PROLINE-CE

WORKPACKAGE T3, ACTIVITY T3.1

DEVELOPMENT OF MEASURES AND FUNDING SYSTEMS FOR SUPPORTING ECOSYSTEM SERVICES

D.T3.1.1 ANALYTIC REPORT ABOUT POTENTIAL PUBLIC SERVICES OF SUSTAINABLE LAND USE

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1. Introduction

The Deliverable D.T3.1.1 – "*Analytic report about potential public services of sustainable land use*" forms the mandatory basis to fulfil the purpose of Activity A.T3.1 – "*Development of measures and funding systems for supporting ecosystem services*".

Ecosystem services (ESS) are the conditions and processes through which natural ecosystems (sustainable land uses) sustain and fulfil human wellbeing. Ecosystems are not static but dynamic and discontinuous systems with interactions and connections evolving both spatially and temporally. They represent ecological processes and the resources they provide can be expressed in terms of "quasi-services", taking into account that, in the classical definition, the services are payed for. Ecosystem services (ESS) therefore are the benefits people obtain from ecosystems.

The most widely adopted classification is the 'functional grouping' where ESS are divided into four categories. Some overlap occurs between categories but the four main groupings include *provisioning, regulating, cultural* and *supporting* ESS. An abundant scientific production (grey and white) investigated existing overlapping between ESS and public services (PS).We can define defined according the neoclassical definition: non-excludable, non-rivalrous, non-rejectable resources or according the socio-political one, stating PS as "particular asset, state or service which may merit public intervention or public oversight, concern and/or governance or perhaps different forms of collective action simply because it is much valued or demanded by society" (Dwyer et al., 2014).

In this regard, it is clear that, although partly overlapping, not all ESS can be viewed as PS. By way of example, e.g. the use of an aquifer can be rival in consumption while a beautiful view from a private point results as an excludable good.

Within the context of PROLINE-CE, the focus is on drinking water protection and flood mitigation; to this aim, according Brauman (2015) "water is often discussed as a provisioning service, presumably because people generally experience water as coming from a watershed. However, ecosystems do not create water but move and modify flows, so research and management may be better served by considering terrestrial water-related services to be *regulating* services" representing the core of this investigation. An example on *regulating* ecosystem service is water storage in wetlands, riparian areas or forest ecosystems, which contribute to flood and water quality mitigation and to drinking water supply. On the other side, in recent years, policies and scientific communities proposed several high-level ESS classifications (e.g. MA, 2005; TEEB, 2010; UK NEA, 2011; CICES 2018) where the role of ES as "water providers" is debated and properly justified.

Water supply and flood damage mitigation services (e.g. water quality preservation and flood mitigation) are generally named *hydrological services*, a subset of ESS. While we define them as ESS one should clearly note that in the most part of European actual hydrological services, especially for the surface water, are heavily affected by the human interventions, some of them starting even in Roman times.

Water is a vital resource for all living organisms on earth. Humans rely on ecosystems for the provision of *hydrological services*, essential for their well-being. However, concerns over the water problems have been increasing in the last decades, with special emphasis for water scarcity, quality and disasters, including issues related to climate change. This has been raising interest in the sustainable management of ecosystems and in promoting best practices.

The report provides an attempt to classify the main concepts of Ecosystem Services and Public services, stressing the potential overlapping between them and in which way a proper land management can be viewed as a positive externality within the socio-economic framework of PS. Then, thanks to support of National experts, the report tries to collect the intended functionality in terms of drinking water protection of each analysed land use type in its *optimal (functional) conditio*n. Hence, it is a description of the provision of ESS under the presumption of the application of the whole Best Practices Catalogue (T1), so to speak under conditions of sustainable land use. At same time, an attempt was made to identify main public services and related providers for each land cover and hydrological service.

2. Ecosystem and public services

2.1 Ecosystem services

Humans are not only part of ecosystems but we also benefit from ecosystems in different ways. These benefits are known as ecosystem services (ES). The Millenium Ecosystem Assesment (MEA, 2005) derives ESS definition from two representative and commonly used definitions, Daily (1997) and Costanza et al. (1997). The concept of ESS is rather recent; it was first used in the 1960 but its research has rapidly grown in the last decade. It should be also noted that the ecosystem services approach was, at its core, developed with a purpose of conceptual confrontation necessary for the identification of the roles of the ecosystem and the confrontation with the classical provisioning concept. As conceptual tool, it was not intended for the modelling purpose.

ESS have been categorized in different ways, among them as functional groupings, organizational groupings or descriptive groupings. The MEA (2005) classifies ESS with functional groupings, using 4 main categories/ groups, (i) supporting; (ii) provisioning; (iii) regulating; and (iv) cultural services (Figure 1) (MEA, 2005).

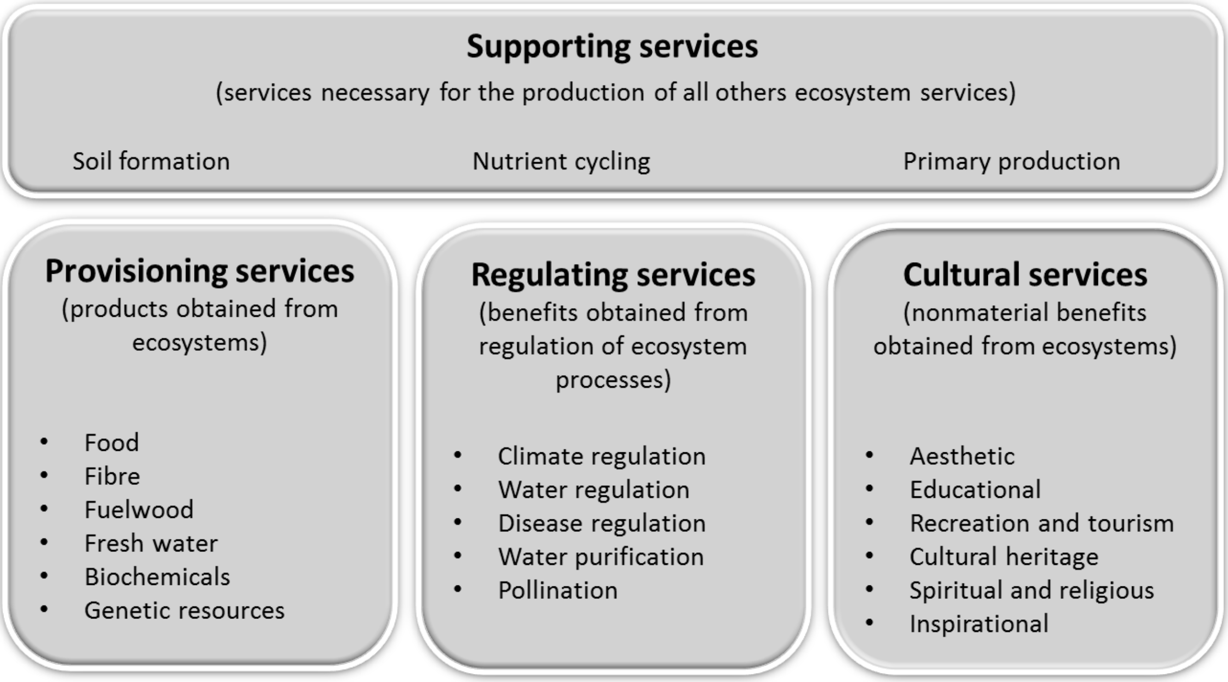

Figure 1: Groups of ecosystem services (MEA, 2005)

In order to recall the differences between Ecosystem functions and Ecosystem services, the glossary made available by TEEB (The Economics of Ecosystems and Biodiversity) initiative can be considered:

- **Ecosystem function**: a subset of the interactions between ecosystem structure and processes that underpin the capacity of an ecosystem to provide goods and services;
- **Ecosystem services**: The direct and indirect contributions of ecosystems to human wellbeing. The concept ‘‘ecosystem goods and services’’ is synonymous with ecosystem services.

