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Deliverable. 3.1.4	**Guidelines for sustainable capitalization of regulative services related to water resources management**

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Guidelines for sustainable capitalization of regulative services related to water resources management

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ABBREVIATIONS

Term	Explanation
CICES	Common International Classification of Ecosystem Services
CLC	CORINE Land Cover
CORINE	Coordination of Information on the Environment
EC	European Commission
ES	Ecosystem Service
ESC	Ecosystem Capacity
ESTAT	Eurostat, Statistical office of the European Union
EU	European Union
EUNIS	European Nature Information System
EUSTAFOR	European State Forest Association
FAO	Food and Agriculture Organisation of the United Nations
FES	Forest Ecosystem Services
HD	Habitats Directive
InVEST	Integrated Valuation of Environmental Services and Tradeoffs
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre
MEA	Millennium Ecosystem Assessment
MAES	Mapping and Assessment of Ecosystems and their Services
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NCA	Natural capital accounting
NEA	National Ecosystem Service Assessment
NEP	Net ecological production
NFI	National Forest Inventory
NGO	Non-Governmental Organisation
NPP	Net Primary Production
NWRMs	Natural Water-Retention Measures
SEEA	System of Environmental Economic Accounts

TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNEP	United Nations Environment Programme
WFD	Water Framework Directive
WISE	Water Information System for Europe
WWF	World Wide Fund for Nature

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Foreword

The main aims of the project BIOPROSPECT are to explore and document the bioprospects of forested protected areas and the ways of sustainable capitalization as a mean for their wise management and conservation, to encourage cooperation partnerships and networking among economic development planners and PA managers, to develop a cross-border bioprospect assessment methodological framework and economic valuation model in order to achieve outcomes which benefit both economic development and conservation.

BIOPROSPECT Work Package 3 aims to develop a tool box for the economic valuation and sustainable capitalization of biodiversity-ecosystem services. This will be achieved through the specific project objectives; to provide operational tools for the conservation of forest biodiversity through economic valuation and sustainable capitalization.

This report, (deliverable D3.1.4 under Task 3.8 in Work Package 3) approaches this objective by providing guidelines for sustainable capitalization of regulative services related to water resources management.

The starting point of this report is an introduction to the conceptual framework of forest ecosystem services and a review of capitalization mechanisms of ecosystem services. The report analyses forest regulative services related to water as also the links among conservation drivers, pressures, ecosystem services and economic importance. The D3.1.4 also targets to develop a guide for the capitalization of regulative forest ecosystem services related to water resources management.

Executive Summary

Deliverable 3.1.4 (D3.1.4), under Task 3.8 in Work Package 3 (WP 3) - Tool box for the economic valuation and sustainable capitalization of biodiversity-ecosystem services, approaches a guide for the capitalization of regulative forest ecosystem services related to water resources management. This report presents an overview of forest regulative services related to water and capitalization techniques and policies for forest managements and water resources, as also targets to the creation of the appropriate guidelines for economic valuation of forest ecosystem services ensuring the sustainability of regulating services related to water.

The report is structured in six main sections. Section 1. The Introduction (Section 1) provides information about the concept under which the D3.1.4 is implemented.

Section 2 as the starting point of the analysis, provides a conceptual framework of forest ES nomenclature and typology, as well background information about capitalization and sustainability of ESs, incorporating the economic valuation of water-related forest services into relevant policies and strategies on ESs.

Section 3 is an overview of capitalization mechanisms for ES facilitating the development and implementation of measures, which include economic tools such as payments for ecosystem services (PES) in order to broaden and diversify the financial basis for sustainable forest management and to maintain the protective functions of forests. Section 3 analysis forest regulative services related to water, outlines the forest managements techniques ensuring sustainability of regulating services, and presents policies for forest and water resources management and capitalization projects that contribute to the maintenance of ecosystems and the sustainable provision of their services. Moreover, this section illustrates the links between pressures, ecosystem status and ecosystem services.

Section 4 refers to case studies for capitalization of ecosystem services targeted and interventions for sustainability, emphasizing the vital importance of water or human beings and for the environment.

