-situation	Protected areas in the Pilot Action Imotsko field springs: Prološko blato, Vrljika, Crveno jezero, Modro jezero, Bočni kanal uz Vrljiku, Kanjon Badnjevica, Izvor Krčevac.

▪ BP WM3 Flood protection	
Description of the measure	Location of the Kozłowa Góra reservoir that serves, among others, as flood protection. The reservoir is operated according to strictly determined procedures that include actions in case of a flood. So called “rigid” water management instructions in the Kozłowa Góra dam reservoir have been developed. They provide instructions for actions in case of a flood. Activity of the Flood Protection Coordination and Information Center is to collect, process and share information regarding flood protection. Levees, located along the riverbanks, separate the flood hazard areas from the neighbouring territories, thus mitigating the effects of floods.
Measure advantages	▫ Flood mitigation. ▫ The aims of the Flood Riverbed Management Plans (FRMP) are reducing flood levels, keeping or repairing capacity of riverbed and ensure the flood protection safety. ▫ Identification of flood hazard zones and consideration of their limitations; ▫ Identification, development and protection of flood retention volumes; ▫ Development of individual flood protection measures;

	▫ Revision of the existing constructive flood protection measures; ▫ Maintenance of the watercourses, hydraulic works and river banks; ▫ Adequate management of hydraulic structures.
Challenges	▫ Cost of operating of the reservoir, conflict between water supply and flood mitigation functions of the reservoir. ▫ Reaction time for endanger of flood event, data exchange between OKI and reservoir management.
PA2.1-situation	The Flood Riverbed Management Plans relied on technical viewpoints, hydrodynamic modelling which determine the flood river bed and indicate the flow zones. There are several structural measures to reduce flood risk, like ▫ Deepening of riverbed by dredging ▫ Storage, and water retention in river bed ▫ Dyke relocation, building dykes, developing flood protection dykes ▫ Building flood channels or spillways ▫ Deepening of floodplains ▫ Demolition of river regulation structures ▫ Removal of buildings and other constructions from the flood area. ▫ Dredging and restoration of side branches ▫ Removal of summer dams from the flood area. ▫ River reef or river bend regulation From these structural measures there are several ones which could affect negatively the surface drinking water abstraction and the bank-filtered system. The deepening of riverbed has negative effect on the river minimum flow, in the perspective of surface drinking water abstraction. The dredging endangers keeping this level. The dredging risks eliminating the natural filter (gravel and film layer) of the riverbed which is the base of natural purification of bank filtering. On the PA there are also several perspective bank-filtered drinking water sources. Keeping the minimum flow in this case is also important. Further negative effect is the modification of river line.
PA2.4.1-situation	Non-structural flood defence of Spatial plan of City of Imotski prescribes measures against the floods: ▫ in areas with the potential flood risk, land use that is not vulnerable to floods should be planned, ▫ in areas with the potential flood risk where construction of buildings is allowed, resistant and hard materials should be used in construction,

	▫ existing local springs, wells and water tanks should be protected, ▫ protection against the flood must be in compliance with Water Act, National plan for flood control (Official Gazette No. 84/10) and Plans for the protection against the floods of Split-Dalmatia County, ▫ water bodies and water resources should be regulated in such a way as to ensure the prescribed water regime, quality and protection of water.

▪ BP WM4 Drought and Water Scarcity Management System	
Description of the measure	Hungary is considered highly vulnerable from climate change point of view. The drought monitoring network was established with 16 stations in 2016 to be extended in the upcoming years. On the PA there are some stations, which are working or planned status. The preparation of a freely accessible online platform for the dissemination and visualization of drought information is in the process now. Measures usually put in place by the water sector in case of serious droughts could be more planned and established after the system fully come to life. For instance: water retention in canals; filling reservoirs; water transfers; pumping due to low water levels; limiting regional water transfer between water directorates etc.
Measure advantages	▫ The measure's biggest advantage is timely prevention. Instead of the current follow-up assessments it provides up-to-date data of the evolution of drought and the current water scarcity. ▫ Prevention of drought losses has measurable effects on the national economic costs. ▫ With the Hungarian Operative Drought and Water Scarcity Monitoring System water scarcity of soils will be expressed in mm which enables the determination of soil specific proper operative measures. ▫ Nature of the HDI index (meteorological parameters and soil's water content) enable to characterize the drought/water scarcity on a daily basis. The index is modular; its meteorological parameter can be used alone where proper soil water content data is not available. Data needs can be satisfied from national monitoring systems up-to-date. Its calculation can be eased with algorithmization depending much less from subjective decisions.

	▫ Its integration into the existing water damage control system will ease the introduction and usage of the system and make it less expensive. ▫ The system will continuously support the agricultural sector by providing timely relevant data. It can be further developed with web tools, mobile applications etc. ▫ The data stemming from the monitoring system can contribute to new developments in drought and agricultural research while it will also build a much needed new and detailed data base. There is the possibility to interpret the drought index and water scarcity for different crops. ▫ Through the system's internet portal drought and water scarcity data will be available for free for users.
Challenges	In order to have an adequate drought picture in national level proper density of monitoring network should be ensured. Existing monitoring stations could be used if arrangement with their operators is concluded. Costs of long term maintenance should be provided.
PA2.3-situation	As the heart of the monitoring system the Hungarian Drought Index (HDI) based on meteorological parameters and soil's water content and data processing software was also developed.

▪ **BP WM5 Promote integrated ecosystem-based solutions of natural water retention measures**	
Description of the measure	Seeking ecosystem-based solutions for the mitigation of the water challenge. Water resources and ecosystems are primarily impacted by climate change, but water retention is also a key element in CCA (Climate Change Adaptation). The prototypes of NWRM that will be developed and implemented on the pilot sites will serve as a replicable model to other municipalities in the Danube basin, facing similar water and climate risks. The demonstrated water retention measures will build on ecosystem services and form part of the local green infrastructure, which serve as natural habitat and support biodiversity.
Measure advantages	The project will develop and promote integrated ecosystem-based solutions of natural water retention measures that support the sustainable land use practices and increase ecological flows, the quantity of water available for nature. Water retention in the landscape contributes to halting the loss of biodiversity and the restoration of ecosystem services through creating green infrastructure. The project targets the pressures on biodiversity that are classified by

	the Prioritized Action Framework (2013) as the most significant threats on the status of the Natura 2000 network in Hungary, namely factors influencing the natural water regime and water supply, land use – especially farming and forestry – and biotic and abiotic natural processes, such us the drying out of natural ecosystems due to climate change.
Challenges	Action A.2 will be 'Preparation of NWRM pilot project in Püspökszilágy'. The location of the village is extraordinary, as it lies on the drainage divide between the Danube and Tisza river basins. The key surface water is the Szilágyi stream, which is a minor brook with a small catchment area (10 km2). The annual mean precipitation is only ~600 mm/y. All these geographical characteristics make the village extremely exposed to droughts. Besides, the village has experienced record level flash floods in every two-three years in the last 10-20 years which had never happened before. Both flash floods and droughts cause many damages to agriculture, urban areas and infrastructure. In the upper watershed, the croplands and some forests dominate the landscape, covering steep slopes which significantly increased soil erosion and flash flood risks. Huge amount of sediment (soil loss) can be observed in certain creeks and gullies in case of flash floods. In the lower watershed, where the settlement is built, the floodplain along the Szilágyi stream does not fulfil its water retention role which leads to a broken balance between the stream and the valley bottom. In summer the valley bottom is completely dries, what has negative impacts on agriculture, ecosystems and the groundwater level. On the other hand, flash floods cause damages to public and residential buildings.
PA2.3-situation	The Ministry of Interior as coordinating beneficiary applied for the Life Project titled 'Municipalities as integrators and coordinators in adaptation to climate change'. The General Directorate of Water Management would be also a project partner. One of the main objective of the project is to raise awareness and increase knowledge of decision makers at Hungarian local governments, relevant public administration bodies and economic actors about the impacts of climate change and about ecosystem-based natural water retention measures (NWRM) as a powerful tool to improve climate resilience.

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

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

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

Both Pilot Actions are riparian sites. Drinking water source in PA3.2 is bank filtration. The main land use conflicts for both PA stem from agriculture and settlements, in PA3.1 also from traffic infrastructure. Both pilot Actions face drought problems. In the Po delta area in PA3.1 water quality issues are present due to salt water intrusion. Furthermore, in PA3.1 drier and more humid areas will be defined.

4.1. Land use

The dominating land use types within PA3.1 and PA3.2 are forest and agriculture. There are also pastures, urban areas and water reservoirs.

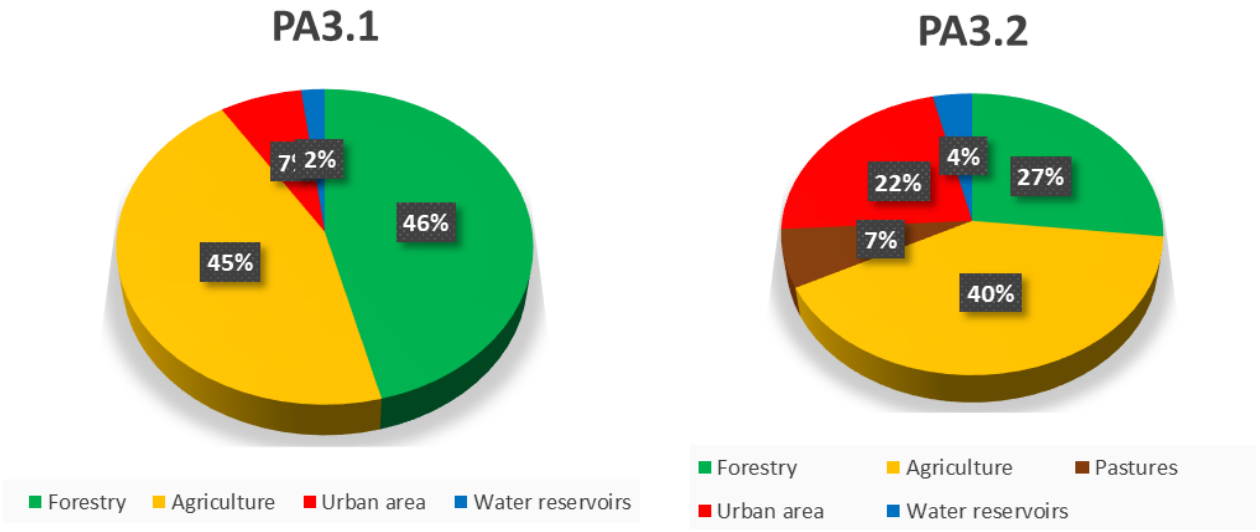


Figure 3: The land use types within PA3.1 and PA3.2.

The land use in the Po River Basin District [PA3.1], main land use areas and are retrieved by Corine Land Cover (CLC) 2012. An agriculture area and forest and grassland area cover the majority of P-RBD territory (46% and 45%, respectively) while urban and industrial area concerns about 7%.