Furthermore, the example reported in the framework below provides a further exemplification.

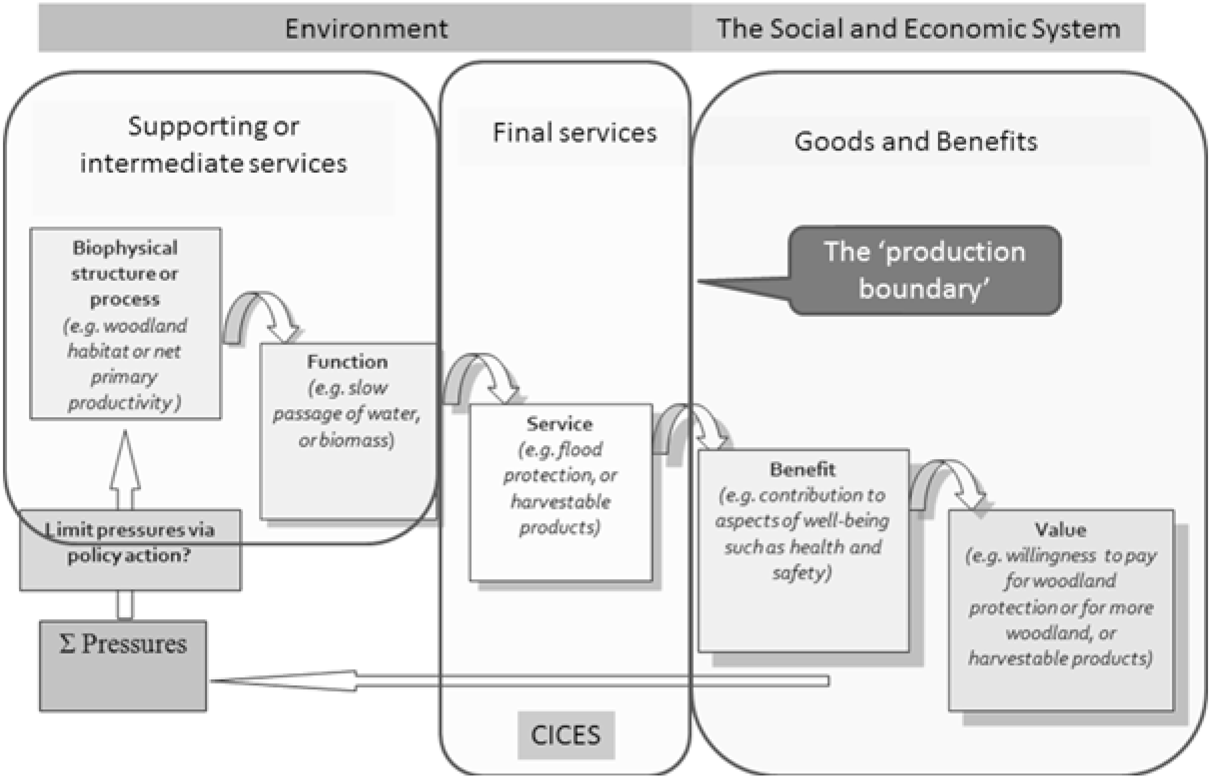

Figure 2: Cascade model, Potschin, M. and Haines-Young, R. (2016)

Further research is needed to build the integrity of the ESS approaches, by (i) combining direct biophysical measurements to estimate the monetary value of ESS; (ii) developing non-monetary methods for valuing human health and security, and cultural services, and incorporating these tools for valuing ESS; and (iii) developing methods for identifying who benefits from ESS, and where and when those who benefit live relative to the lands and waters in question (Daily et al., 2009 and Pagiola et al., 2005). These concepts could be then gradually linked to the neo-classical concept of public services.

Hydrologic services encompass the benefits to people produced by terrestrial ecosystem effects on freshwater. For the purposes of the report, which focuses on intended functionality in terms of water supply and water damage mitigation of each analysed land use type (ecosystems according Brauman (2015, Figure 3), it is useful to organize hydrologic services into the following three broad categories:

- improvement of water supply;
- securing water quality;
- flood damage mitigation (reduction).

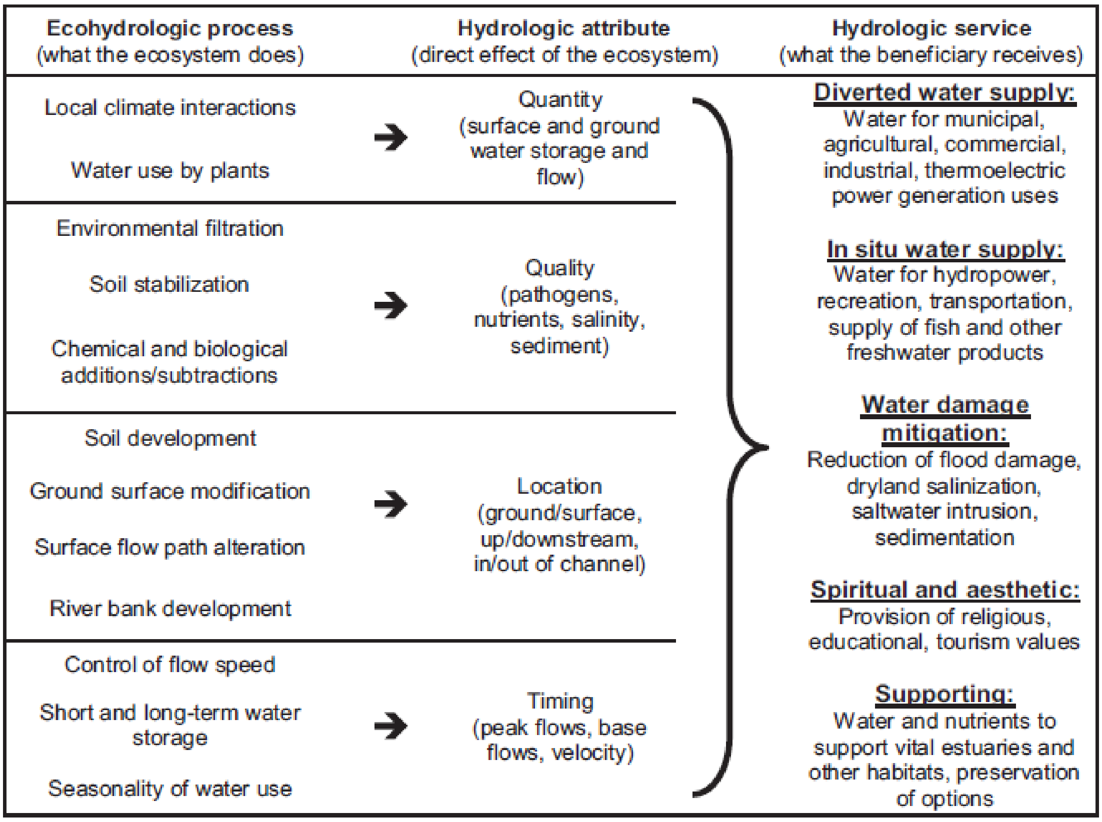

Figure 3: Relationship of hydrologic ecosystem processes to hydrologic services (Brauman, 2015)

Each of these hydrologic services is defined by attributes of quantity, quality, location, and timing of flow. These attributes intrinsically depend on the natural physical (functions) – eco-hydrological processes - that characterize the status of an ecosystem, in terms of its current conditions. Within an ecosystem, the eco-hydrologic processes may have competing effects on the same attribute or have simultaneously positive and negative effects on different attributes of a particular service (i.e. some hydrologic services could be improved at the expense of others). This concern is especially important in the relation to water supply, where some retention measures (i.e. forestation) might have observable negative effects on the availability of water for human use (wellbeing) in dry periods.