The last part of the report (Section 5) presents key stages and processes of sustainable capitalization and a checklist to guide economic valuation of ES under study.

Finally, for a more complete approach, the report closes with section 6 “Conclusions and recommendations” where the limitation of economic valuation and the potential for improvement and remaining challenges in the procedure of sustainable capitalization of FES are discussed.

Εκτεταμένη Ελληνική περίληψη

Το παραδοτέο D3.1.4, το οποίο ανήκει στο Πακέτο εργασίας (WP 3) - Εργαλεία για την οικονομική αποτίμηση και τη βιώσιμη κεφαλαιοποίηση των Ο.Υ, προσεγγίζει την ανάπτυξη ενός πλαισίου οδηγιών για την κεφαλαιοποίηση των ρυθμιστικών υπηρεσιών των δασικών οικοσυστημάτων που σχετίζονται με τη διαχείριση των υδάτινων πόρων. Στην παρούσα έκθεση παρουσιάζεται μια επισκόπηση των δασικών ρυθμιστικών υπηρεσιών που σχετίζονται με τις τεχνικές και τις πολιτικές διαχείρισης και κεφαλαιοποίησης των υδάτινων πόρων. Επιπλέον, στόχος του D3.1.4 είναι η δημιουργία κατάλληλων κατευθυντήριων γραμμών για την οικονομική αποτίμηση και την αειφόρο διατήρηση και διαχείριση των δασικών οικοσυστημικών υπηρεσιών (Ο.Υ), οι οποίες και θα ληφθούν υπόψη κατά το σχεδιασμό και την υποβολή των σχετικών σχεδίων δράσης.

Η έκθεση διαρθρώνεται σε επτά ενότητες. Ενότητα 1, η Εισαγωγή παρέχει πληροφορίες σχετικά με την έννοια της εφαρμογής του D3.1.4. και όπου υπογραμμίζεται η σημασία της κεφαλοποίησης των οικοσυστημάτικών υπηρεσιών.

Η ενότητα 2, ως αφετηρία της ανάλυσης, παρέχει ένα εννοιολογικό πλαίσιο για την ονοματολογία και την τυπολογία των δασικών Ο.Υ δίνοντας ιδιαίτερη έμφαση τους υδάτινους πόρους. Επιπλέον παρέχει πληροφορίες σχετικά με την κεφαλαιοποίηση και την αειφορική διαχείριση των Ο.Υ.

Η ενότητα 3 αποτελεί μια επισκόπηση των μηχανισμών κεφαλαιοποίησης των Ο.Υ που διευκολύνουν την ανάπτυξη και εφαρμογή μέτρων για την οικονομική αποτίμηση και αειφόρο διατήρηση των οικοσυστημικών υπηρεσιών που σχετίζονται με τους υδατικούς πόρους Στους εν λόγω μηχανισμούς περιλαμβάνονται και οικονομικά εργαλεία όπως πληρωμές για υπηρεσίες οικοσυστήματος (Payment for ecosystem services-PES) κτλ. Επίσης, στην ενότητα 3 γίνεται ανάλυση των δασικών ρυθμιστικών υπηρεσιών που σχετίζονται με τους υδάτινους πόρους, καταγράφονται διαχειριστικά μέτρα που χρησιμοποιούνται για την αποδοτικότερη κεφαλαιοποίηση και αειφόρο διατήρηση των συγκεκριμένων Ο.Υ, και γίνεται μια προσπάθεια περιγραφής του τρόπου με τον οποίο τα διαχειριστικά μέτρα επιδρούν στους υδάτινους πόρους. Επιπλέον παρουσιάζονται μοντέλα και εργαλεία για την ποσοτική εκτίμηση των Ο.Υ σχετικά με τους υδάτινους πόρους, καθώς και διεθνείς πολιτικές και έργα σχετικά με την κεφαλαιοποίηση και την αειφορική διαχείριση των υδάτινων πόρων. Τέλος στην ίδια ενότητα 3 γίνεται μια προσεγγιστική εκτίμηση των κινητήριων δυνάμεων, των παραγόντων πίεσης (θεσμική και βιοφυσική προσέγγιση) καθώς και της σχέσης μεταξύ κατάστασης του οικοσυστήματος, Ο.Υ και αειφορικής κεφαλαιοποίησης τους.