Regarding the Danube Bend [PA3.2], the zone which covers an area of about 2572 km2 the main identified land use areas consist in non-irrigated arable land (35.4%), broad-leaved forest (17.4%), discontinuous urban fabric (14.1%) and pastures (6.4%). Focusing on the bank-filtered drinking water protective zones area (DWPZ) (389 km2), the relevant land use areas remain the

same but with different percentage (non-irrigated arable land at 38.5%, discontinuous urban fabric at 11.4%, broad-leaved forest at 11% and pasture 6.5%).

4.2. Drinking water protection

Table 7: DWPZs within PAC 3.

PA 3.1-situation	a drinking water source such as a well or spring is to be protected by a three-level safeguard zone: a) Absolute Safety Zone close to the source, b) Respect Zone depending on groundwater travel time c) Protection Zone in the outer part. Those protection zones are defined on the basis of hydrogeological, hydrochemical and hydrological analysis; vulnerability to pollution is also taken into account
PA 3.2-situation	a) the inner protective block, zone: protection of the abstraction works and the water supplies from direct pollution and damage b) the outer protective block, zone: protection against refractory, further bacterial and other decomposable pollutants c) the hydrology or hydrogeological block, zone: Protection against refractory pollutants by measures prescribed for the entire, or part of the catchment (recharge) area of the abstraction. The hydrogeological protective block or area is subdivided to "A", "B" and "C" protective zones

4.3. Other Protection areas

Table 8: other protection areas within PAC 3.

PA 3.1-situation	There are some areas of Natura 2000 within the Pilot area.
PA 3.2-situation	a) Considering the Danube Bend from Szob to Tass (Hungary), there are large areas of Natura 2000 on the northern and south-eastern parts of the Pilot Area b) The Special Areas of Conservation (SAC) cover 837 km2, the Special Protection Areas (SPA) types cover 587 km^2, and between them there are overlaps. c) the national protected areas (National Parks, Landscape Protection Areas and Nature Conservation Areas) cover altogether 586 km^2, and there are 129 km^2 Ramsar areas on the Pilot Area d) Natural bathing waters are also protected, of which 29 are located on the Pilot Area.

4.4. Best Management Practices

Best Management Practices are classified regarding types of land use and can be identified with a specific colour (see Table 8).

Table 9: Legend of Best Management Practices classification

	Forest
	Grassland
	Agriculture
	Urban Areas
	Industrial Areas
	Wetland, flood mitigation and Karst region
	Tourism
	Stone Quarries and Gravel Pits

4.4.1. Forest

▪ BP MF1 Continuous forests cover (CFC)	
Description of the measure	Continuous forest cover (CFC) systems involve continuous and uninterrupted maintenance of forest cover and avoid clearcutting.
Measure advantages	CFC is a true alternative to simple timber production and provides the basis for an economical strategy in forestry with the overall purpose of drinking water protection and/or flood prevention. It ensures the soil and water protection functionality of forest ecosystems over space and time.
Challenges	In Hungary only a few forestry has started establishing CFC systems yet. The application of CFC requires specific knowledge and understanding of long-term benefits.
PA3.2-situation	In the mountainous northern part of the PAC3.2 there are forest areas which are specifically managed for protecting the soil or drinking water. These CFC protects bank filtered water sources from the background.

▪ BP MF 3 Protective forest management and afforestation of DWPA	
Description of the measure	Protective forests are especially important for the protection of the bank filtered systems. These forests mitigate or prevent the impact of a natural hazard, including soil erosion, landslide or flooding. The protective effect consists in maintaining the 'natural' flow regime. With regard to floods forests reduce stormflow peaks and delay. Protecting stream and river banks from undue horizontal erosion is function of a buffer zone of trees along both sides of a watercourse. The buffer area also acts as a filter and depository for sediment, pesticides and fertilizers from upslope land use, thus preventing them entering to the DWPAs. The forest cover (nearly 19%) of the Pilot Area is improving but at international level it is still low when compared to the average of the EU (34.2%). The problem is that the forests disappeared after the deforestation of the plains for agricultural reasons in the previous century. The significance and necessity of afforestation can be characterized by favourable impacts on the soil, water, air and biodiversity, in short on the environmental state, in addition to the economic benefits.
Measure advantages	▫ Mainly the mountainous protective forests have established for protecting against landslides and rock crumbling. These are forests on steep slopes or banks of waters, forests in torrential type areas withhold excessive discharge of water and thus protect the land from erosion. Protective forests also form forest belts, which protect forests and land from wind, water, snowfall, ▫ Establishing protective forests at banks of waters prevents leaching of agricultural pollution to waters. Planting trees can be effective in increasing water infiltration, and reducing and slowing runoff. ▫ The main aims of the measure are to increase the forest cover of the PA's plain sites; by developing the forestry sector, to enable the agricultural restructuring, by the help of alternative use of areas. Objectives of forestry also include the establishment of high biodiversity natural forests. ▫ The whole area of afforestation contributes to protection against erosion and combating climate change mitigation. ▫ Positive impacts on both river flood protection and riverine ecological quality ▫ Decreased diffused discharge of nutrients (e.g. nitrate)

Challenges	▫ In Hungary the management of forests depends on the owners. The good practices in forest management ensured if waterworks can treat the protective areas of drinking water sources. ▫ Compatibility with current land uses and infrastructures in riparian strips implementation and maintenance costs
PA3.1-situation	Pro Silva Hungaria was established in 1999 as a non-governmental organization, it's made for stakeholders of the forest sector for forestry practice. It promotes sustainable and profitable forest management strategies. As a result of the discussions silviculture includes not only wood production but an emphasis on maintaining forest biodiversity, recreational, landscape, soil, air and water protective functionalities as well as socio-economic and cultural functions. It ensures the soil and water protection functionality of forest ecosystems, ensures up-to-date knowledge transfer. The guidelines for programming and implementation of maintenance operations on vegetation and riparian forests propose, in relation to the different requirements of securing intervention (insufficient maximum hydraulic discharge flow, need to laminate the flood flow, etc.), the type of action on vegetation riparian and of river bed more consistent with the environmental quality objectives of the water course his critical issues highlighted (macrobenthos, diatoms, fish communities, etc).
PA3.2-situation	Riverine forests (mainly alders, willows and poplars) have been heavily transformed but important areas remain along the large rivers, like the Danube. The most of them show rather pristine state and they are Natura 2000 sites. Only a few "relicts" show the original natural vegetation because of the spread of invasive species of non-native plants and of weeds (IUCN, 1993). Man-made flood defenses – engineered embankments, flood walls and temporary structures – are an essential part of the fight against flooding. However, forests/trees can provide a sustainable and low maintenance solution to lessening the risk of flooding as well as delivering other environmental and economic benefits when combined with other flood defenses on floodplain. Establishing protective forests at banks of waters or in DWPAs prevents leaching of agricultural pollution to waters. Planting trees can be effective in increasing water infiltration, and reducing and slowing runoff. Woodland located on floodplains can mitigate large flood events by absorbing and delaying their progress downstream. Trees and green space could play a critical role in adaptation to climate change

	in addition to reducing flood risk.

▪ BP MF 4 Protective forest management on floodplain	
Description of the measure	Protective forests are especially important for the protection of the bank filtered systems. These forests mitigate or prevent the impact of a natural hazard, including soil erosion, landslide or flooding. The protective effect consists in maintaining the 'natural' flow regime. With regard to floods forests reduce stormflow peaks and delay. Protecting stream and river banks from undue horizontal erosion is function of a buffer zone of trees along both sides of a watercourse. The buffer area also acts as a filter and depository for sediment, pesticides and fertilizers from upslope land use, thus preventing them entering to the DWPAs. The significance and necessity of afforestation can be characterized by favourable impacts on the soil, water, air and biodiversity, in short on the environmental state, in addition to the economic benefits.
Measure advantages	▫ Mainly the mountainous protective forests have established for protecting against landslides and rock crumbling. These are forests on steep slopes or banks of waters, forests in torrential type areas withhold excessive discharge of water and thus protect the land from erosion. Protective forests also form forest belts, which protect forests and land from wind, water, snowfall, ▫ Establishing protective forests at banks of waters prevents leaching of agricultural pollution to waters. Planting trees can be effective in increasing water infiltration, and reducing and slowing runoff. ▫ The main aims of the measure are to increase the forest cover of the PA's plain sites; by developing the forestry sector, to enable the agricultural restructuring, by the help of alternative use of areas. Objectives of forestry also include the establishment of high biodiversity natural forests. ▫ The whole area of afforestation contributes to protection against erosion and combating climate change mitigation.
Challenges	In Hungary the management of forests depends on the owners. The good practices in forest management ensured if waterworks can treat the protective areas of drinking water sources.
PA3.2-situation	The forest cover (nearly 19%) of the Pilot Area is improving but at

	international level it is still low when compared to the average of the EU (34.2%). The problem is that the forests disappeared after the deforestation of the plains for agricultural reasons in the previous century.

▪ BP MF5 Prohibition or restriction of grazing in forests/ Establishment of agro-forestry systems (grazing) and wood-pastures	
Description of the measure	Overgrazing can occur when undergrowth is exposed to intensive grazing for extended periods of time, or without sufficient recovery periods. The only thing to stop overgrazing is to limit the animals space to roam around. Overgrazing reduces the usefulness, productivity, and biodiversity of the land and is one cause of desertification and erosion. Overgrazing is also seen as a cause of the spread of invasive species of non-native plants and of weeds. The agro-forestry systems are extensive land use systems where trees are attended and agricultural activities are pursued simultaneously, thus a mosaic of agricultural and forestry systems is created. They combine extensive agricultural and forestry systems aimed at the production of excellent quality wood and other forestry products. Introducing agro forestry system in special regions of PA (floodplains) are expected to achieve major positive environmental effects.
Measure advantages	▫ Negative impacts of overgrazing can be prevented and/or reversed by proper forest management. ▫ The agro-forestry systems have major importance in reintroducing sustainable landscape management and the strengthening of the mosaic character on plain areas ▫ The measure aids the protection of rural natural resources and improves their state ▫ The measure provides a good opportunity for integrated and ecological farming, decreasing the conflict of interest between agriculture and drinking water protection ▫ For farmers on the DWPAs the agro-forestry systems are perfect for making the rural area more attractive, for maintaining jobs and creating new ones, and for improving the living conditions
Challenges	Undergrowth management have to solve by forestry. The quality of forest management depends on the owners of the forest. The traditional use of woodlands and its essential influence on the land's structure and dynamics have become commonly known among the Hungarian ecologists only in the past few years. The abandoned

	wood-pasturing occurred in all types of forests. In all cases the decrease of pasturing livestock was the reason for the abandonment of the areas. Although, wood pasturing which is based on the traditional knowledge has a great importance in conserving nature and landscape but for re-establishment of agro-forestry systems a lot of obstacles have to defeat, for example: intensive husbandry has replaced grazing. It would be necessary evolving a consciously controlled and sustained wood pasturing system again.
PA3.2-situation	According to the Hungarian actually Forest Law grazing in the forests has been prohibited for the last decades. The grazing in forests was maintained until the middle of the 20th Century, but it had been regulated by laws since the early times. After the date of 01.09.2017 the law will cancel the prohibition of the grazing in forests, it will be allowed with restrictions. Only horses, cattles and sheeps are allowed to be grazed or rested in forest. The reasons of prohibition were to protect soil from degradation, increase game production and biodiversity as well. Compaction of soil can reduce plant growth, inhibit root penetration, restrict water and air movement in the soil and, ultimately, reduce yields.