In the following sections, a sort of scheme for each treated ecosystem (in turn divided in PROLINE-CE PA Cluster) summarizes hydrologic attribute and related eco-hydrologic processes/functions defining a datum hydrologic service (i.e. improvement of water supply, water-quality damage mitigation and water-flood damage mitigation).

Some best management practices (MP), consistently with the D.T1.2.2 - Transnational best management practice report (PROLINE-CE) and the D.T1.2.2 - Transnational review report of existing BMP (CAMARO-D), are indicated for specific eco-hydrological function and they could be therefore related to some ecosystem services, having also a consideration on their position in the public services provision as well.

The schemes are developed based upon the contributions of the project partners. In the following table (Table 1), for each PA cluster and related ecosystem, the potential hydrological services are checked. Nevertheless, the lack of the check does not mean that the service cannot be provided from the ecosystem, but that no feedback has been received from any project partner for the observed, reference ecosystem and the related possible hydrological service. Hence, the contents of the schemes tend mainly identifying the most significant characteristics in terms of processes and functions that are at the base of the main hydrologic services.

Table 1: Potential hydrological services identified in each Cluster.

PILOT ACTION	CLUSTER 1		CLUSTER 2		CLUSTER 3	
ECOSYSTEMS	Forest in mountain areas	Grassland in mountain areas	Agricultural used ecosystems	Grassland in plains	Wetlands	Riparian strips
HYDROLOGIC SERVICES						
Improvement of water supply	X		X	X		
Water-quality damage mitigation	X		X	X	X	X
Water-flood damage mitigation	X		X	X	X	X

2.2 Public services

Public services represent a complex category of services that provide public goods for the population with associated net social benefits. The main characteristics of the public goods, by which they are verified, are:

1) **Non-excludability:** benefits derived from pure public goods cannot be confined solely to those who have paid for it. Non-payers can enjoy the benefits of consumption at no financial cost to themselves.
2) **Non-rival consumption:** each part's enjoyment of the good or service does not diminish others' enjoyment – in other words, the marginal cost of supplying a public good to an extra person is zero. If a public good is supplied to one person, it is available to all.
3) **Non-rejectable:** the collective supply of a pure public good for all means that it cannot be rejected by people.

The UK National Ecosystem Assessment describes a public good as “a good or service in which the benefit received by any one party does not diminish the availability of the benefits to others, and where access to the good cannot be restricted” (UK NEA, 2011).

Examples of public goods include clean air, flood control, landscape, and beautiful views; anyway, it is important to highlight that not all public goods are environmental resources (e.g., lighthouses and road signs are public goods, and their sub-domain – public services). Therefore, they do not have to be ‘goods’ in the physical sense (e.g., national health schemes, global climate regulations, and birdsong are public goods) (Kretsch et al., 2016)

Public goods clearly provide benefits to the user, but they do not exist with defined supply and demand with defined markets in a market economy. As such they usually meet the definition of the missing market - a situation in microeconomics where a competitive market allowing the exchange of a commodity would be Pareto-efficient, but no such market exists. Generally, goods with these characteristics are typically funded by government out of tax revenues and provided free of charge at point of use (Burrel, 2012). Furthermore, because of the public services are often in the positon of natural monopoly, their provision is performed by different governmental structures and by public or private companies; it can be also assigned to private as in the case of farmers and forest owners through compensation or incentive mechanisms (e.g. Payment for Ecosystem Services) [see D.T3.1.2 in this regard].

Identifying that the provision of public goods composed by public goods and services have several common dimensions with ecosystems services, especially the objective function: human wellbeing (ES) in comparison to aggregated marginal social benefits (PS) it is necessary to analyse them together.

2.3 Ecosystem services as public services

A relevant aspect that deserves to be taken into account is the relation between the public services concept and the ecosystem services. In fact, accounting for the ecosystem services, it is possible to realize that many of them show features that meet the characteristics of public services, in particular with regards to non-excludability and their objectives. However, ES can be either rival or non-rival (i.e. not subject to physical consumption or renewable) and either exclusive (e.g., if access is limited to groups) or non-exclusive (Kretsch et al., 2016).

Table 2: Degrees of "publicness" adapted by from Jongeneel et al (2009); Ostrom (2005) as reported in Dwyer et al., 2015

	Non-rival goods and services (indivisible)	Rival goods and services (divisible)
Impossibility of exclusion	(1) Pure public goods Stable climate, cultural heritage, Peace, public TV	(2) Common goods (common pool resources) ground and surface water, fish in the ocean, rivers and canals, wildlife,
Possibility of exclusion	(3) Quasi public goods (club goods) Nature reserves, toll roads, libraries, golf clubs	(4) Pure private goods agricultural products, timber, agri-tourism, hunting, [social farms?]

In the recent years, there is an increase in attention towards the public ecosystem services management due to the potential increase in negative impacts induced by climate change and related environmental issues. At European level, high interest in public goods from ecosystem is focused on agricultural and land use and on the development of policies aimed to the delivery of public goods from rural lands (EC, 2015). Moreover, the development of River Basin Management Plans under the EU Water Framework Directive is an example of situation where an effective planning and implementation process is requested by the EU member states for the management of the fresh water system. In this context, the concept of ecosystem services can be adopted to recognize the multi-functionality of the water system and account for the benefits people receive from nature (Grizzetti et al., 2016).

The management and the prevention of the loss of public goods as consequence of ecosystem degradation require integrated systems of governance and engage a wide variety of actors, due to the complexity of ecological and social context in which public services are provided by ES (Gatzweiler, 2006). As shown in Figure 4, the providing and the maintaining of the public goods is already ensured by local national agencies, governmental structures, and privates as defined function of the public services. Specifically, public services providers and managers differ from one European country to another, mainly in institutional structures, various legal rights and responsibility division between public and private institutions on a national, regional and local level. Within the PROLINE-CE project, the public services providers are identified mainly in the stakeholders but, due to the different national management in each PA, no detailed local information can be further provided. Following the processes of PS provision defined in the figure 4 we can clearly recognize that there are already set in place existing payment mechanisms for enhancing and sustaining public services.