Στην ενότητα 4 γίνεται αναφορά σε παγκόσμια παραδείγματα κεφαλαιοποίησης και σε μελέτες περιπτώσεων για την αειφορία των ρυθμιστικών δασικών υπηρεσιών που σχετίζονται με το νερό

Το τελευταίο μέρος της έκθεσης (ενότητα 5) παρουσιάζει βασικά στάδια και διαδικασίες αειφορικής κεφαλαιοποίησης όπως επίσης και μια λίστα παραμέτρων για την καθοδήγηση της οικονομικής αποτίμησης των υπό μελέτη Ο.Υ. Επίσης στην ενότητα 5 γίνονται κάποιες προτάσεις-συστάσεις για την κεφαλαιοποίηση των υδάτινων πόρων μέσω οικονομικών συστημάτων.

Τέλος, για μια πληρέστερη προσέγγιση, η έκθεση κλείνει με την ενότητα 6 «Συμπεράσματα και συστάσεις» όπου και γίνεται μια σύντομη συζήτηση για του ενδεχόμενους περιορισμούς των μεθοδολογιών οικονομικής αποτίμησης, τις δυνατότητες βελτίωσης αλλά και τις προκλήσεις στη διαδικασία της αειφορική κεφαλαιοποίησης των δασικών Ο.Υ.

1 INTRODUCTION

Water is the most vital element of all natural resources and is essential to life. Watersheds and the functioning of the hydrological cycles are crucial not only for the natural ecosystems, but also provide a lot of benefits at the society. The ecosystem services related to water and water-land interaction over forests, agricultural lands, riparian areas, wetlands, and water bodies Croitoru (2006), are the most important of services in many Mediterranean countries (CRPF PACA, 2012).

Forests are widely recognized as recommended land cover for protection of water resources (Johnson et al., 2001). It is accepted that forests improve water quality, control erosion, and regulate water flows in catchments (Muys et al., 2014). Hence, forests and woodlands have a close link with water resources, and forest management; the management or mismanagement of forests can affect the hydrological outcomes that humans demand ecosystems to provide (Thorsen et al., 2014).

Valuation at local, national and international level of services provided by forests and woodlands is important for the sustainable management of the forests according to the proper estimation of the value and services they provide. Therefore the existence of valuation tools for the quantification and visualization of the multiple services of forest (Lette and de Boo, 2002).

Environmental valuation is important for assigning monetary values to all ecosystem services, even if they have no established market values (e.g., biodiversity protection, watershed protection) and are not considered in traditional economic valuation frameworks (Thorsen et al., 2014). Defining the monetary value isa tool for making costs and benefits commensurable. Both Quantification and valuation (economic and non-economic) produces information for designing the sustainable use of natural resources. Valuation reveals the viewpoints of different stakeholders, and how the benefits of the actions are distributed. Valuation helps in assessing how the forms of use of an ecosystem and changes in forms affect the gained societal benefits (Kosenius et al., 2013). Furthermore, valuation can be reflected in policy decisions, indicators and accounting systems, providing useful estimates regarding the impact of specific changes on forest ecosystems, and therefore protecting their biodiversity (Chaudhary, 2017).

The Goal of BIOPROSPECT project is to explore and document the economic value of forested areas and the ways of sustainable capitalization as a mean for their wise management and conservation. One of the specific objectives is to provide operational tools for the conservation of forest biodiversity through economic valuation and sustainable capitalization. The main aim of this report is to develop guidelines for sustainable capitalization of regulative services related to water resources management.

2 BACKGROUND AND CONCEPTUAL FRAMEWORK

2.1 Forest ecosystem services nomenclature and typology-focus on water related

A large variety of ecosystem services have been addressed by assessments such as

- ✓ Millennium MEA - Millennium Ecosystem services Assessment (2005)
- ✓ TEEB -The Economy of Ecology and Biodiversity (2008)
- ✓ CICES - The Common International Classification of Ecosystem Services (2010)

As also reported in 3.1.2 Deliverable Assessing the status and trends of forest services availability and distribution, we follow the CICES classification system.