▪ **BP MF6 Forestry administration and control**	
Description of the measure	On the PA in terms of forest management, it can be distinguished between state-owned and non-state-owned forests, mostly private ones. The non-state-owned areas are managed mostly by private management companies. These must be recorded by the forestry authorities. The management of the state forests is mainly carried out by the state forest management companies. However, there are also other state organizations – e.g. Water Management Authorities, National Parks – managing state forest areas. The share of community ownership on forests is low, usually municipal, town and city councils are the forest managers.
Measure advantages	▫ The control on Forestiers ensures to reach sustainable forest management objective ▫ Clear legislative background system
Challenges	Not managed forests also exist in Hungary most of them being in private property. At these areas there is no forest manager recorded in the register of the forestry authority. It is a key objective of forest policy in Hungary to further reduce the size of unmanaged forests.
PA3.2-situation	The Directorate of Forestry of the National Food Chain Safety Office

	(NFCSO FD) carries out tasks in general of forestry administration. The main activity is to ensure, through its administrative functions, the sustainable forest management in the country. It must be stressed again that forestry authority organizations do not carry out any forest management activities in Hungary, independently of the ownership type.

4.4.2. Grassland

▪ BP MG1 Protective grassland management	
Description of the measure	The Government Regulation 123/1997. prescribe, that within the inner protective zone, the terrain shall be levelled to prevent surface runoff from accumulating in stagnant pools. The terrain should be planted as continuously as practicable with grass. No fertilisers, manure and pesticides must be spread. The surfaces on which no grass can be planted shall be paved with durable, non-polluting material. Over aquifers close to the surface, further in the vicinity of pipelines and structures no trees and shrubs with roots reaching down to these must be planted.
Measure advantages	▫ Clear legislative background system ▫ Grassland may reduce quantitative and qualitative vulnerability of groundwater and surface water resources by retaining water, filtering and attenuating pollutants, reducing erosion
Challenges	Control of prescibtion.
PA3.2-situation	In karstic areas of Budai hills and Pilis mountain, grasslands are managed for protecting grassland ecosystem and drinking water resources.

▪ BP MG2 Special good practices of grazing in protected areas	
Description of the measure	A significant portion of grasslands are over utilized by livestock. Although a parcel of land is not overgrazed there are some parts where signs of degradation can be found. These special areas are attractive for ungulates because there is water, added by salt sources, shelters. Overgrazing has detrimental effects

	on soil and vegetation but changes are reversible. High grazing pressure negative influences the ecosystems. Moreover, overgrazing increases area covered by no vegetation, reduces infiltration, soil moisture and fertility, accelerates runoff increases soil ammonia and nitrate content and changes soil microbial activity. If this befalls on DWPAs the drinking water aquifer can polluted. Nevertheless, all these negative impacts can be prevented and/or reversed by proper grassland management practices. According to the Government Regulation 123/1997. within the inner protective zone is prohibited grazing, but in particular instances (e.g. groundwater table deeper than 2 m) grazing may also be allowed inside the outer protective zone, only watering and noontime rest of the animals shall be outside the protective zone.
Measure advantages	▫ The measure preserves retention capacity, consequently ESSs, in the frame of general grassland management without considerable additional cost or loss of production: so increases cost efficiency ▫ Appropriate grazing can efficiently contribute to weed control
Challenges	▫ The correct information of farmers ▫ Need increased awareness of the farmers
PA3.1-situation	PAC3.1 does not provide examples for Po River Basin.
PA3.2-situation	In karstic areas of Budai hills and Pilis mountain, grasslands are managed for protecting grassland ecosystem and drinking water resources.

4.4.3. Agriculture

▪ **BP MA1 Creation of buffer strips and wetland basins**	
Description of the measure	EU legislation related to the Common Agricultural Policy (CAP) from 2014 to 2020, confirms that farmers, in order to qualify for economical subisdes, are required to comply to conditionality (basic rules

	on the environment, climate change, good agricultural and environmental conditions land, public health, animal health, plant health and animal welfare). Conditionality applies through a set of Management Criteria Required (SMRs) and standards of Good Agricultural and Environmental (BCAA), identified in Annex II to Regulation (EU) No. 1306/2013, and adopted annually by a Decree Mipaaf. BCAA1- Establishment of buffer strips along water courses is a conditionality aimed to protect surface and groundwater pollution resulting from agricultural activities. The term "buffer zone" identify 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. The efficacy of nitrogen removal is variable in function of the selected type of buffer strip and, in particular, varies in function of its complexity. The PSR envisages three types of interventions (Operazione 4.4.03 - Realizzazione di fasce tampone e bacini di fitodepurazione di contrasto ai nitrati): - buffer strip with herbaceous band and single-strand arboreal and / or shrubby: farmland band 4 m wide, adjacent to the cultivated field, sown with a mixture of long life forage species and single-strand arboreal and / or shrubby of 1 meter wide interposed between the grassy strip and the drainage water body; - buffer strip with herbaceous band and single-strand arboreal and / or shrubby, with load ditch: load ditch parallel to the channel/stream that collects the waters, with higher water levels to facilitate a subsurface flow between the ditch and the canal/stream; strip of land between the load ditch and the channel/stream consisting of grassy band of 3 m width seeded with a mixture of long life forage species and single-strand arboreal and / or shrubby 1 m wide; - basin for the phytoremediation of farm land runoff waters: basin, not waterproofed, of area equal to 1-

	5% of the UAA, buffer strip surrounding the basin of at least 5 m covered with vegetation, main entrance ditch, outflow ditch able to ensure the maintenance of a 50 cm average level in the basin, depressions of 0.50 and 2 m on at least a third of the surface of the basin. Similar measures exist in other Regions, e.g. Veneto, Lombardia, where it is possible that technical characteristics required for the realization of buffer strips are a little different.
Measure advantages	▫ Decreased soil erosion ▫ Decreased diffused discharge of sediments and nutrients (e.g. nitrate, phosphorus) ▫ Reduction of flood discharge (wetland basins)
Challenges	▫ Compatibility with current land uses and infrastructures in riparian strips ▫ Reduction of extension of productive farmland ▫ Implementation and maintenance costs
PA3.2-situation	For example, in Emilia-Romagna the realization of buffer strips and wetland basins is the Submeasure 4.4 - support for non-productive investments linked to the achievements of agri-environment-climate targets of the Rural Development Plan of the Emilia-Romagna Region (PSR 2014-2020). The Emilia-Romagna region has large areas vulnerable to nitrates and areas at risk of erosion to which is associated transport of nutrients in sediments. The measure of PSR is designed to mitigate the impacts resulting from the use of fertilizers, but also to control the pollution associated with the sediment transport through a farm scale creation of buffer strips and wetland basins.

▪ **BP MA2 Wooded Buffer Strips in rural areas**	
Description of the measure	The pollution of water resources is one of the main problems connected with 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 not adapted to crop cycles and by inappropriate tillage or irrigation practices. The transfer of polluting agents is linked to water flows: for substances with lesser absorbance by soil particles (e.g. nitrates) the transfer happens mainly through surface flowing or deep percolation of solutions; for highly absorbed substances, (phosphorus compounds), erosion and sedimentation are the main transfer systems. The Woody Buffer Strips (WBS) are an effective means to retain, assimilate and remove the nutrients coming from agricultural fields. A cost-benefit analysis quantified the results in terms of Measure advantages for the environment and opportunity for the farmers. The environmental benefits were clearly quantified with an analysis of the conditions that make the investment convenient for farmers, with or without public incentives. The main results of such assessment are: - water quality and nitrogen retention: young WBS are able to reduce up to 50% the amount of total fluid nitrogen that percolates through them by the sub-superficial layer; - in terms of % retention no appreciable difference was observed between 5 and 15 meters wide WBS, confirming the key role of the first 5 meters of the hedge as the main area where waters enriched with nitric nitrogen meet favourable conditions for denitrification; retention capacity of a 100 meters long and 5 meters wide WBS was 6.3 kg per year of total fluid nitrogen; - the most evident effects were a decrease in the releasing of nitric nitrogen and an increase in the releasing of organic nitrogen; - the main factor limiting denitrification processes is carbon, energy source for bacteria; this leads to the assumption that trees growth with a higher biomass production will support an increase in nitrate-reducing bacteria's activity; - when WBS is intended mainly for environmental purposes or where the wood production is meant for construction purposes it's not profitable; WBS that partially uses species aimed at producing wooden

	biomass for energy purposes, shows profitability only when there are public incentives, it's clearly profitable in those cases in which plants are used to produce wood biomass, even without public incentive.
Measure advantages	▫ Decreased soil erosion ▫ Decreased diffused discharge of sediments and nutrients (e.g. nitrate, phosphorus)
Challenges	▫ Compatibility with current land uses and infrastructures in riparian strips ▫ Reduction of extension of productive farmland ▫ Implementation and maintenance costs
PA3.1-situation	Similar experiences have been obtained in central Italy with the projects REWETLAND (Widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino, LIFE+08 ENV/IT/000406) and RIPARI (Reduction of impacts of agricultural pressures on water resource, funded by Regione Toscana, POR FESR 2007-2013).
PA3.2-situation	The LIFE project "Progetto dimostrativo sull'impiego di Fasce Tampone Boscate (FTB) in ambiente agricolo" aimed to demonstrate that WBS offered an efficient method for reducing nutrients-leaching from agricultural field, and also could provide an interesting economic opportunity for farmers, by enabling the production of wooden biomass for energetic use and giving economic support through financial subsides (Structural Funds).

▪ **BP MA3 Prohibition or restriction of application of manure in high-risk areas**	
Description of the measure	The engineering structures of drinking water supply" define the rules of the application of manure, of dissolved fertiliser and liquid manure and the release of liquid manure on the DPWZs. On the inner zone of the surface and groundwater resources it is strictly prohibited, on the outer and on the hydrogeological "A" protective zones it is allowed depending on the outcome of an EIA, or environmental audit, or a special equivalent investigation. The dissolved fertiliser and liquid manure land application to

	agricultural land within the inner, outer and hydrogeological "A" protective zones are prohibited, inside the hydrogeological "B" protective zone is allowed depending on the outcome of an EIA, or environmental audit, or a special equivalent investigation. Release of liquid manure on the DPWZs is strictly prohibited.
Measure advantages	▫ NO_3 (plus ammonium and nitrite) leaching losses and indirect and direct NO_2 emissions would be reduced by a small amount ▫ Soluble and particulate P losses would be reduced by a small amount ▫ Organic load losses would be reduced by a small amount ▫ It should be used in other sensitive areas
Challenges	▫ It is difficult to verify
PA3.2-situation	The "Government Regulation 123/1997. (VII.18.) on the protection of the actual and potential sources, and the engineering structures of drinking water supply" define the rules of the application of manure, of dissolved fertiliser and liquid manure and the release of liquid manure on the DPWZs.