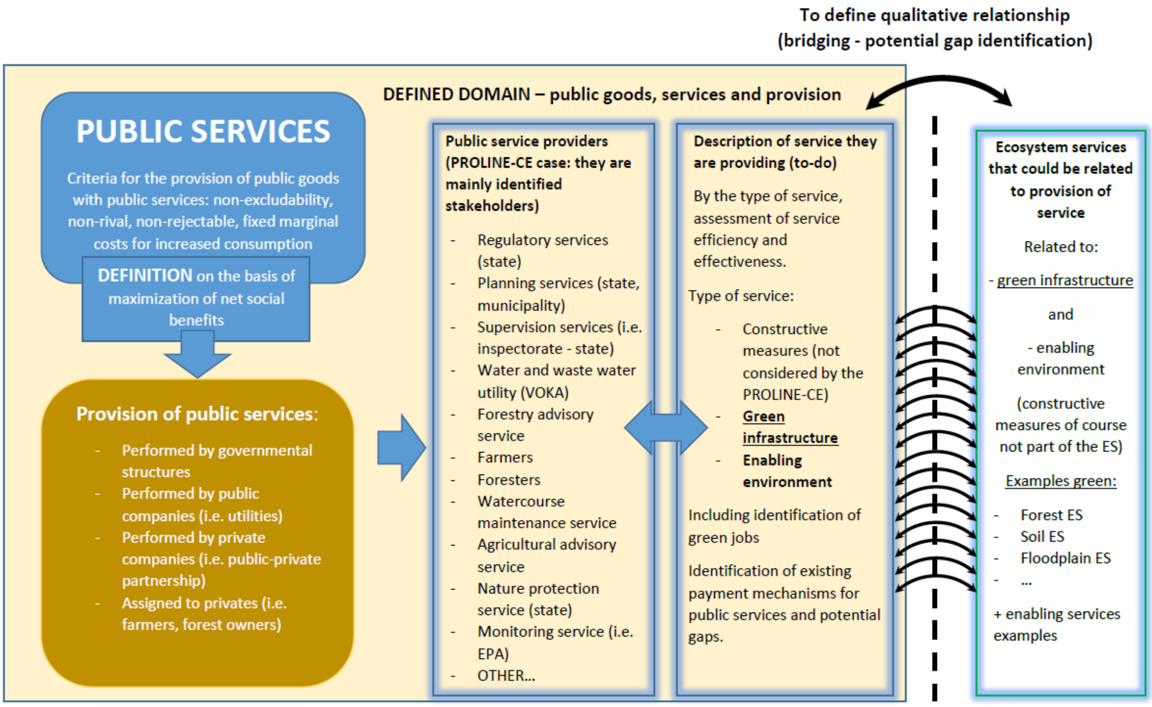

Figure 4: Definition of public services, provision of public services and related ecosystem services (PROLINE-CE Slovenian D.T3.1.2 report).

FP7 PEGASUS Project (Dwyer et al., 2015) stress the role of effective land use management in achieving, specifically for forest and agriculture, not only private goods and services but also the “positive externalities”.

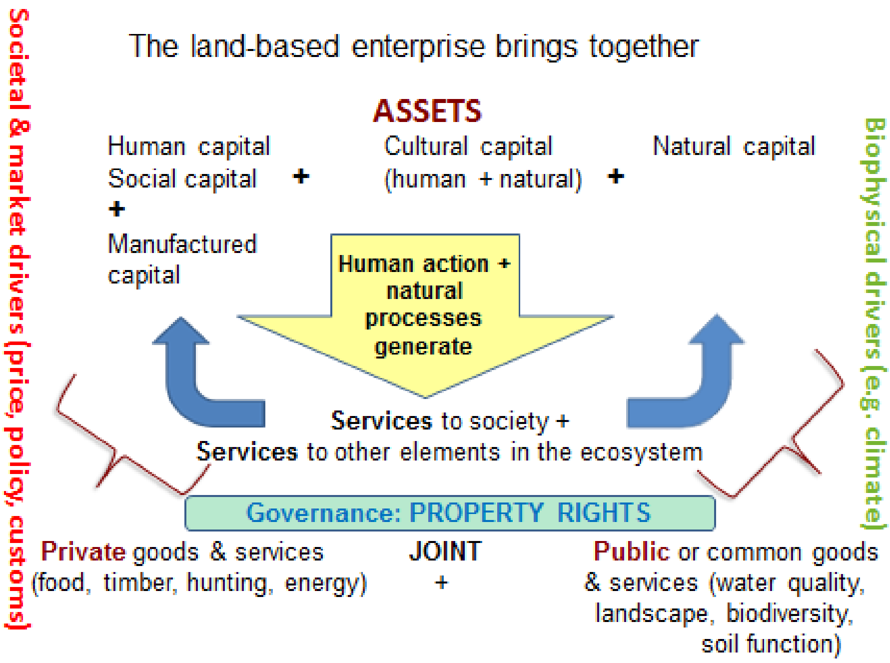

Figure 5: Illustrating relations between PGs, ESS for farming and forestry (PEGASUS Project – Deliverable 1.1; 2016).

The ecosystem services provided by the different land covers (ecosystems) identified in the PROLINE-CE project, particulary relevant to ensure flood management and drinking water protection, both in terms of water quality and quantity, can be widely considered as public services. In order to ensure the effective completion of these services, management practices are required (Figure 5 and 6) which, at the same time, represent categories of public services commonly related to integrated management practices for ecosystem and environmental protection and restoration, including application of design of green infrastructure, the introduction of new green jobs.

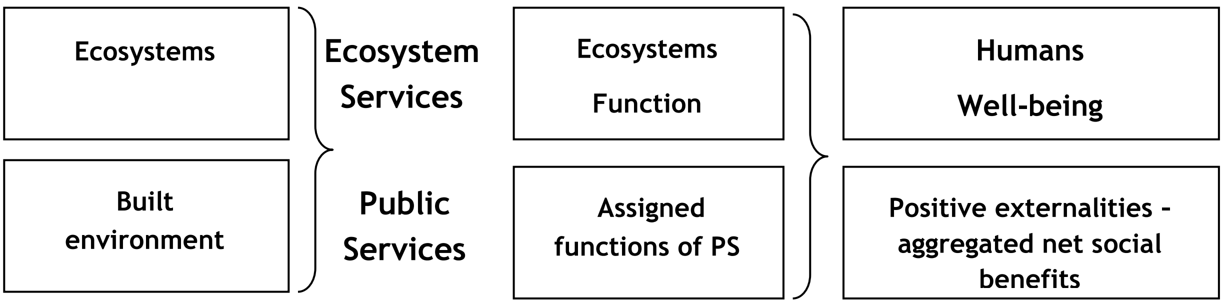

Figure 6: Schematic representation of the relation between Public Services, Ecosystem Services, and comparable objectives: human well-being and positive externalities.

Water-related public services provided by ESS are closely related to the general water governance system, which is often not really known by the population. The most common services that occur under the framework of different institutional arrangement are:

- Water services water quality and quantity management;

- Water management planning processes;
- Flood risk reduction;
- Erosion control;
- Maintenance of watercourses;
- Accidental pollution management and disaster response systems;
- Water and climate monitoring;
- Supporting services to those: water management in spatial planning process, water governance, education, research, ICT, archives, permitting, etc.

These services are almost in line with the basic characteristics of public services: non-rivalrous, non-excludable, difficult to charge, and characterized by a natural monopoly.

Furthermore, water-related services as “drinking water supply” and “waste water treatment”, which represent the services most recognized by users, are also positioned in the domain of public services. In fact, even if for these services the charging system is well established in most of the countries, there are several criteria that allow considering the water supply and waste water management systems as public services. They are:

1) These services are recognized as natural monopoly;
2) The marginal cost of supply drinking water as public good to an extra-person is zero;
3) Drinking water supply is (in some countries) non-rejectable, being related to the right of man regarding the access to drinking water;
4) Waste water collection and treatment services are non-rejectable, having direct effects on the overall health of the communities and environment, recognized also as spill-over effect.

As previously explained, private markets might, in general, fail in supplying the optimum quantity of public services and goods, especially in the case of water related services. Nevertheless, the level of services provided by the government could be debated, as in the case of flood safety, which is still a challenging issue, especially accounting for climate change conditions. Flood risk management is beside that prone to the free-rider problem. By definition the free-rider problem occurs when those who benefit from resources, public goods, or services do not pay for them, which results in an under-provision of those goods or services. For the part of the services the population is charged for (i.e. water supply), the optimization process is under way with clear effects (long-term trends of diminished water consumption per capita). For the services with free-rider problem, i.e. flood management, these mechanisms are in general not established.