Forests are widely acknowledged for protection of water resources, control erosion, improve water quality and regulate water flows (Muys et al., 2014). The services provided by forests according to CICES can be divided in three categories.

Forest Provisioning services: products such as food (e.g. game, roots, seeds, honey, mushrooms, nuts and other fruits), fibre (e.g. wood, water and cellulose), medicinal products (e.g. aromatic plants), and drinking water.

Forest Regulation and maintenance services: are the ways in which forest ecosystems can regulate the environment and include services for (1) water and air purification; (2) climate and water regulation; (3) protection from natural hazards, such as floods, avalanches, rock-fall and erosion; (4) carbon sequestration; and (5) disease and pest regulation.

Forest cultural services consist of the non-material outputs of forest ecosystems. Cultural services should be regarded as the physical settings, locations aesthetic inspiration, cultural identity etc (EEA, 2016).

A crucial initial step for considering water-related forest ecosystem service values into an inclusive framework is to have well-defined individual services. Water related benefits for forest ecosystems can be found in all three categories described by CICES, such as drinking water (provisioning ES), the use of rivers and lakes for recreational purposes and eco-tourism (cultural ES), climate regulation and water purification (regulation ES) (Pinto et al., 2013).

Regulating services encompass all benefits obtained from the regulation of ecosystem processes (Reynaud et al., 2010). Forest ecosystems provide people with four types of water-related benefits (Johnson et al., 2001)

These include:

1. Regulation of the chemical condition of freshwaters

Water purification is a regulating service provided by forest ecosystems through the retention of pollutants, ultimately preventing them from reaching the water course resulting to better water quality (Acuna et al., 2014).

2. Attenuation of mass movement

Erosion control is a regulating service provided by forest ecosystems through sediment and soil retention contributing in issues such as avoiding sedimentation in reservoirs , (which can minimize water capacity and hydropower production) (Acuna et al., 2014). The erosion prevention service corresponds to the fact that the vegetative cover plays an important role in soil retention and the prevention of landslides, avoiding thus soil degradation (Reynaud et al., 2010).

3. Hydrological cycle and water flow regulation

Regulation of water flow relates to the influence of forest ecosystems on the hydrological fluxes at the surface of the Earth (Egoh et al., 2008) and includes processes associated with irrigation maintenance, natural drainage and buffering stream flow extremes (de Groot et al., 2002).

4. Atmospheric composition and conditions

Forest ecosystem may affect climate at local, regional and national scale. Lakes and rivers affect climate through exchange of heat and water with the atmosphere (Krinner 2003). Inland waters regulate local temperatures by absorbing heat in summer time and releasing it in winter, in summer humidify the atmosphere, and may shape the precipitations pattern of. (Hardin and Jensen 2007, (Reynaud et al., 2010).

5. Water Supply

Forests can decrease or increase groundwater recharge. Forest cover can lower groundwater recharge due to precipitation interception by forest canopy and subsequent return to the atmosphere through evapotranspiration. Yet, according to Falkenmark et al. (1999), forest canopy removal may result in a soil surface crusting reducing or preventing water infiltration and groundwater recharge.

6. Aquatic Productivity

The condition of adjacent or upstream watersheds affect the condition and quality of fisheries which is important for fishery management and the tourism-related industry (Johnson et al., 2001).

2.2 Capitalization and sustainability of forest ecosystem services

Natural capital and especially forest areas includes conventional resources as the source of raw material, land, and energy inputs to the economy- fossils fuels, mineral, metals. However, forest areas include also ecosystems that through their natural functioning and habitats provide essential goods and services to the economy. Barbier (2007) suggested that these benefits are wide-ranging, which in economics would normally be classified under three different categories:

(i) “goods” (i.e. products, such as resource wood, water and genetic material),
(ii) “services” (e.g., ecological regulatory and habitat functions, - water purification, climate regulation, erosion control and habitat provision), and
(iii) cultural benefits (e.g., religious beliefs, heritage and cultural values).