▪ **BP MA4 Controlling storage of manure**	
Description of the measure	All drinking water protected areas are designated as nitrate sensitive areas as well. To protect the nitrate sensitive areas, and to protect waters, the use of artificial fertilizers and plant protection chemicals shall be reduced. In order to protect waters and to diminish the existing nitrate pollution, the rules of Good Farming Practice have to be observed in the affected agricultural areas. The sound use of soil, which takes into consideration the perspectives of the nutrients and the soil management, has to be fostered. Rural Development Program supports conversion arable land farming practices into less intensive land use near vulnerable water resources. This measure has provided for areas in the protection zone of vulnerable drinking water resources, or on land with a

	slope steeper than 12%, or in areas affected by floods to preserve and improve the condition of the environment. The specifications referring to the sustainability of "good agricultural and environmental condition" are display in the national legislation. The minimum requirements referring to nutrient management and application are imposed in the pieces of national legislation below. These minimum requirements must be met by the beneficiaries of RDP in the complete areas of their agricultural lands. ▫ The amount of nitrogen from organic manure disposed in an agricultural area on an annual basis cannot exceed 170 kg/ha ▫ Manure cannot be applied on frozen ground, land filled with water or covered completely with snow ▫ Manure shall not be spread in prohibited period ▫ Manure cannot be applied in a radius within the protection zone of surface water, source, and wells whose water is used for human consumption or watering animals ▫ Improvement of acidic, saline and sand grounds can be undertaken in line with ground protection authority permit and complying with regulations of relevant legislation ▫ Treated wastewater, sewage sludge and slurry application shall be done in accordance with the permit issued by soil protection authority and meeting specifications of relevant legislation
Measure advantages	▫ Clear legislative background system ▫ Controlled nutrient use by authorities ▫ The measure prevents the pollution of water resources, so reduces quality vulnerability of drinking water supply
Challenges	▫ Need of professional knowledge, permanent education of farmers/users of fertilizers
PA3.2-situation	According to the Government Regulation 123/1997 inside the inner protective zone is prohibited the

	fertilizer application, within the outer, hydrogeological "A" and hydrogeological "B" zones it is allowed depending on the outcome of an EIA, or environmental audit, or a special equivalent investigation.

▪ BP MA5 Controlled application of manufactured fertilizer in high-risk areas	
Description of the measure	Controlled application of manufactured fertilizer in high-risk areas.
Measure advantages	▫ NO_3 (plus ammonium and nitrite) leaching losses and indirect and direct NO_2 emissions would be reduced by a small amount ▫ Soluble and particulate P losses would be reduced by a small amount ▫ Organic load losses would be reduced by a small amount ▫ It should be used in other sensitive areas
Challenges	▫ It is difficult to verify
PA3.2-situation	There is no control over application of manufactured fertilizer in high-risk areas.

▪ BP MA6 Controlling the use of pesticides	
Description of the measure	Inside the outer, hydrogeological "A" and hydrogeological "B" zones it is allowed only depending on the outcome of an EIA, or environmental audit, or a special equivalent investigation. The pesticide application from aircraft is prohibited within the inner, outer and hydrogeological "A" protective zone, within the hydrogeological "B" zone it is allowed only depending on the outcome of an EIA, or environmental audit, or a special equivalent investigation. The pesticide storage and residues disposal and washing pesticide equipment, effluent disposal within the inner, outer and hydrogeological "A" zones is allowed. The washing pesticide equipment, effluent disposal within the hydrogeological "B" zone is allowed only depending on the outcome of an EIA, or environmental audit, or a special equivalent

	investigation.
Measure advantages	▫ Clear legislative background system ▫ Strictly controlled pesticide used by authorities ▫ The measure prevents the pollution of water resources, so reduces quality vulnerability of drinking water supply
Challenges	▫ Uses of not registered pesticides (illegal activities) ▫ Need of professional knowledge, permanent education of farmers/users of pesticides
PA3.2-situation	The Agricultural Office designated as the plant protection and soil conservation competent authority.

▪ **BP MA5 No-chemicals and organic farming**	
Description of the measure	Recent years in Hungary have seen the rapid rise of organic farming, although domestic demand for fresh and processed organic produce has increased at a slower pace. One reason is the higher consumer price of organic products; another is the lack of organization in the internal markets. Most of them deal with wine production, processing of fruits, vegetables, milk and meat. This allows the producers to process an increasing portion of their organic products in their own facilities, under strictly supervised conditions.
Measure advantages	▫ Strictly supervised productions ▫ No-chemicals farming does not affect negatively the drinking water quality
Challenges	▫ Relatively high cost ▫ Need of professional knowledge
PA3.2-situation	Recent years in Hungary have seen the rapid rise of organic farming, although domestic demand for fresh and processed organic produce has increased at a slower pace.

▪ **BP MA8 "Good Agricultural Practice" guidelines**	
Description of the measure	Inappropriate agricultural use of land and use of

	fertilizers and pesticides can cause significant pollution endangering the quality of potable water. Thus, Budapest Waterworks Company created a good practice guideline for farmers to support the protection of drinking water in an agricultural area and at the same time to help farmers making their livelihood in the water protection zones. In the guidelines, clear explanation is given on the connection between land use and the drinking water base and there are suggestions for appropriate and "water-friendly" soil preparation, use of fertilizers and pesticides, sowing and planting, irrigation, husbandry and livestock breeding, as well as administrative obligations. The guideline was especially designed for farmers working in water protection zones and considers all aspects of water protection needs, as well as the need of the farmers. The maps of the protection zones with various levels of restrictions and the detailed description of regulations are also available at the local governments. The appropriate agricultural use considers also soil and water protection, as well nature conservation and do not expose the environment to unnecessary load from irrigation, use of fertilizers and pesticides. Substances not absorbed by plants will be washed out and sink to the ground water, thus they are not only polluted the drinking water, but also they are wasted from the farmers' point of view.
Measure advantages	▫ Farmers are considered as partners and they are positively motivated for water-friendly farming, which is much more positive than only the use of rules ▫ If well-targeted, the information can reach many farmers and may cause significant improvement in water-base management on long term complementing the regulations ▫ "Good Agricultural Practice" can be applied also in other areas ▫ Water-friendly land use favours also nature conservation and human health, thus it is a multi-aspect approach

Challenges	▫ The number of farmers reached ▫ The willingness of farmers to follow the guideline ▫ It is difficult to measure its effectiveness
PA3.2-situation	On Szentendrei or Csepel Island water protection areas managed by Budapest Waterworks (BW) by establishment of a farm advisory system. There are more than 150 wells on Csepel Island and several hundred on Szentendrei Island producing potable water for Budapest and its agglomeration. The long-term sustainability of the excellent quality of that water depends on a number of impacts: the local waste and sewage management, the local industry, its locations and environmental status, mining, presence of open and/or stagnant water and the agricultural activities.

▪ **BP MA9 Agri-environmental payments under Rural Development Programme of Hungary**	
Description of the measure	Agri-environmental payments contribute to the development of rural areas and provide environmental services for the whole of society. These payments encourage producers of agricultural lands to adopt farming and production methods which are compatible with the sustainable use of environment, landscape, and natural resources and with the preservation of genetic resources. At the establishment of agri-environmental actions close attention is devoted to the alleviation and reduction of agri-environmental problems typical in Hungary, and to the promotion of such environmentally friendly farming practices which prevent certain environmental problems to occur. In line with the above, the following specifications have been laid down in accordance with agri-environmental priorities and have been integrated into various schemes: ▫ Soil protection: the amelioration of effects of various soil degradation procedures (land erosion, acidification, soil compaction) by the adoption of a variety of agrotechnical methods. As environmentally friendly nutrient

	management practices are promoted, the negative balance of land nutrients is restored, and this is one of the key objectives ▫ Protection of surface- and ground waters: with the help of the promotion of restructuring land use and the practices of environmentally friendly nutrient management and plant protection, the quality of water resources shall be protected and possible contaminations shall be reduced ▫ Nature conservation: in all areas of agricultural land use (arable farming, grassland management, plantations) the target is the development of an active nature conservation system ▫ Genetic conservation ▫ Reducing air pollution: via extensive farming along with management methods and plant groups requiring low external input schemes contribute to the reduction of contamination produced by agriculture
Measure advantages	▫ Support the sustainable development of rural areas, to preserve and improve environmental conditions, to reduce load on environment from agricultural sources, to offer environmental protection services, and to promote agricultural practice based upon the sustainable use of natural resources ▫ Support the preservation of biodiversity on farm ▫ Support the protection of waters and soil with the establishment of farming structures adequate for production area features, environmentally aware farming ▫ The establishment of sustainable land use is also strongly supported
Challenges	▫ Relatively high cost ▫ Need of professional knowledge
PA3.2-situation	In Hungary, reduction of agri-environmental problems are typical and the promotion of such environmentally friendly farming practices which prevent certain

	environmental problems occur.

▪ BP MA10 Definition of optimum amount of water for irrigation	
Description of the measure	IRRIFRAME, at national scale, and IRRINET, for Emilia Romagna Region, are two web services, available also as application for mobile devices, able to support farmers in definition of optimum amount of water for irrigation according to the weather conditions, crops and soils in the area of interest.
Measure advantages	▫ Reductions in water resource wastage ▫ Support farmers in definition of optimum amount of water for irrigation ▫ Improvement of available information
Challenges	▫ Enforce farmers education
PA3.1-situation	**IRRIFRAME and IRRINET projects.**

4.4.4. Urban areas (settlements)

▪ BP U1 Construction of the sewage system and devices for waste water treatment	
Description of the measure	Construction of new or modernisation of already present sewage treatment plant and sewage network. In case of heavy rainfalls, the wastewater treatment plants are overloaded, so it would be necessary separate the rainwater form the sewage systems. The capital of Hungary (Budapest) is nearly on the centre of the PA, with agglomeration the urban area extent is significant (12%).There are 2.5 million residents on the PA, so the waste water treatment is realised by regional sewage plants. The treated waste water discharges into the Danube, where the bank filtered drinking water supplies are located, so the efficiency of the plants is really important.
Measure advantages	▫ Prevent the deterioration of groundwater quality ▫ Increase the level of human health ▫ Decrease the emission of microbiological pollutants, nutrient N&P compounds and priority substances ▫ Decrease the contamination of surface waters in case of overflowing sewers
Challenges	▫ Increase the connection to the sewage network ▫ Improve the waste water treatment technology

	▫ Prevent incoming rainwater to the sewage system – needs of separated systems
PA3.2-situation	The capital of Hungary (Budapest) is nearly on the centre of the PA and there are 2.5 million residents on the PA, so the waste water treatment is realised by regional sewage plants.