The protection of the natural ecosystems and of their services are guaranteed by conservation policies and strategies implemented at international and national level. More recently, economic incentives and payment mechanisms (e.g. payments for ecosystem services (PES)) are becaming very popular. PES are financial instruments through which the providers of ecosystem services receive economic incentives from beneficiaries for implementing good land management and conservation activities.

Forms of governance for public goods and ecosystem services are particularly needed when there is some degree of rivalry or when changes in land management or ownership can threat the non – excludability characteristic, as for example in the case of over-exploitation of freshwater by one person or a group of people in a location that can limit the availability of freshwater to other users at the same location. Therefore, in the context of polices for securing public ecosystem services, it is relevant considering the relations and the responsibilities of all the involved stakeholders, in order to reduce potential conflicts and social inequalities. In this context, the collaboration between the public and private sectors will be a key component in accelerating the dissemination of the ecosystem services concepts as public services and in increasing the awareness of people and communities.

This issue is partially already addressed within the national legislation defining the legislative mechanisms for the prevention of over-exploitation of natural resources (water quality, quantity, temperature, dynamics, sediments etc.). Different national legislations address the private owner's right and allocation of available resources in different way, usually as a function of historical processes related to those. In some countries all exploitable natural resources are public good (including water, mineral resources etc.) and rivalry concept is therefore already managed by public body. In other countries the riparian law is applied with land owners having sometimes even full ownership of the resources on their land.

In the following tables, for each identified land use/ecosystem category characterizing the pilot actions, providers and public services needed for the maintenance of the ecosystem services are also identified.

3. Pilot Action Cluster 1 – Potential public services

3.1 Forest ecosystems in mountainous areas

3.1.1 Improvement of water supply

BRIEF SERVICES DESCRIPTION
Source Water Provision for water supply is a regulating service describing ecosystem modification of available water used for human purposes, among which drinking one, main topic of the PROLINE-CE Project.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X	X	

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Forest ecosystems can ease good **infiltration** conditions for precipitation water. Forest soils are formed by mineral and organic components. In their natural status they are highly porous which plays a central role in terms of better infiltration. Infiltration is relevant for **water storage** and **groundwater recharge**. During the summer period the shadowing effect of forest cover on the forest soils provides lower soil temperatures in the upper soil horizons (Koeck et al. 2014; Koeck 2008; Kang et al. 2000). This reduces the tendency for the creation of water-repellent upper soils and hence supports better infiltration conditions.	The most important MP for forest soil preservation is the avoidance of the clear-cut technique (**MF 1**). Additionally, the adoption of specific cutting systems that preserve forest soil stability and do not damage the underlying vegetation is very important **(MF 21 & 29)**. Also the creation of stable forest stands with tree species diversity of the natural forest community contributes to forest soil stabilisation (**MF 7**). It is necessary that forest management practices address principles that ensure forest fire prevention **(MF 19, C-D)** (e.g. Italy or Hungary)
Rainwater **interception storage** capacities of a forest ecosystem can be more or less relevant depending on the forest type. Water is also stored by **forest soil**, whose capacity is significantly higher than of the interception storage. The forest soils storage capacity is dependent on geology, ecto-humus layers, soil type, soil depth, soil compartments, soil structure etc.	The clear-cut technique (CCT) does not conform to water protection requirements in general: interception storage reduction, soil exposure, increasing of peak runoff and soil nutrient mobilisation endanger drinking water supply **(MF1)**. In contrast Continuous Cover Forest Systems (CCF) ensure a sustained provision of the forest functions for soil and water protection **(MF2)**.
Forest ecosystem structure is of importance for **snow storage**. Snow storage can support the prolongation of the snow ablation period, what contributes e.g., to a more balanced **groundwater recharge**.	
Forest vegetation has the **capacity to stabilize** the forest soil- and humus layers. The stabilization is given through the dense root network of trees and soil vegetation.	A good soil stabilization is insured by a continuous cover forest systems and a structural forest diversity (MF 8).

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection services; Forest advisory services; Foresters.	Forest protection; Cover forest preservation; Cutting system management; Forest fire prevention; Agroforestry systems promotion.

OTHER INTERRELATED SERVICES
Water quality damage mitigation, water flood damage mitigation; Carbon sequestration, air pollutant removal, soil development, local climate modification, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
X	X		X	X	X	X

3.1.2 Securing Water quality

BRIEF SERVICES DESCRIPTION
Water quality accounts for the chemicals, pathogens, nutrients, salts, and sediments in surface and groundwater. Water quality-damage mitigation is the necessary service to guarantee the safety of water intended for human consumption.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
X			

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Forest ecosystems can ease good **infiltration** conditions for precipitation water, which is relevant for source water protection in drinking water protection zones (DWPZ).	Only stable forest ecosystems can provide ecosystem services for securing water quality, hence the whole set of MP for mountain forests has to be applied for reaching this purpose. The most important aspect is the implementation of tree species diversity of the natural forest community (**MF 7**) and the avoidance of the clear-cut technique **(MF 1).**
Forest soil- and humus layers have the capacity for **filtrating** potential contaminants of the rainwater. Within forest ecosystems, agro-chemicals in general are not applied, hence the related water bodies are not threatened through those substances.	Also adaptive forest management under climate change ensures the provision of Drinking Water Protection over space and time **(MF14).** Chemicals like fertilizers, pesticides or herbicides are substances, which form a threat for water quality. Hence the consequent prohibition of the use of chemicals in forestry practices is crucial within DWPZ **(MF 21 and MF22, C-D)**; likewise, a prohibition/restriction of grazing in forests is suggested **(MF39)**. An integrative planning strategy would establish a structured and operative tool for well-established management for DWPZ **(MF24).** Forest roads construction limitation (**MF 20**) is needed for avoiding potential contaminations and hydrological adverse impacts.

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection services; Forest advisory services; Foresters; Monitoring services.	Forest preservation; Species diversity protection; Forest soil contamination management; Agroforestry systems and implementation/promotion of green infrastructure implementation.

OTHER INTERRELATED SERVICES
Improvement of water supply, water flood damage mitigation; Carbon sequestration, air pollutant removal, soil development, local climate modification, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
X	X		X	X	X	X

3.1.3 Water flood damage mitigation

BRIEF SERVICES DESCRIPTION
Water flood-damage mitigation permits reducing the potential impacts of different type of flood events on communities and assets.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X	X	X

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Forest ecosystems ease **good infiltration** conditions for precipitation water, which is relevant for the prevention of surface runoff.	The clear-cut technique (CCT) does not conform to water protection requirements in general: Soil erosion, water repellency of the upper soil horizons, interception storage reduction, soil exposure, and humus loss are leading to increased surface runoff, erosion and slope instability **(MF1)**. In contrast Continuous Cover Forest Systems (CCF) ensure a sustained provision of the forest functions for soil and water protection **(MF2)**. The application of the MP catalogue for mountain forests helps to increase the water storage capacity of the uppermost soil layer and the forest ecosystems as a whole unit. Naturally, occurring and artificial surface depressions can be used as temporary water retention basins that are filled with water during heavy rain events and fall dry during drought periods. Water is held back during heavy precipitation events, buffering floods. This is a small-scale measure and has no connection to constructing large objects such as water reservoirs **(C-D).**
Forest ecosystem structure is of importance for **snow storage**. Snow storage can support the prolongation of the snow ablation period, what contributes e.g., to a more controlled surface flow. Snow storage can also **mitigate avalanche hazards**.	
Steep slopes of mountains are prone to erosion processes or slope instabilities as rock-fall, landslides or snow avalanches. The two principal driving forces of soil surface erosion are surface runoff and rain splash. Ground cover density (forest) plays a key role in the factors governing soil erosion because it directly **protects the soil against the impact of raindrops and inhibits surface runoff**.	
Forest ecosystems provide good **infiltration** conditions for precipitation water, which is relevant for the prevention of surface flow.	It is necessary that forest management practices address principles that ensure fire prevention. Forest fire facilitates easier erosion conditions and water repellent soils formation **(MF19, C-D)**. The adoption of specific cutting systems that preserve soil stability and do not damage the underlying vegetation **(MF 21 + 29)**.
A stable and dense forest cover provides the best natural **prevention and mitigation of streams lateral erosion processes.**	Forest management practices are necessary to preserve a stable forest cover avoiding the presence of wide uncovered space (**MF 28**) by optimizing the cutting operation **(MF 29)** and dimensioning the cutting areas **(MF 30)**. Practices aim to the prevention of erosion processes through a forest cover along buffer strips **(MF 13)** are very useful against the mobilization of huge amounts of soil-, gravel- and rock material, protecting the streams from lateral erosion and nutrient loads.