Some of these forest ecosystem goods and services contribute directly to human well-being, but some forest services, either on their own or combined with human inputs, also contribute indirectly to human welfare by supporting economic production (Tallis et al., 2012). As a result, forest ecosystem services are often undervalued and in economic jargon, there is a ‘market failure’. With no information on forest ecosystem services value it is likely that their values will be omitted in policy development and decision making (Perman et al., 2011). Given the crucial role of forest ecosystem services is now common sense that forest ecosystems are "valuable" and that decision-makers ranging from individuals to governments should consider this (Daily, 1997). There are two main reasons for this increasing demand to value natural capital;

- Firstly the sustainability that requires the correct account of capital depreciation and, the valuation of natural capital changes.
- Secondly, the need to discover one of the main components of social wealth or to help adequately plan changes in land use (Azqueta and Sotelsek, 2007).

Economic and non-economic valuation of forest ecosystem services is not only an approach for underpinning forest ecosystem services significance for human wellbeing. Furthermore, valuation is useful in sustainability analyses and actions prioritization, efficient allocation of finite resources when the demand exceeds the supply, avoiding unsustainable overuse and degradation of the resource (Kosenius et al., 2013). According to integrated Water Resources Management (IWRM), forest ecosystem services- undervaluation, led to their over-exploitation and wide spread environmental degradation (Carlos and Mesa-jurado, 2017)

Overall, the economic valuation of natural capital and forest ecosystem services is broadly acknowledged as crucial to better advising decision-making and policy instruments designed towards the sustainable management and conservation of natural resources (de Groot et all., 2012; de Groot et all., 2010; Pascual et all., 2010; Rode et all., 2016), to facilitate communication of the biophysical underpinning of ecosystems for services provision in monetary units (Costanza et all., 2014) and to enable an environmental awareness-improvement in support of conservation and protection of ecosystems through showing hidden benefits of ecosystems for society (Kumar et all., 2013; Grizzetti et al., 2016), among others.

2.3 Economic value and forest ecosystem services management

Climate change impacts have increased pressure on forest areas to deliver more and more. The MEA and the TEEB Study have highlighted the importance of healthy forest ecosystems to meet society's growing demands both in terms of quality and quantity of the services delivered.

Multi-functional assets of forest s take a major role for securing public well-being into the future. The sustainable forest management model of balancing economic, social and environmental values aims to prevent degradation and maintain the provision of forest services.

The current state could be framed accordingly:

1. The overall demand for forest ecosystem services is increasing
2. Due to the dynamic nature of forest ecosystems, changes occur in their extent, state and condition, affecting the ability to provide services
3. The willingness or desire to pay for the work to secure the sustainability of ecosystem services is not being offered.
4. There is little information for the costs of providing those goods and services, nor is there a precedent or a designated responsibility for paying for them.

As a result there is no market-based incentive to support the necessary management activity targeting forest ecosystems services (EUSTAFOR and Patterson, 2011).

The welfares associated with many forest ecosystem services are often not formally accounted in forest management costs or project-level planning and analysis. In turn this burdens management plans to contribute for sustainable ecosystem services. The TEEB studies concludes that sustainable maintenance (and restoration if needed) of forest areas is more cost effective than developing (from scratch) areas for providing these services via man-made processes. The differences are often only seen when the full life-cycle costs are accounted for. Ultimately to balance the use with the source of ESs, new techniques to describe the accounting to contribute more to ecosystem services and to be innovative in offering products and services need to be adopted (Figure 1) (EUSTAFOR and Patterson, 2011).