▪ BP U2 **Set up of individual waste water treatment plants for individual houses**	
Description of the measure	Only the settlements higher than 2000 PE (population equivalent) are involved to the national sewage program, the others need to find individual solutions for waste water treatment. There are many known technologies, but actually their applications are on low level in Hungary because of the higher prices. At the households without connection to the sewage network there are usually septic tanks and the waste water is transported to the sewage plants.
Measure advantages	▫ Prevent the deterioration of groundwater quality ▫ Increase the level of human health ▫ Decrease the emission of microbiological pollutants, nutrient N&P compounds and priority substances ▫ Decrease the charging of the sewage network
Challenges	▫ Improve the waste water treatment technology ▫ Need of professional knowledge ▫ Increase the environmental awareness of residents
PA3.2-situation	In Hungary only the settlements higher than 2000 PE (population equivalent) are involved to the national sewage program, the others need to find individual solutions for waste water treatment.

▪ BP U3 **Implementation of decentralized rainwater infiltration**	
Description of the measure	The centre of the PA is mostly covered by urban area (Budapest and agglomeration), so the importance of the urban rainwater management is significant. It needs decreasing sealed artificial surfaces to prevent the further quality and quantity degradation of groundwater.
Measure advantages	▫ Decreased pollution deposition from air ▫ Increased water quantity and recharge, increased infiltration and drainage capacity
Challenges	▫ Increase the amount of green surfaces

PA3.2-situation	The centre of the PA is mostly covered by urban area (Budapest and agglomeration), so the importance of the urban rainwater management is significant.

4.4.5. Industrial areas

▪ BP I1 More stringent persecution of contaminated site remediation	
Description of the measure	On the PA there are some well-known industrial contaminated areas which impact some groundwater drinking water resources without effecting the surface drinking water sources. These contaminations provide from industrial locations nearby the Szolnok waterwork: Szolnok, Szajol, Törökszentmiklós. These contaminations are mainly TPH, TPX. The remediation has been going on. It needs significant material cost, high level skills and know-how and stringent authority controlling. After the remediation the areas can be used newly for other activities. On the PA there are Seveso and e-PRTR plants, but not on the upstream of the Tisza in case of Szolnok waterwork.
Measure advantages	▫ The areas can be used newly for other activities. ▫ Increase the human health quality. ▫ Increase the value of real estate.
Challenges	▫ Implementation of the remediation and recultivation ▫ Increase the level of controlling by authorities ▫ Increase the level of know-how
PA3.2-situation	On the PA there are some well-known industrial contaminated areas which impact some groundwater drinking water resources

4.4.6. Drinking water quality and quantity measures – General best practices

▪ BP GP1 Identifying vulnerable areas and Nitrile Vulnerable Areas	
Description of the measure	Specific measures are in place directed at avoiding contamination of water resources. The general demarcation has been established on the basis of geological, hydro-geological, hydrological criteria. The

	vulnerable areas (**Error! Reference source not found.**) are designed by Regional Administrations, local authorities and Water Services Regulation Authority during planning procedures, whereas monitoring plans are carried out by Environmental and Health Agencies.
Measure advantages	▫ The vulnerable areas, defined by cartographic delimitation, are considered in the planning procedures and territorial management; in these cases, local authorities must make provisions in protection zones to protect water resources ▫ The Regional Environmental Agencies (ARPA/ARPAE/APPA) monitor compliance with the law and regulation requirements for the dispersion of sewage treatment sludge, waste water and livestock effluents.
Challenges	▫ Reducing of fertilizers and phytosanitary products ▫ Enforcement of education and of the implementation of regulations.
PA3.1-situation	Vulnerable areas are designed on basis of field investigations and desk studies. According to Italian D.Lgs. 152/06, Environmental Code, the criteria for determining these zones are defined by the Regional Administrations in Water Protection Plans.

▪ **BP GP2 Identifying and providing Minimum Vital Flow**	
Description of the measure	The Minimum Vital Flow (MVF) is a management tool designed to cope with critical situations that arise in river ecosystems due to large exploitation of natural discharges for civil, industrial or agricultural purposes, aimed to ensure a minimum hydrological component for the survival of local ecosystems downstream and along the river basin. Regional Regulations define procedure to evaluate the MVF in each river and introducing procedures for issuing public water-supply concessions in according with the Po River Basin Management Plan. Water supply and water distribution are subject to the availability of water bodies resources and when a drought event is imminent or occurs, water intake must be limited or ceased.
Measure advantages	▫ Produce an effective and objective benefit to the

	water bodies hydrological regime ▫ Manage and control of water consumption and protection of river or stream ecosystems ▫ Mitigate the conflicts between upstream and downstream communities ▫ Regulation governing concessions for public water abstraction
Challenges	▫ Reducing exceptions to the quality targets of water bodies ▫ Reducing derogations from regulation and concession acts requirements ▫ Enforcing of education and of the implementation of regulations ▫ MVF is limited to the assessment of the minimum hydrological component, while it appears more and more important to move to the environmental flow (EF)
PA3.1-situation	The Guidelines, approved by the Regional Council of Emilia-Romagna in 2012 (Bollettino Ufficiale della Regione Emilia-Romagna n. 52 del 28.03.2012 periodico (Parte Seconda), are the result of this study and represent an initial list of usable techniques for environmental rehabilitation of the canals; these are to be meant not so much as a technical-design manual, but rather as a tool to address operators in the address of project types and "environmental management" of canals. Similar Guidelines/Manuals exist in Lombardia region ("Linee guida per la Riqualificazione dei Canali Agricoli" (LIRICA) funded by Piano per la Ricerca e lo Sviluppo 2006, Delibera n. 2216 del 29 marzo 2006) and Veneto region ("Manuale per la gestione ambientale dei corsi d'acqua a supporto dei Consorzi di bonifica" edited by Veneto Agricoltura under the agreement signed with Region of Veneto, Regional Council Decision no. 3759 of December 9, 2009).

▪ **BP GP3 Technical regulation on water uptakes: the water intake directive**	
Description of the measure	When new water concession or a renewal application are presented, the Authority evaluates the submitted form

	and may decide to approve or reject it on the basis of a risk analysis. A water intake, in fact, represents a specific pressure on a water body state and an environmental risk analysis must be carry out using the "ERA" methodology (Exclusion, Repulsion, Acceptance).
Measure advantages	▫ Manage and control of water consumption and protection of river or stream ecosystems ▫ Mitigate the conflicts between upstream and downstream communities ▫ Manage and control water consumption and reduction in water utilizations
Challenges	▫ Reconsider and balance water abstractions taking in account the effect of ongoing and future climate changes ▫ Water Balance Plan for Po River Objective 2 requires a reduction of about 5% on basin scale of water for irrigation withdrawals considering the current discrepancies in water use and the farmers who put in place tools and procedures that allow water resource saving ▫ Define an objective tool for the Authority with decision-making power able to manage water crisis conditions avoiding time losses and bureaucratic problems
PA3.1-situation	Water intake directive (*Direttiva tecnica contenente i criteri per la valutazione dell'impatto degli usi in situ e dei prelievi sullo stato dei corpi idrici superficiali e sotterranei ai fini del rilascio e del rinnovo si concessioni di acqua pubblica nel Distretto idrografico Padano*), included in the Po Basin Water Balance Plan, concerns an objective tool to evaluate an application for water concessions.

▪ **BP GP4 Salt intrusion management and monitoring**	
Description of the measure	Especially during low flows periods the Po river delta is affected by salt intrusion from the Adriatic Sea, moving upstream. As the Po river serves as water supply for the agricultural activities in the area, it is therefore of utter importance to have a warning system, which issues an alert in case salinity threshold values are exceeded and

	provides salt intrusion length along the Po river delta reaches. The salt intrusion is computed by two numerical suites respectively based on the Sobek hydraulic numerical model, with its quality module DELWAQ, and the simplified salinity distribution analytical model (Savenije et al., 2006). The salt intrusion is also managed with mobile barriers installed in the Tolle and Gnocca branches, to prevent salt intrusion in the Po Delta branches. They operate a one directional opening in order to allow river-to-sea flow and to constraint the reverse one.
Measure advantages	▫ Salt intrusion observation and forecasts to support water managers in P-RBD ▫ Reduce salt intrusion and the impact of saline wedge in the delta Po ▫ Consider the variability of resources linked to water demands ▫ The salt intrusion management is a component of the flood/drought alerting system FEWS/DEWS
Challenges	▫ Currently, some barriers (Po di Tolle and Po di Gnocca) are working but they do not result sufficient ▫ Further investments should be made but they should be covered by all communities and actors living/working in Po river basin and not in charge only of affected ones
PA3.1-situation	The Po river delta is composed of 5 reaches: Goro, Gnocca, Maistra, Tolle, and Pila. They are affected by salt intrusion from the Adriatic Sea, moving upstream especially during low flows periods.

▪ **BP GP5 The Drought Steering Committee and DEWS (Drought Early Warning System)**	
Description of the measure	Drought Steering Committee is a Multisectoral partnership that consists in a forum of major water users in River Po basin, initiated and presided by the Po River Basin Authority (P-RBA). It was firstly established in May 2003 to face a severe drought event in Po river Basin and then set up as a permanent institution. Its main scope is to manage water shortage on a basin level, enforces water restriction

	on existing water withdrawal across the district, and instructs water releases from the Alpine reservoirs and large regulated lake, assess needs and water consumption in the various sectors and address the rules for withdrawals and uses, including adaptation measures to climate change as well. Drought Steering Committee manage an extensive monitoring network and uses the outcomes of numeric model system to manage the water balance and evaluate alternative water resources allocation (**Error! Reference source not found.**). The numerical modelling system used includes fully-distributed physicallybased hydrologic model TOPKAPI (TOPographic Kinematic APproximation and Integration) and RIBASIM (RIver BAsin SIMulation Model) water balance model. TOPKAPI reproduces the hydrological behavior of the basin, including subsurface, overland and channel flow, infiltration, percolation, evapotranspiration and snow melt. The model outputs (simulated discharges) are the input for RIBASIM model, designed for river basin planning and management. Both models are fed with real-time precipitation and discharge data. The modelling framework also allows for forecasting over the next few weeks and up to season simulation. The hydro-meteorological monitoring network consists of 600 water level gauges, more than 1000 rain gauges and more than 700 thermometers. The system also uses the daily updated data from the Italian Dams Registry (RID). The reservoir management rules are based on past observation data.
Measure advantages	▫ These measures were and are the result of cooperation and negotiated agreements and voluntary commitments, founded on long term experiences and territorial knowledge included in water balance and drought emergency management plans ▫ DEWS Drought Early Warning System, is a decision support tool for management of water shortages during the drought spells and allow to face some difficult conflicts thanks to the evaluation of alternative water resources allocation in a river basin. The flexibility of its structure allows the evaluation of a large set of alternative options for water resource allocation, as well as for sensitivity

	and scenario analysis
Challenges	▫ Available and reliable data collection taking in account the sensitive data ▫ Implementation of indices/indicators/tools suitable to represent water availability (for instance "siccidrometro" and so on) ▫ Systematic and unified collection of data related to climatic, hydrological and water uses scenarios ▫ Strategic proposals for seasonal water resource uses
PA3.1-situation	On 13 July 2016, a permanent network of "Observatories on water uses" has been established among all public and private stakeholders of national relevance. According to this network the Po Drought Steering Committee has the new role of Observatory on water uses in the P-RBD.