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection services; Forest advisory services; Foresters; Water course maintenance services.	Forest preservation; Water retention basin preservation; Cutting and removal operations management; Forest fire prevention; Water stream lateral erosion prevention also by implementing green infrastructures.

OTHER INTERRELATED SERVICES
Improvement of water supply, water quality damage mitigation; Carbon sequestration, air pollutant removal, soil development, local climate modification, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
X	X		X	X	X	X

3.2 Summary Cluster 1

Forest ecosystems can provide sustainable water protection functionality if managed accordingly. The main forest ecosystems functions that sustain these ecosystem services are: 1) adequate infiltration conditions for precipitation water into the soil matrix, 2) water storage and retention, 3) snow storage, 4) stabilization of soil- and humus formations, 5) prevention or mitigation of erosion processes and 6) filtration of the precipitation water.

Forested watersheds capture and store water, thus contributing to the quantity of water available and the seasonal flow of water. Forests also help purifying water by stabilizing soils and filtering contaminants.

Grasslands mountainous areas are the result of long-term human agricultural activities, and they have been used for mowing and livestock grazing for centuries. Many of these permanent grasslands are biodiversity hotspots owing to extensive farming practices (MacDonald et al., 2000; Schermer et al., 2016) that provide a variety of ecosystem services. While in the past mountain grasslands were managed principally for forage provision, nowadays their importance for regulating (e.g. soil stability, water provision, carbon storage) ecosystem services is increasingly recognized (Bürgi et al., 2015; Lamarque et al., 2011), although a specific feedback was not given by the project partners.

4 Pilot Action Cluster 2 – Potential public services

4.1 Agricultural used ecosystems

4.1.1 Improvement of water supply

BRIEF SERVICES DESCRIPTION
Source Water Provision for water supply is a regulating service describing ecosystem modification of available water used for human purposes, among which drinking one, main topic of the PROLINE-CE Project.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X	X	

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Root channels of all kind of agricultural crops represent preferential flow paths for **infiltration** water easing **groundwater recharge**. Moreover, activity of the soil animal community (e.g. earthworms) creates an additional system of macropores, which enhances the aeration in the soil and the water transferability.	In general, any measure designed to encourage the maintenance of agricultural used ecosystems ease the soil “structure” preservation, improve infiltration and the groundwater recharge. Stabilization of soil helps to improve the hydraulic properties of soil thus increasing infiltration capacity and decreasing surface runoff.
Soils used for agricultural activities have high ranges of possible thicknesses. The soil matrix represents a valuable **water storage** that is able to store considerable volumes of water. Agricultural used ecosystems represent **valuable groundwater recharge** zones and contributes to drinking water provision.	

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Agricultural advisory services; Farmers.	Water irrigation system management; Land use planning; Sustainable and effective agricultural practices promotion also by payment, compensation mechanisms (PES); Drought events management.

OTHER INTERRELATED SERVICES
Flood mitigation, water quality improvement; Carbon regulation, nutrient cycling, soil maintenance, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
	X		X		X	X

4.1.1 Securing Water quality

BRIEF SERVICES DESCRIPTION
Water quality accounts for the chemicals, pathogens, nutrients, salts, and sediments in surface and groundwater. Water quality-damage mitigation is a necessary service to guarantee the safety of water intended for human consumption. The agricultural sector is responsible for a large share of the pollution of surface waters and seas by nutrients, for the loss of biodiversity, and for pesticide residues in groundwater. Agriculture is changing to provide many services that society demands. Agricultural-related ecosystem services, as the water quality preservation, are strictly conditioned by best management practices (MP) adoption.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
X			

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Stabilization of soil helps to improve the hydraulic properties of soil thus decreasing surface runoff and related soil erosion processes.	Soil erosion leads to transport processes of particulate substances, which negatively affects the agricultural productivity and causes an enrichment of nutrients close to or even in surface water systems. The protection of the crop is crucially important for drinking water provision. Maintaining the share of grassland is a highly effective for the stabilization of soil surface and decrease of soil erosion **(M(P)A1).** Crop rotation contributes not only to the conservation of soil fertility but also decreasing of erosion. For perennial crops on slopes, negative erosion impact is reduced by maintaining vegetation cover between rows as well as the construction and maintenance of terraces; conservation tillage increases crop production an at the same time reduces soil erosion risk; mulching which improves soil's physical characteristics (reduction of soil erosion and compaction) and enrichment with organic matter; keeping vegetative cover on sloped land throughout the year (winter crops or grass sowing on areas with erosion risk). A rich root system of permanent pastures and meadows retains humus, reducing the impact of intense rainfall **(MA10, C-D).** Maintenance of terraced agricultural areas **(MA17), etc.** Buffers and filter strips are areas of permanent vegetation located within and between agricultural fields and the watercourses to which they drain to interrupt sediment fluxes and allow infiltration and sedimentation of eroded material. The strips must be designed with proper dimensions (width) according the field topography and have to be maintained (mowed) (**C-D).** Establishment of action programme which include a set of measures to prevent and reduce water pollution (**MA5), Sustainable use of pesticides (MA6)** and **Encouraging organic farming (MA7), etc.**
Sustainable fishery management which should be treated as the first stage of the water treatment process	The bio-manipulation, made by restocking and harvesting, should be aimed at limiting the amount of phytoplankton and, as a result, reducing the trophy of the drinking (surface) water reservoir. The reservoir should be stocked with predatory fish (pike, zander, eel), which are treated as natural allies in the process of pre-treatment of drinking water. Too many bottom feed fishes could cause increase in phytoplankton thus increase in nutrients concentration in water and decrease in water quality. The practise might fit in protection of water from pollution caused by nitrates

	originating from agriculture **(MA5)**

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Agricultural advisory services; Farmers, Waste-water treatment plant operator.	Sustainable agricultural practices promotion through the identification of payment mechanisms (PES); Organic farming promotion; Watercourses and riparian areas management; Flood events forecasting, post-event response and management.