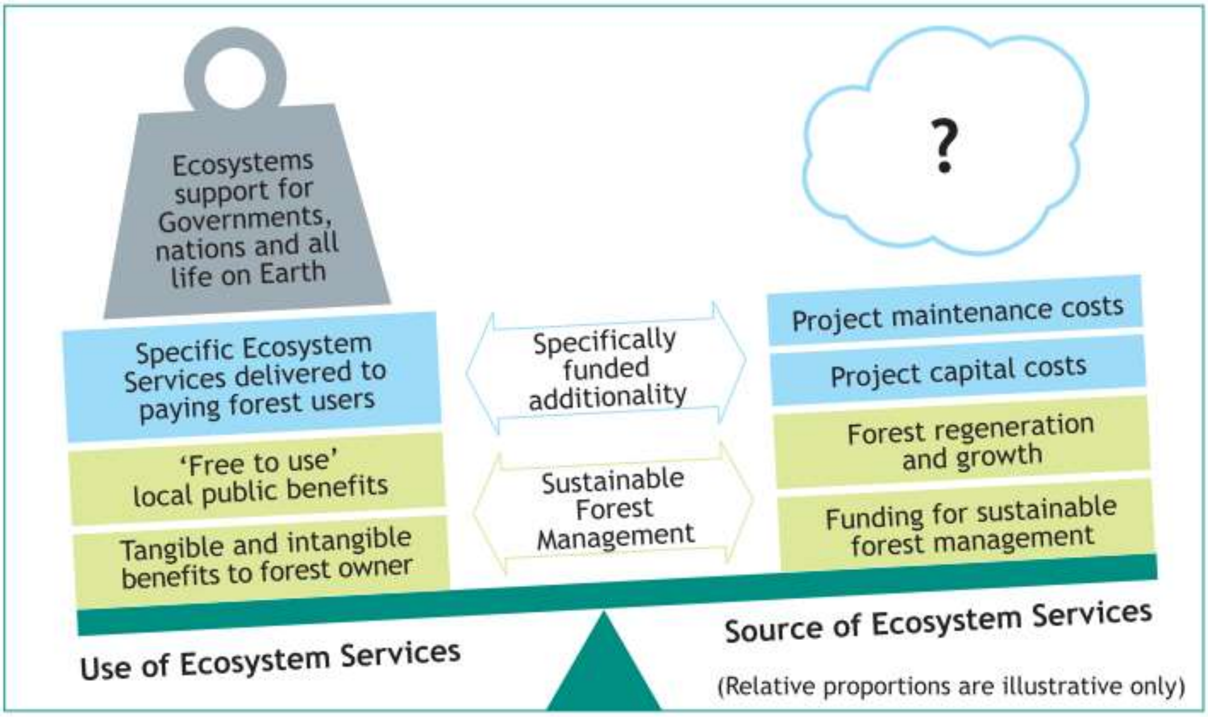

Figure 1 Balancing ecosystem service delivery from forests. Source: (EUSTAFOR and Patterson, 2011)

3 REVIEW AND ANALYSIS

3.1 Typology of capitalization mechanisms for forest ecosystem services

3.1.1 Total Economic Value

The concept of Total Economic Value (TEV), including use and non-use values of (forest) ecosystem is used for identifying the different types of value that an ecosystem provides and describe the comprehensive set of values derived from it (Burkhard and Maes, 2017). **The "total" in TEV refers to the aggregation of different sources of value rather than the sum of all values derived from a resource**. Accordingly, "total" make a comprehensive view of sources of value.

Figure 2 represent the components of TEV.

Use values are the benefits derived through the physical use of the forest resource, where humans make use of an ecosystem service. This can be in the form of consumptive use which derive from on-site extraction of resources (e.g. food, timber, fuel wood) and non-consumptive use, which is the use of the services without extracting any elements from the ecosystem (e.g. recreation, landscape amenity). Indirect use values are derived from off-site services that are related to the resource (e.g. downstream flood control, climate regulation). Option value are the value that people place on having the option to use a resource in the future even if they are not current users (i.e. a protected area where people will not visit in the near future but they are willing to pay to keep this option alive in the future. For forest ecosystems services, option value describes the value placed on maintenance for possible future use of forest ecosystems, species and habitats (some of them still be unknown). These activities can be traded on a market (e.g. timber) or can be non-marketable i.e. there is no formal market on which they are traded (e.g. recreation or the inspiration people find in directly experiencing nature).

Non-use values may be related to

a) altruism (maintaining a forest ecosystem for others) attached values to the availability of the ecosystem resource to others in the current generation,

b) bequest (for future generations) where individuals attach values from the fact that the forest ecosystem resource will be passed on to future generations and existence (preservation unrelated to any human use) motivations and

c) existence value: derived from the existence of a forest ecosystem resource, even though an individual has no actual or planned use of it (Defra, 2007).

Non-use values are derived from the knowledge that a forest ecosystem is maintained without regard to any current or future personal use.