4.4.7. Wetland and Flood mitigation

▪ **BP GP1 Naturalistic restoration for the integrated hydraulic-environmental sustainability of the canals**	
Description of the measure	The emilian plain is crossed by a dense network of artificial canals, built by man in the course of centuries for the hydraulic drainage: in the artificial network, waters flow not only because of gravity, but also thanks to pumping stations. Therefore, malfunctions of a system so distinctly artificial can cause catastrophic damages, thus is essential to increase the levels of flood safety. At the same time, the ecological restoration of the drainage canals represents an important opportunity for the joining of the ecologic network and the improvement of the quality of the environment. The canals selected for the interventions suffer in similar degree of environmental and hydraulic problems: they characterize themselves for a rectilinear course and a geometrical section of trapezoidal shape and there are no floodable areas linked to them. It is important not to forget that the development of urban settlements of the last decades, has further increased runoff outflow, leading to an efficiency crisis of the various hydraulic networks. Add to this the problems of discharge of polluting substances, thus worsening the

	quality of the waters. On the whole, the interventions consist of the requalification of canals, by creating floodable naturalistic areas along the banks, the forestation of banks and the creation of an expansion area destined to become a naturalistic humid zone for the accumulation of flood and the phyto-depuration of the water.
Measure advantages	▫ Positive impacts on both river flood protection and hydromorphological quality ▫ Decreased diffused discharge of nutrients (e.g. nitrate)
Challenges	▫ Availability of strips of territory facing the canals to be allocated to riverine/floodable areas ▫ Implementation and maintenance costs
PA3.1-situation	The best practice originates from the results of the project LIFE13 ENV/IT/000169 RINASCE ("Naturalistic Restoration for the integrated hydraulic-environmental Sustainability of the Emilian Canals"). The project proposes to realize for demonstrative purposes the hydraulic-environmental restoration of some drainage canals in the Emilia-Romagna region and aims to show that the key concepts of the "floods" (2007/60/EC) and "water framework" 2000/60/EC directives, concerning the need to reduce flood risk, at the same time improving the ecological status of the water courses, can also be applied to the artificial water network.
PA3.2-situation	The Flood Riverbed Management Plans relied on technical viewpoints, hydrodynamic modeling which determine the flood river bed and indicate the flow zones and to reduce flood risk, with several possible structural measures like: ▫ Deepening of riverbed by dredging ▫ Storage, and water retention in river bed ▫ Dyke relocation, building dykes, developing flood protection dykes ▫ Building flood channels or spillways ▫ Deepening of floodplains ▫ Demolition of river regulation structures ▫ Removal of buildings and other constructions from the flood area ▫ Dredging and restoration of side branches

	▫ Removal of summer dams from the flood area ▫ River reef or river bend regulation From these structural measures, there are several ones that effect negatively the bank-filtered system. The dredging risks eliminating the natural filter (gravel and film layer) of the riverbed which is the base of natural purification of bank filtering. Further negative effect is the modification of river line.

▪ BP GP2 The Flood Forecast Center for the Po River and FEWS Flood Early Warning System	
Description of the measure	Successively the Civil Protection Directive on 8.2.2013 established the Command and Control Unit for the Po river Floods, the Flood Forecast Center for the Po river, in charge to the Interregional Agency for the Po river supported by the Hydrology Unit of ARPA-ER, managing the FEWS PO system. Through FEWS PO it is possible to manage observed data (in situ and remote sensed), and forecasts obtained from meteorological-hydrological-hydraulic simulation to early detect floods, their occurrence entity and characteristics to support Civil Protection System. The numerical modelling system used includes 3 chains of hydrologic and hydraulic model. Both models are fed with real-time precipitation, temperature and discharge data. The modelling framework also allows for forecasting up to 72 hours and up to 120 hours for ensemble simulations. The hydro-meteorological monitoring network consists of 600 water level gauges, more than 1000 rain gauges and more than 700 thermometers. The outcomes provide the information on the basis of which flood warnings can be issued and provided in time to allow a proper response by the responsible authorities. The modelling chain is completed by a number of scenarios simulating different possible operations of the flood control structure in real time to support the flood service management.
Measure advantages	▫ It is a regional and national guide for flood alert strategies ▫ An early flood warning and flood management could minimize the risk of damage and casualties caused

	by a flood event
Challenges	▫ Verification and validation of forecast models, tools and procedures ▫ Manage and reduce the lead time, the time between the moment the warning is issued and the moment flooding starts. In fact, the fast flood propagation has pointed out the necessity of implementing specific modelling procedures allowing the forecast of rapid phenomena, for instance by more frequent runs of hydro-meteorological chains when hydrological thresholds are reached or statistical decisional trees based decision support system
PA3.1-situation	The Po operational forecasting and modelling system for flood events on the Po river FEWSPO was designed and implemented by the Environmental Agency of Emilia Romagna ARPA-ER on the base of the 2005 Agreement among the National Civil Protection (DPCN) the Interregional Agency for the Po river, the Po River Basin Authority, the Emilia-Romagna, Lombardia, Piemonte Valle d'Aosta and Veneto Regions. The FEWS is a pillar o for the National and regional Distributed Early Warning System Network for hydrogeological extremes, build according to the Civil Protection Directive on 27.2.2004 Directive.

▪ **BP GP2 Integrated hydraulic-environmental restoration of water streams within the piedmont belt**	
Description of the measure	To retain water in the upstream stretch of towns at most, the river section was expanded, wherever possible, to recover the stream bed width lost over the years due to human intervention. In the mountain stretches, due to steep slopes, simple riverside enlargements were not sufficient to "retain water". Hence, stream bed enlargements, "closed" downstream by pebble narrowings, were developed, replenishing green-belt vegetation, in order to retain water during floods. The creation of large floodplains upstream from narrowings, which would be often flooded, encouraged the development of wetlands, characterized by the temporary presence of water, being rather rare habitats in that local context.

	Furthermore, in mountain stretches the water outflow was slowed down by creating natural differences in elevation by means of pebbles and timber by fastening trunks with roots to the river banks. It should be highlighted that these works, besides reducing the steepness of the stream bed slope locally, contribute to an environmental enhancement both due to the diversification introduced in the stream bed itself but also thanks to the creation of new natural habitats. To reconnect existing floodplains to the stream bed, making them periodically floodable, alternative solutions were implemented by rising the stream bed elevation to make streams more easily floodable during floods, also allowing morphology and habitat diversification. Finally, environmental and natural enhancement measures were implemented in all streams. In particular, the continuity of riparian vegetation strips was improved by planting native hardwoods species and by replenishing green-belt vegetation in barren stretches. Locally sourced indigenous selective plant species cuts were carried out to promote the regrowth of plants and to enhance natural vegetation along the most deteriorated stretches. In all plant management actions, a special attention was paid to preventing the proliferation of invasive species.
Measure advantages	▫ Positive impacts on both river flood protection and hydromorphological quality ▫ Decreased diffused discharge of nutrients (e.g. nitrate)
Challenges	▫ Availability of strips of territory facing the river beds to be allocated to riverine/floodable areas ▫ Implementation costs
PA3.1-situation	The best practice originates from the results of LIFE 11 ENV/IT/000243 RII ("Integrates hydraulic –environmental restoration of water streams within the piedmont belt of the Emilia-Romagna region"). The LIFE RII project is designed to enhance the environmental conditions and hydraulic safety of some minor water streams within the piedmont belt and high plains in the province of Reggio-Emilia. More specifically, it points out that the key concepts underlying the Water Framework Directive 2000/60/EC and the Floods Directive 2007/60/EC, on the

	need to reduce the flooding risk by improving the ecological status of rivers, can also be applied on the minor water streams network.

▪ BP GP3 Guidelines for integrated rehabilitation of drainage canals	
Description of the measure	The Emilia-Romagna Region in 2003 has created, within the European project LIFE Econet, the activity entitled "The canals and waterways of the provinces of Modena and Bologna - Towards the creation of lowland ecological network ". This work has identified a first set of operating procedures relevant to the establishment of the ecological network substantiated in the first "Guidelines for the rehabilitation of drainage canals" and 17 project sheets for redevelopment feasible in situations and specific sites. The Region, after 5 years away from the first interventions, decided to integrate and further develop the 2003 document by using, as a starting point, an analysis of the redevelopment projects of canals is made under the LIFE Econet. The Guidelines, approved by the Regional Council of Emilia-Romagna in 2012 (Bollettino Ufficiale della Regione Emilia-Romagna n. 52 del 28.03.2012 periodico (Parte Seconda), are the result of this study and represent an initial list of usable techniques for environmental rehabilitation of the canals; these are to be meant not so much as a technical-design manual, but rather as a tool to address operators in the address of project types and “environmental management” of canals. Each type of intervention described in the Guidelines is accompanied by a brief description of the suggested technique and problems that it intends to deal with, the precautions that must be taken in its implementation and possible need for future research; there are also “Project Box” related to interventions on the Italian territory, which show a possible practical application.
Measure advantages	▫ Positive impacts on both river flood protection and hydromorphological quality enhancement
Challenges	▫ Compatibility with current land uses and infrastructures in the territory near the channels ▫ Implementation and maintenance costs.

PA3.1-situation	Similar Guidelines/Manuals exist in Lombardia region ("Linee guida per la Riqualificazione dei Canali Agricoli" (LIRICA) funded by Piano per la Ricerca e lo Sviluppo 2006, Delibera n. 2216 del 29 marzo 2006) and Veneto region ("Manuale per la gestione ambientale dei corsi d'acqua a supporto dei Consorzi di bonifica" edited by Veneto Agricoltura under the agreement signed with Region of Veneto, Regional Council Decision no. 3759 of December 9, 2009).