OTHER INTERRELATED SERVICES
Flood mitigation, improvement of extractive water supply; Carbon regulation, nutrient cycling, soil maintenance, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
	X		X		X	X

4.1.2 Water flood damage mitigation

BRIEF SERVICES DESCRIPTION
Water flood-damage mitigation permits reducing the potential impacts of different type of flood events on communities and assets.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X	x	X

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Ground cover density plays a key role in the factors governing soil erosion because it directly **protects the soil against the impact of raindrops and inhibits the overland surface flow**.	The protection of the crop is crucially important for drinking water provision. Maintaining the share of grassland is a highly effective for the stabilization of soil surface and decrease of soil erosion **(M(P)A1).**
Agricultural used ecosystems provide excellent **infiltration** conditions for precipitation water. Root channels of all kind of agricultural crops represent preferential flow paths easing **infiltration and runoff reduction.**	Sustainable agro-techniques with the aim of mitigating soil erosion on agricultural land (e.g. perennial crops, rich root system of permanent pastures and meadows retains humus, reducing the impact of intense rainfall, etc.) **(MA10).**
Ground cover density plays a key role in the factors governing soil erosion because it directly **protects the soil against the impact of raindrops and inhibits the overland surface flow**.	
Low slopes **reduce overland flow and erosion**.	Construction/maintenance of terraced agricultural areas allow to “resetting the slope” **(MA17).**
Artificial/semi-artificial structures to supply water for agricultural purposes allow retaining amount of surface runoff during rainfall events, smooth and retarding **peak flow rates. Short-term flooding of agricultural land during the flood events** is important mechanism enabling activation of significant retention volumes on areas with low flood damage potential.	Retention ponds or system of retention ponds collect surface water during rainfall events and they may also collect large quantities of sediment, nutrients and undesired elements (heavy metals, pesticides….) **M(P)A3,(C-D)**. Linear retention features obstruct the free flow of surface runoff. Similarly to retention ponds they may act as buffer element to smooth runoff peaks for surface runoff **M(P)A4.**
	Hydraulic-environmental restoration of drainage channels; the ecological restoration of the drainage channels represents an important opportunity for the joining of the ecologic network and the improvement of the quality of the environment **(SR6-SR8).**

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Agricultural advisory services; Farmers; Watercourse maintenance services.	Sustainable agricultural practices promotion through the identification of payment mechanisms (PES); Watercourses and drainage channels management also by means of green infrastructures; Flood events forecasting, post-event response and management.

OTHER INTERRELATED SERVICES
Water quality damage mitigation, improvement of extractive water supply; Carbon regulation, nutrient cycling, soil maintenance, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
	X		X	X	X	X

4.2 Agricultural used ecosystems – Grassland in plains

In total, grasslands in plains have similar boundary conditions as agricultural used ecosystems; grasslands can be managed intensively (i.e. operating with heavy machinery up to four times per year) or extensively while their soils suffer more or less from the applied operations. Due to a permanently covered surface and, typically, intensive bioturbation, the valuable effects for the water provision and water retention fit similarly well to agricultural used ecosystems.

4.3 Summary Cluster 2

Agricultural used ecosystems are essential to human wellbeing. Beyond the self-evident food provisioning services, these systems produce a variety of services, such as regulation of soil and water quality, carbon sequestration, support for biodiversity and cultural services. Regulating services from agriculture include flood control, water quality control, carbon storage and climate regulation through greenhouse gas emissions, disease regulation, and waste treatment (e.g. nutrients, pesticides).

The provision of sufficient quantities of clean water is an essential ecological service provided to agricultural used lands (FAO, 2003). Perennial vegetation in natural ecosystems can regulate the capture, infiltration, retention and flow of water across the landscape. The plant community plays a central role in regulating water flow by retaining soil, modifying soil structure and producing litter. Through hydraulic lift and vertical uplifting, deep rooting species can improve the availability of both water and nutrients to other species in the ecosystem. In addition, soil erosion rates are usually low, resulting in good water quality. Well-aerated soils with abundant organic matter are fundamental to nutrient acquisition by crops, as well as water retention. Soil pore structure, soil aggregation and decomposition of organic matter are influenced by the activities of bacteria, fungi and macro-fauna, such as earthworms, termites and other invertebrates.

Grasslands in plains are typical water related ecosystems so they largely affect water quality, its cycling and balance and therefore deserve protection. Out of optimal condition hypothesis, most threats for freshwater originate from present cropland structure with its definite predominance of arable lands over grasslands. An improvement of the agricultural used land structure and management to minimise environmental hazards and to guarantee at the same time optimum economic effects is needed. This could be achieved by turning arable lands into grasslands (where justified) or at least by maintaining present grassland area and management that would consider environmental protection among others: − adjustment of intensity of agricultural use to natural conditions, − achieve equilibration of nutrient cycling in a farm, − using fertilisation mainly with farm fertilisers (manure).

5 Pilot Action Cluster 3 – Potential public services

5.1 Wetland ecosystems

5.1.1 Securing Water quality

BRIEF SERVICES DESCRIPTION
Wetlands are natural treatment systems that employ activities of microbes, media, or plants, in waste stabilization without the aid of mechanical or energy intensive equipment. Two main wetland types are: (i) surface-flow wetlands, in which the wastewater is flowing horizontally over the wetland sediment; and (ii) infiltration wetlands, in which the wastewater flows vertically through a highly permeable sediment and is collected in drains.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
X			

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
The purification processes of surface-flow wetlands include 1. settlement of suspended solids, 2. diffusion of dissolved nutrients into the sediment, 3. mineralization of organic material, 4. nutrient uptake by micro-organisms and vegetation, 5. microbial transformations into gaseous components, 6. physicochemical adsorption and precipitation in the sediment.	Promote restoration of existing wetland ecosystems and their services **(PW11)**. Promote constructed wetlands: they operate by the principle of imitation of natural processes of self-cleaning or purification and consist of the properly selected plants and soil substrates as well as suitable water flow **(PW2)**.
The vertical water movement (**infiltration/soil filtration**) brings the wastewater directly into contact with the sediment, where nutrient removal processes are optimal. The coarse sediment also leads to a good aeration of the sediment during the dry part of a wet-dry cycle.	

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection service (state).	Wetland ecosystem protection; Wetland restoration

OTHER INTERRELATED SERVICES
Improvement water supply and flood-damage mitigation; Productive areas for plant life, animals and wetland agriculture, recreational, historical, scientific, and cultural values.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
				X	X	X

5.1.2 Water flood damage mitigation

BRIEF SERVICES DESCRIPTION
Wetlands deliver a wide array of hydrological services. Swamps, lakes, and marshes assist with flood mitigation and regulate river flows.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X		X

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Wetlands have the capacity to **temporarily store** floodwater during high runoff events, **smooth and retard peak flow rates.**	**Preserve and revitalize wetlands on floodplains;** they present a vital part of the river ecosystems. The main function of the floodplains is carrying excess water in time of flood events and consequently reducing the flood water's potential energy **(PW1). Enlarging wetland areas (PW6).** The dense root mats of wetland vegetation also help to stabilize soil and sediments, thus reducing erosion. **Restore existing wetlands.** The dense root mats of wetland vegetation also help to stabilize soil and sediments, thus reducing erosion. Wetland restoration means re-establishes these advantageous functions for the benefits of floods, erosion and water protection **(PW11).**

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection service (state); Watercourse maintenance services.	Wetland ecosystem protection; Wetland restoration; Watercourses, retention basin, and drainage channels management; Extreme rainfall events forecasting, post-event response and management. Nature-based flood protection measures.

OTHER INTERRELATED SERVICES
Improvement water supply and quality damage mitigation; Productive areas for plant life, animals and wetland agriculture, recreational, historical, scientific, and cultural values.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
				X	X	X

5.2 Special sites: Riparian strips

5.2.1 Securing Water quality

BRIEF SERVICES DESCRIPTION
Establishment of riparian buffer/strips along water courses is a conditionality aimed to protect surface and groundwater pollution mainly resulting from agricultural activities. Water quality-damage mitigation is the necessary service to guarantee the safety of water intended for human consumption.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
X			

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Interrupting the movement of diffuse substances from agricultural/urban areas to surface waters.	An adapted land-use management of riparian strips is crucial to improve their protective function during flood events and low water discharge as well as their potential to purify the inflow and to regulate the diffused discharge of nutrients into the river. Extensively used grasslands represent good land-use options for riparian strips. Moreover, the organic matter content of the topsoil on grassland sites favours the water storage capacity and the process of water purification. **(SR3-SR7)**.
Filtering sediment and other suspended solids from surface flow.	
Shading functionality. Loss of shade from riparian stripes can greatly warm water bodies reducing the amount of dissolved oxygen available in the water.	Hydraulic-environmental restoration of drainage channels; the ecological restoration of the drainage channels represents an important opportunity for the joining of the ecologic network and the improvement of the quality of the environment **(SR6-SR8)**.