Various methods are used for quantifying forest ecosystem services economic value. These valuation methods try to address the complexity of the natural environment. These methods can be distinguished between methods generating new or original information **(primary valuation methods**) and those that use existing information in new policy contexts (**value transfer methods**).

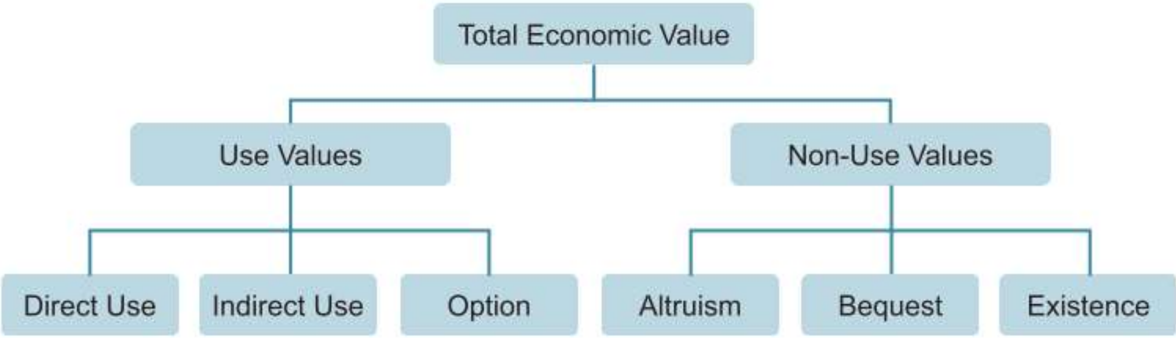

Figure 2 The components of Total Economic Value. Source: (Burkhard and Maes, 2017)

Table 1 provides an overview of primary valuation methods, typical applications and limitations and indicates which primary valuation methods can be used to value which ecosystem service.

Table 1 Primary valuation methods. Source: (Burkhard and Maes, 2017)

Valuation method	Approach	Application to FES	Example forest ecosystem service
Market prices	Prices for ES that are directly observed in markets	FES that are traded directly in markets.	Timber and fuel wood from forests; Recreation at national parks that charge an entrance fee.
Public pricing	Public expenditure or monetary incentives (taxes/subsidies) for ES as an indicator of value.	FES for which there are public expenditures	Watershed protection to provide drinking water; Purchase of land for protected areas
Defensive expenditure	Expenditure on protection of ecosystems	FES from protected ecosystems	Nutrient filtration by protected wetlands
Replacement cost	Estimate the cost of replacing an ES with a man-made service.	FES that have a man-made equivalent.	Water storage and filtration by forests.
Restoration cost	Estimate cost of restoring degraded ecosystems to ensure provision of ES	Any FES that can be provided by restored ecosystems.	Water storage and filtration by forests.
Damage cost avoided	Estimate damage avoided due to ecosystem service	Ecosystems that provide storm or flood protection to houses or other assets.	River flow control by forest
Net factor income	Revenue from sales of environment-related good mi- nus cost of other inputs	Ecosystems that provide an input in the production of marketed goods.	Filtration of water by forest
Production function	Statistical estimation of production function for marketed goods including an ES input	Ecosystems that provide an input in the production of marketed goods	Soil quality or water quality as an input to forest production

Hedonic pricing	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	Air quality
Travel cost	Use data on travel costs and visit rates to estimate demand for recreation sites.	Recreation sites	Outdoor open access recreation.
Contingent valuation	Ask people to state their willingness to pay for an ES through surveys	All FES	Species loss; natural areas; air quality; water quality landscape aesthetics.
Choice modelling	Ask people to make trade-offs between ES and other goods to elicit willingness to pay	All FES	Species loss; natural areas; air quality; water quality landscape aesthetics.
Group / participatory valuation	Ask groups of stakeholders to state their willingness to pay for an ES through group discussion	All FES	Species loss; natural areas; air quality; water quality landscape aesthetics.