▪ BP GP1 Guidelines for integrated requalification of natural watercourses	
Description of the measure	The territory is potentially subject to flooding of lowland areas caused by disruption or overlap of defence levees or hydraulic failure; in the mountainous-hilly areas the prevailing phenomena are linked to hydro-morphological dynamics of river beds and are expressed by local floods and, especially, by intense erosive processes in river beds, which can lead to destabilization of the infrastructure close or overlying the rivers. The causes are partly natural, however are due to a large extent to the change of land use, and to the progressive artificiality of the hydrographic network, who removed part of the areas naturally appointed to the morphological evolution of riverbeds and floods restraint. The guidelines aim to develop a territorial defence strategy that addresses toward an approach to the management of the watercourses more in accordance with their natural processes, aiming at a synergy between the river ecosystem objectives and at decreasing the risk from floods and morphological dynamics and deal specifically with those interventions of morphological requalification which can bring positive effects on flood and morphological dynamics risk mitigation. The measures suggested are intended to reduce the danger of the areas potentially subject to flooding and are designed to be a tool that aims to clarify what are the possible alternatives, the related areas of application, the relevant variables involved, the expected effects. Non-structural flood defense measures include reducing flood levels, keeping or repairing capacity of riverbed and ensure the flood protection safety, also: ▫ Identification of flood hazard zones and consideration of their limitations ▫ Identification, development and protection of flood retention volumes ▫ Development of individual flood protection measures

	▫ Revision of the existing constructive flood protection measures ▫ Maintenance of the watercourses, hydraulic works and river banks ▫ Adequate management of hydraulic structures
Measure advantages	▫ Positive impacts on both river flood protection and hydromorphological quality enhancement
Challenges	▫ Compatibility with current land uses and infrastructures in the territory near the riverbeds ▫ Implementation and maintenance costs
PA3.1-situation	The Guidelines, approved by the Regional Council of Emilia-Romagna in 2015 (Bollettino Ufficiale della Regione Emilia-Romagna n.301 del 20.11.2015 (Parte Seconda), aim to develop a territorial defence strategy that addresses toward an approach to the management of the watercourses more in accordance with their natural processes, aiming at a synergy between the river ecosystem objectives and at decreasing the risk from floods and morphological dynamics, as indicated by the EU, which requires to a joint implementation of the directives "Water" (2000/60/EC) and "Flood" (2007/60/EC). The guidelines are directed to the natural hydrographical network, and focus specifically on innovative interventions of "land protection" that allow to reach the objectives of the "Water" Directive by improving the ecological status of rivers.
PA3.2-situation	The aims of the Flood Riverbed Management Plans (FRMP) are reducing flood levels, keeping or repairing capacity of riverbed and ensure the flood protection safety. FRMP includes some measures on land use as well including changing, optimization of plant cultivation or land use on floodplain. In aspects of drinking water protection these non-structural measures (modify land use in floodplain and inundation areas, vegetation conversion and reservation) are favourable, because the flood does not remain on the DWPAs for a long time.

▪ BP GP2 Guidelines for integrated rehabilitation of drainage canals	
Description of the measure	The Emilia-Romagna Region in 2003 has created, within the European project LIFE Econet, the activity entitled "The canals and waterways of the provinces of Modena and Bologna - Towards the creation of lowland ecological network ". This work has identified a first set of operating procedures relevant to the establishment of the ecological network substantiated in the first "Guidelines for the rehabilitation of drainage canals" and 17 project sheets for redevelopment feasible in situations

	and specific sites. The Region, after 5 years away from the first interventions, decided to integrate and further develop the 2003 document by using, as a starting point, an analysis of the redevelopment projects of canals is made under the LIFE Econet. Each type of usable techniques for environmental rehabilitation of the canals; these are to be meant not so much as a technical-design manual, but rather as a tool to address operators in the address of project types and "environmental management" of canals, described in the Guidelines is accompanied by a brief description of the suggested technique and problems that it intends to deal with, the precautions that must be taken in its implementation and possible need for future research; there are also "Project Box" related to interventions on the Italian territory, which show a possible practical application.
Measure advantages	▫ Positive impacts on both river flood protection and hydromorphological quality enhancement
Challenges	▫ Compatibility with current land uses and infrastructures in the territory near the channels ▫ Implementation and maintenance costs.
PA3.1-situation	The Guidelines, approved by the Regional Council of Emilia-Romagna in 2012 (Bollettino Ufficiale della Regione Emilia-Romagna n. 52 del 28.03.2012 periodico (Parte Seconda), are the result of this study and represent an initial list of usable techniques for environmental rehabilitation of the canals; these are to be meant not so much as a technical-design manual, but rather as a tool to address operators in the address of project types and "environmental management" of canals. Similar Guidelines/Manuals exist in Lombardia region ("Linee guida per la Riqualificazione dei Canali Agricoli" (LIRICA) funded by Piano per la Ricerca e lo Sviluppo 2006, Delibera n. 2216 del 29 marzo 2006) and Veneto region ("Manuale per la gestione ambientale dei corsi d'acqua a supporto dei Consorzi di bonifica" edited by Veneto Agricoltura under the agreement signed with Region of Veneto, Regional Council Decision no. 3759 of December 9, 2009).

▪ **BP GP3 Implementation of the Technical regulations for the maintenance of natural and artificial watercourses in the RN2000 sites**	
Description of the measure	The "Habitats" Directive 92/43/EC provides for the establishment of the European ecological network Natura 2000, requiring conservation / restoring of the related habitats. This means that even the maintenance of the watercourses, must take into account, among other

	things, the possible presence of habitats and animal and plant species of conservation interest. The Technical Regulations try to combine the preservation of biodiversity in the areas included in the Natura 2000 sites with hydraulic safety criteria and water management which are the basis of the routine maintenance of the waterways, natural and artificial. The Disciplinary has the main purpose to regulate the maintenance of natural and artificial waterways that can be considered to low environmental impact and that, consequently, if located in the Natura 2000 network sites, are exempt from the execution of the incidence evaluation or pre-assessment, if the works are compliant with the conditions, the types and the execution times indicated.
Measure advantages	▫ Positive impacts on both river flood protection and riverine habitats quality.
Challenges	▫ Implementation and maintenance costs
PA3.1-situation	The Technical Regulations for the maintenance of natural and artificial watercourses in the RN2000 sites, approved by the Regional Council of Emilia-Romagna in 2009, tries to combine the preservation of biodiversity in the areas included in the Natura 2000 with hydraulic safety criteria and water management.

5. Conclusions

The best management practices should answer to anthropogenic and natural pressures on drinking water and they should be applied in a site-specific manner, focusing on local research and local characteristic signs. Efficiency and effectiveness need to be examined before implementing the measures. Starting with broad and non-structural measures can have more harmonized effect and can be more effective, so international, integrating national strategies are important to be carefully planned and implemented. Local adjustments are although necessary for reflecting the various and often complex pressures and problems. In this way best management practices should be integrated in international, national, (regional) and local level planning. Therefore, it can be reasonable to later examine these measures on which level can they have the more effect and are they applicable and transferable on the specific level.

Drinking water protection zones (DWPZ) are established with the purpose of protection groundwater and surface water sources. DWPZs are specific for each country and it is interesting to compare them, see Table 10: Drinking water protection zonesTable 10. There are Pilot Areas without concerning DWPZs (Poland, Germany), country with two (Austria), three (Slovenia, Hungary, Italy) and even one country with four zones of water protection (Croatia).

Table 10: Drinking water protection zones

PA 1.1 and 1.2 Austria	a) Protection Zone I b) Protection Zone II
PA2.1 Slovenia	a) wider area with the moderate protection regime (III) b) subzone with milder protection regime (IIIA) c) subzone with mild protection regime (IIIB) d) narrow area with the rigorous (strict) protection of the water protection regime (II) e) subzone with strict protection regime (IIA) f) subzone with less strict protection regime (IIB) g) the narrowest area with the most rigorous protection regime (I)
PA2.2 Poland	No DWPZ concerning surface water on the Pilot Action area.
PA2.3 and PA3.2 Hungary	a) The inner protective block, zone, b) The outer protective block, zone: c) The hydrology or hydrogeological block, zone: "A", "B" and "C"

PA2.4.1 and PA2.4.2 Croatia	a) zone of limitation (IV. zone), b) zone of limitation and surveillance (III. zone), c) zone of strict limitation and surveillance (II. zone), d) zone of strict protection regime and surveillance (I. zone).
PA2.5 Germany	No DWPZ concerning surface water on the Pilot Action area.
PA 3.1 Italy	a) Absolute Safety Zone close to the source, b) Respect Zone depending on groundwater travel time c) Protection Zone in the outer part.

Areas with restrictions are among Pilot areas very common, mostly nature parks, special reserves, Nature monuments, Significant landscapes, natural heritages locations and areas of Natura 2000, see Table 11.

Table 11: Nature Protection zones

PA1.1 Vienna	There are areas of Natura 2000.
PA1.2 Waidhofen	No Nature protection zones are located within the pilot area.
PA2.1 Dravlje valley	Two nature parks and several natural heritages locations (caves, trees, marshes, karst area…).
PA2.2 Kozłowa Góra	No Nature protection zones are located within the pilot area.
PA2.3 Tisza	Many nature reserve areas protected on national and international levels and large areas of Natura 2000
PA2.4.1 South Dalmatia: Prud, Klokun and Mandina spring	- Four areas protected with Nature Protection Act: Nature park, special reserves, significant landcape - Natura 2000 areas
PA2.4.2 Imotsko polje	- Areas protected with Nature Protection Act are: Special reserve, Nature monument, Significant landscape, - Natura 2000 areas.
PA 2.5 Neufahrn	No Nature protection zones are located within the pilot area.
PA 3.1 Po	There are areas of Natura 2000.

PA 3.2 Danube	- large areas of Natura 2000 - The Special Areas of Conservation (SAC), the Special Protection Areas (SPA), and inbetween overlaping area - the national protected areas (National Parks, Landscape Protection Areas and Nature Conservation Areas), and Ramsar area - Natural bathing waters are also protected

PAC 1 BMPs

The main thematic focus in Pilot Action Cluster 1 is put on the land-use types forestry and grassland cultivation (pastures) in mountainous areas. The grassland is especially in PAC1.1 dominated by subalpine pastures. The actual land use activities form in some cases threats for water quality, water quantity and flood prevention.

Land use category forestry is present in both PA. There are given fundamental differences between the PAs, as in the case of the city of Vienna (PA1.1) the overall purpose of drinking water protection for forestry is defined since decades, whereas in Waidhofen/Ybbs (PA1.2) the overall purpose for most of the various forest owners is still maximised timber yield. Forestry actually exerts in PA1.2 the most relevant threats, as the clear-cut technique is still applied there, which in contrast is already forbidden in PA1.1. Elevated wild ungulate densities are present in both PAs, but in PA1.1 in some areas of the DWPZ there is already implemented a forest ecologically sustainable wild ungulate density, which is reflected through vital and abundant regeneration of all relevant tree species for each forest hydrotope type. The different Best Practices were discussed according their implementation status within each of the two PAs. All Best Practices in the field of forestry are valid for both drinking water protection and flood prevention. Land use category grassland cultivation is also present within both PAs. In PA1.1 it is dominated by subalpine pastures, in PA1.2 cultivated grassland areas are dominant. The prevention of the entrance of liquid manure, manure or cow dung into the aquifers is a declared purpose for both PAs. The status of the defined Best Practices in the field of grassland was again discussed for both PAs. Land-use category agriculture has no relevance in both PAs. Urban areas are present within PA1.2 and related Best Practices encompass utmost care in case of the use of mineral oil products and pesticides, as well as controlling the novel sewage systems. Industrial areas again are only present within PA1.2 and demand attention within the context of potentially hazardous materials. Best Practices were discussed for two already existing facilities within the DWPZ. For PA1.2 there were discussed Best Practices for the stone quarries situated within the DWPZ, while for PA1.1 the existing gravel pits within the DWPZ were thematised. Tourism infrastructure was thematised within the context of alpine huts for PA1.1. The karst research program of the City of Vienna was discussed as Best Practice for PA1.1.