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Nature protection service (state); Watercourse maintenance services.	Re-naturalization of rivers; Riparian ecosystem protection; Riparian strips restoration also by means of green infrastructure; Flood events management, post-event response; Nature-based flood protection measures.

OTHER INTERRELATED SERVICES
Water flood-damage mitigation; Productive areas for plant life and animals, recreational, scientific, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
			X	X	X	

5.2.2 Water flood damage mitigation

BRIEF SERVICES DESCRIPTION
Riparian strips/buffers, similarly to wetlands in floodplains, contribute to flood mitigation. Water flood-damage mitigation is a necessary service to guarantee the safety of citizens.

HYDROLOGIC ATTRIBUTE			
Quality	Quantity	Location	Timing
	X		X

ECO-HYDROLOGICAL PROCESSES OR FUNCTIONS	BEST MANAGEMENT PRACTICES (MP)
Capacity to **temporarily store** floodwater during high runoff events, **smooth and retard peak flow rates**. Retention capacity is heavily dependent on the space availability, discharge rate and retention volume on the riparian strips. Intensive sedimentation on riparian inundation plains is sometimes observed. Uncontrolled vegetation development might lead to increased flood risks in direct proximity of the riparian strip, while on the other hand improving flood safety downstream.	An adapted **land-use management** of these sites is of vital importance to keep or even to improve their protective function during flood events **(SR3-SR7)**. Integrated-hydraulic-environmental restoration of water streams. Coordination of measures aimed at hydraulic risk reduction with the need for protection and enhancement of forests and tree and shrub vegetation in the riparian areas, through managing modes of programming and control of the activities of maintenance of the vegetation. **(SR5-SR10). Main limitation component is space availability for the water (flood volume) retention.**
Roots from grasses, shrubs and trees protect vulnerable soils and **stabilize stream banks**. They do not stabilize the stream banks in the case of higher water velocities. Shrubs and trees might reduce the objective (designed) conveyance capacity of the streams - target maintenance is necessary.	
Vegetation **reduce erosion** and ensure that soil located in riparian areas does not become a source of sediment in streams. Management of vegetation including occasional removal of retained sediment.	

MAIN PUBLIC PROVIDERS AND EXAMPLES OF RELATED SERVICES	
Planning services (state, municipality); Public flood management service (preventive, response, mitigation) implementing EU Floods Directive (2007/60), national implementation framework for this directive (flood hazard and risk mapping, programming and implementation of measures. Nature protection service (state); Agricultural advisory service, Common Agricultural Policy schemes enabling compensation payments for the inundated agricultural land.	Objective specific management of streams, rivers their conveyance capacity and retention volumes using green infrastructure measures - EC Green Infrastructure COM(2013) 249 final, COM(2013) 155 final;; Riparian restoration by the means of green infrastructure; Watercourses, retention basin, and drainage channels management; Flood events forecasting, post-event response and management; Nature-based flood protection measures.

OTHER INTERRELATED SERVICES
Water quality-damage mitigation; Productive areas for plant life and animals, recreational, scientific, etc.

REQUIRED OR SUPPORTED BY						
Austria	Bavaria	Croatia	Hungary	Italy	Poland	Slovenia
			X	X	X	

5.3 Summary Cluster 3

Although only about 2.6% of land is covered by inland water bodies (FAO/ITPS, 2015), wetlands, including rivers and lakes, play a disproportionately large role in hydrology per unit area. The case for wetland conservation is often made in terms of hydrological processes, including groundwater recharge and discharge, flood flow alteration, sediment stabilization and water quality (Maltby, 1991).

Riparian zones refer to the areas along rivers and streams (Coles-Ritchie, 2009), which are the transition areas between terrestrial and aquatic ecosystem (Gregory et al., 1991). These areas generally have distinct vegetation and landforms compared to the surrounding uplands and they are dynamic because they are formed and affected by rivers that change and move over time.

Riparian strips are crucial to the protection and enhancement of water resources. They are extremely complex ecosystems that can provide multiple ecosystem services, including water protection functionality (WPF) that helps in mitigating or controlling nonpoint source pollution. Used as a component of an integrated management system including nutrient management, sediment and erosion control practices, riparian strips can produce a number of beneficial effects on the quality of water resources.

Riverside buffer strips can be effective in removing excess nutrients and sediment from surface flow and shallow groundwater and in shading streams to optimize light and temperature conditions for aquatic plants and animals. They can also ameliorate the effects of some pesticides and directly provide dissolved and particulate organic matter that can lead to high biological productivity and diversity in the associated water body.

Riparian zones in good shape (i.e. large and depth enough with high absorption capacity) provide a high potential capacity for retention and absorption high flows which could reduce risks and damage of flood events. Moreover, they enhance the flood protection level by strengthening stabilization capacity of stream-banks along rivers and streams and and protect the soil from erosion especially in case of extreme precipitation or flood.

Flood plains providing significant retention volumes usually extend beyond the riparian zones as the retention volumes of riparian zones do not match the necessary retention potential and conveyance capacity of the streams and rivers. This results in the flooding of the areas of low flood damage potential – usually agricultural land. Ecosystem service of floods on the agricultural land is often neglected.

6 Conclusions

The work that led to this Deliverable consisted of the following main steps:

- preliminary collection of the requested contributions to the project partners;
- individuation/description of the main eco-hydrological functions/processes for each hydrologic service and related PA Cluster;
- checking and referencing to the main best management practices (MP) listed in D.T1.2.2 - *Transnational best management practice report (PROLINE-CE)* and the D.T1.2.2 - *Transnational review report of existing BMP (CAMARO-D)*;
- indication about the potential public services of sustainable and functional land use management;
- indication of other main interrelated services in addition to properly hydrologic services.

The result is concise schemes that try to collect for each main hydrological services group – water supply, quality and flood damage mitigation - the most significant characteristics of the treated land uses ecosystems, both in terms of natural processes/functions and best MP. Furthermore, the main public services related to the effective land use management, which supports drinking water protection and flood/drought prevention, are highlighted.

The provision of the hydrological services from land-use ecosystems cannot be conceptually (and practically) “disconnected” from the supposition of the application of specific (best) management practices; this supposition allows to make “sustainable” a datum land-use and to really provide benefits (services) to human-life.

This aspect appears relevant especially in the context of the agricultural used ecosystems: depending on management practices, agriculture can be the source of numerous disservices (negative externalities), including loss of wildlife habitat, nutrient runoff, sedimentation of waterways, greenhouse gas emissions, and pesticide poisoning of humans and non-target species. Appropriate management and practices can reduce many of the negative impacts of agriculture, while largely maintaining provisioning services.

It is also good to highlight how different natural processes/functions – within a datum land-use ecosystem - may have competing effects on the same attribute (e.g. quality, quantity, location and/or timing) or have simultaneously positive and negative effects on different attributes of the same service (e.g. a forest might increase water infiltration while decreasing total water volume).

A variety of other essential services, including air quality, carbon dioxide sequestration and soil generation, are provided from each treated ecosystem in addition to the hydrologic services.

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