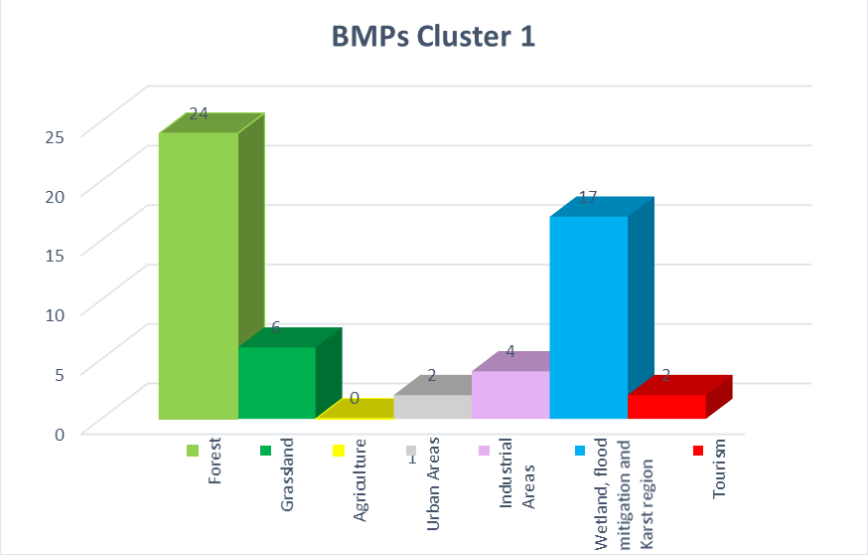


Figure 1: Distribution of BMPs among different land use types within Cluster 1

PAC 2 BMPs

The dominating land use types within plain areas of Pilot Action Cluster 2 are forest and agriculture, also pastures, urban areas and water reservoirs.

Among pressures on drinking water quality within PAC 2, the increasing of settlement spaces can cause more point pollutions, where sewer system and private systems can be damaged. Old industrial locations can also pollute drinking water aquifers. Substantial leaching of nutrients to the groundwater and surface waters are a threat of the improper application of organic and synthetic fertilizers. Together with this, agricultural sector has responsibility in applying proper irrigation practice as overuse of irrigation systems during dry periods in the summer times can cause enhanced leaching of nutrients. There is the threat of pollution at leaky liquid manure pits, conventional soil tillage and open croplands between main crops can have negative pressures by increased leaching of nutrients and further intensification of farming activities increases the threat of overstressing the soils.

Among pressures on drinking water, sealed surfaces have an effect of reducing groundwater recharge. Improper soil tillage can cause compression of soil, where recharge is hindered and at the same time threat of inland water is increasing. Open croplands between the main crops amplifies the threat of surface sealing and decreased infiltration capacity through aggregate destabilization as a consequence of splash effects during rainfall events.

Furthermore, we would mention the extreme weather conditions due to climate change. As runoff is increasing, soil erosion can transfer nutrients and pesticides to surface waters. As a result of more intensive rainfalls and increasing runoff recharge of ground waters can decrease.

Regarding flood issues, presented results state variously flood hazard and flood risk. In some cases, measures are presented on flood hazard areas and a possible connection with groundwater aquifers is highlighted. Although further investigations would be necessary on some of the pilot areas.

Particular challenge can be in case of surface drinking water abstraction the necessity of protection the river upstream and the background. There are some conflicts of interest with flood protection, so solving this conflict it is necessary secure strong expert background and interdisciplinary consultations. The complex interaction between surface water and groundwater considerably increase the uncertainty related to the groundwater flow direction and hence to the definition of an appropriate groundwater protection zone. In general, for different forms of water use, the principle of rational water management should be used by all new users, and a runoff from urbanised sub-basins should be used and treated with modern purification technologies. In relation to already existing water users, the pursuit of rational water use should be achieved through the ability to verify water permits and regulation of system of water use charges.

Best management practices were distributed according to the planning relevance to international, national and local level. On international level national strategies and plans need to be harmonized in countries sharing the same water basin. On national level the implementations of national strategies and legislation is a challenge. Despite of the legislation the implementation and authority inspection is insufficient. Further problem is the low willingness to cooperate between farmers, other stakeholders and some water suppliers to ensure water protection. The biggest challenge is cooperating with society. It seems that education the society how their activities, like agriculture, inappropriate waste water management etc., may impact, both, water quality and quantity, and enforcement of regulation and policy concerning best practices could be a milestone in preserving drinking water resources.

Socio-economic changes are rapidly occurring in some pilot areas. In particular, a decrease in interest for agricultural activities may lead to important changes in land use and land management in the next years. For example, agricultural activity has a negative impact on both quality and quantity and can present a major challenge for water management and protection. Moreover, also the urban area is rapidly changing, with the construction of new commercial and residential areas and a change in the industrial activities. Such a dynamic environment represents a challenge for water management when they need to choose the most appropriate land use management practices.

Summarizing the experiences, two main aspects seem to evolve. Implementation of strategies, plans, legislation should be developed, but in parallel, education, innovation, efficiency, feeling responsible on each responsible level should be developed and increased and cooperation between these levels should be strengthened. Some measure may have a short impact, some a long-term effect, but simultaneous application seems necessary.

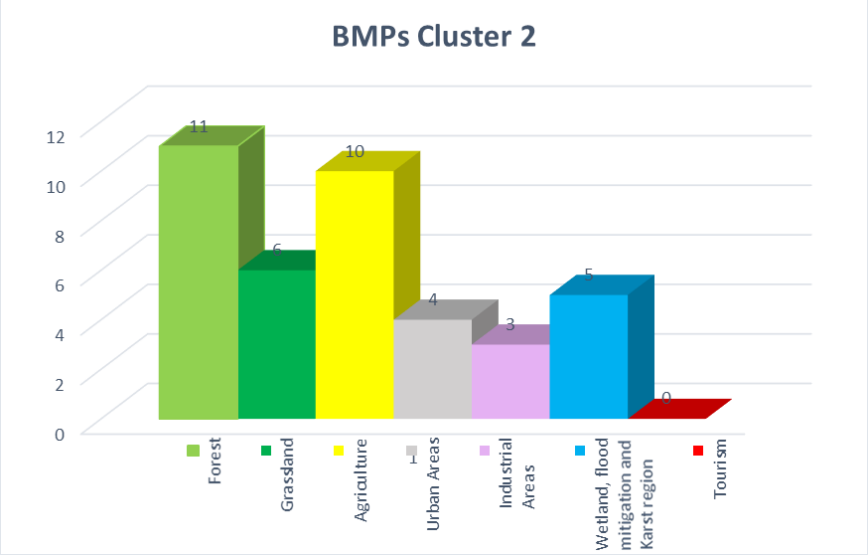


Figure 2: Distribution of BMPs among different land use types within Cluster 2

PAC 3 BMPs

PAC3.1 is rich of water resources but the increase of water consumption and climate change are affecting them and especially during drought events the conflicts among the users reach an extreme level. Only on a river basin level the optimal area for soil, subsoil and water protection actions can overcome institutional fragmentation and competence with unitary plans and an Authority with decision-making power able to manage water crisis conditions. This is a starting point but not only stakeholders involved in technical issues but also communities, actors and not technical stakeholders in the area should be involved on the issues directly and indirectly associated to water shortage. In this perspective the main best practices briefly shown could be useful. For instance, the generalized utilization of IRRIFRAME and IRRINET could both improve the amount of available and reliable data collection on water usage, and entail remarkable reductions in water resource wastage or reconsidering the adoption of surface irrigation (flooding, furrows) that should be instead limited as far as possible. Moreover, the activities of the Observatory could represent a valuable option to address activities and actions like the need of reconsidering and balancing water abstractions along the river course in attempting to mitigate the conflicts between upstream and downstream communities, taking into account the effects of ongoing and future climate changes, as well. Finally, different experiences carried out in recent years also through European funding opportunities permitted to test/suggest effective solutions often included in Regional Regulations and guidelines.

For what concern PAC 3.2, the main aim of preventing the quality and quantity deterioration of drinking water sources results especially challenging. Indeed, in case of bank-filtration the necessity of protection from both the river side and the background arises. In the same time, the wells are shallow drilled, so the system is exceptional vulnerable. Due to the dual endangering there is conflict of interest with flood protection, so solving this conflict it is necessary secure strong expert background and multipoint consultations.

In attempting to cope with such issue, several BMPs have been identified, included in national plans (River Basin Management Plan, Flood Risk Management Plan in regards of drinking water

protection) and legislation (Government Regulation on the protection of the actual and potential sources, defines the criteria of water protection zones) in order to minimise the negative impact of agriculture and industry on the DWPZs. Despite of the legislation the implementation and authority inspection is currently recognized insufficient. Further problem is the low willingness to cooperate between farmers, other stakeholders and some water suppliers to ensure water protection. Despite of this national level insufficiency, there is a very good cooperation practice on this PA. Budapest Waterworks Company created a good practice guideline for farmers to support the protection of drinking water in an agricultural area and at the same time to help farmers making their livelihood in the water protection zones. The greatest drinking water sources are situated on the Szentendrei or Csepel Island, and their water protection are managed by Budapest Waterworks (BW). These islands are not covered by urban area, the main land use is agriculture and nature reservation is also significant. The DWPAs are situated on high-value real estates; this facility makes more difficult the procedure of designation by authorities. Another issue is represented by detected contaminated sites, on which remediation has been going on. On the DWPAs there are professionally built monitoring systems (water quality and water level) permitting a prompt emergency response.

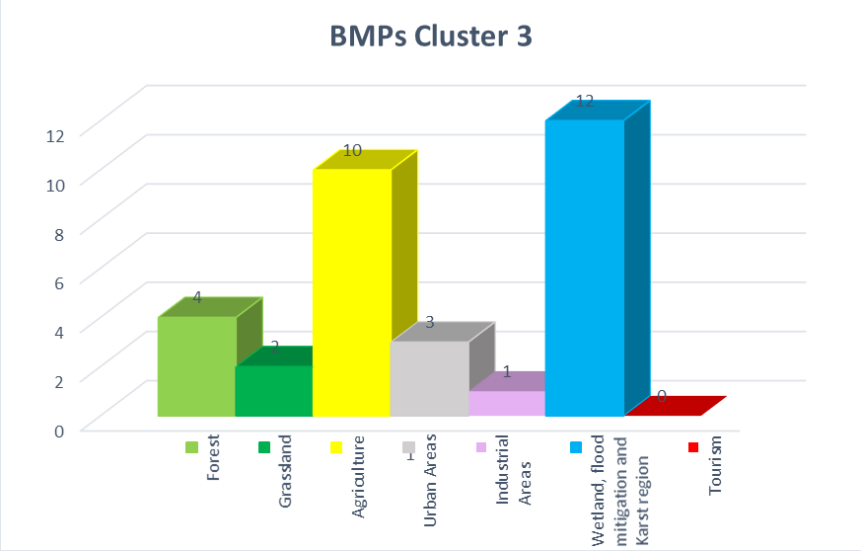


Figure 3: Distribution of BMPs among different land use types within Cluster 3

The implementation of the Best Practice Catalogues defined and discussed in this report is of high importance for the sustainable protection of the related drinking water resources and for flood prevention.

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