3.1.2 Value transfer methods

Value transfer is the use of research results from existing primary studies at one or more sites or policy contexts ("study sites") to predict welfare estimates or related information for other sites or policy contexts ("policy sites") with similar characteristics (Burkhard and Maes, 2017; Richardson et al., 2014; Wilson and Hoehn, 2006). According to Häyhä et al., (2015) the validity and reliability of the transferred value is related to the the adequacy of existing studies).

Value transfer is also known as benefit transfer but since the values that are transferred may be costs as well as benefits, the term value transfer is more generally applicable. Value transfer can possibly be used for any forest ecosystem service valuation, only if the estimates are primary valuations of the original forest ecosystem service.

Table 2 Value transfer methods. Source:(Burkhard and Maes, 2017)

	Approach	Strengths	Weaknesses
Unit value transfer	Select appropriate values from existing primary valuation studies for similar ecosystems and socio-economic contexts. Adjust unit values to reflect differences between study and policy sites (usually for income and price levels)	Simple	Unlikely to be able to account for all factors that determine differences in values between study and policy sites. Value information for highly similar sites is rarely available
Value function transfer	Use a value function derived from a primary valuation study	Allows differences between study and policy sites to be controlled for (e.g.	Requires detailed information on the

	to estimate ES values at policy site(s)	differences in population characteristics)	characteristics of policy site(s).
Meta-analytic function transfer	Use a value function estimated from the results of multiple primary studies to estimate ES values at policy site(s).	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics, area of ecosystem, abundance of substitutes etc.). Practical for consistently valuing large numbers of policy sites.	Requires detailed information on the characteristics of policy site(s). Analytically complex.

3.1.3 Primary valuation methods

Methods for valuing ecosystem services vary depending on the nature of the service, and belong to two main categories namely **revealed preference** and **stated preference methods** (Hackbart et al., 2017).

Revealed-preference methods exploit the actual choices people make within markets, including damage cost avoidance, travel cost, replacement cost, market price hedonic pricing and production function.

Stated preference methods are based on survey questions where people explicitly or implicitly state their preferences and values for specific goods including contingent value and discrete choices.

The choice of valuation method is related to the context and ecosystem services targeted i.e.:

- Stated preference techniques can be hypothetically used to any forest ecosystem service type valuation. However, cognitive limitations to stating preferences may exist (Reynaud and Lanzanova, 2017). Specific to water related forest ecosystem services, flow regulation or run-off processes can be evaluated, by their impact on the maintenance of base flows during rainless periods for drinking water or recreation, the attenuation of flood peaks and associated reductions in damages to property and life or the retention of nutrients and sediment to reduce costs at a water-treatment plant (Guswa et al., 2014).
- Revealed preference are not appropriate to estimate nonuse values

3.1.3.1 Replacement cost method

Replacement cost method estimates the costs incurred by replacing forest ecosystem services with man-made technological solutions. When uncertainties exist, the method should be used with caution (Pascal et al., 2010), under these assumptions (Notaro and Paletto, 2012):

(a) The man-made technological solutions it is a close substitute and has the same functionality as the original ecosystem,

(b) The man-made technological solutions is the least costly alternative for the forest ecosystem service, and

(c) There is a public demand for this alternative, meaning that people would be willing to pay the costs instead of losing the service.

3.1.3.2 Contingent valuation

Contingent valuation relies on surveys. Through these surveys, people state the amount that they would be willing to pay for specific forest services, rather than inferring them from observed behaviours in regular market places (Bateman and Willis, 1995).

The strong point of contingent valuation is the capability to estimate in money terms non-use values of forest ecosystem services (not containing market purchases or direct input).

The weak point of this method is that especially in the case of regulating services, the public have not always knowledge's about ecosystem functions and services and, moreover, the complexity of the issue makes the survey description very difficult (Nunes and van den Bergh, 2001). Also people not used to pay for a certain service in the past, they could be unwilling to understand the need to pay for it at present. Also, the responders of the survey can overemphasize the willingness-to-pay because they do not need to actually pay (Riera et al., 2012).

3.1.4 Payments for ecosystem services

The most common definition of Payments for Ecosystem Services (PES) draws from Wunder (2005): "a voluntary transaction where a well-defined service (or a land-use likely to secure that service) is being 'bought' by a (minimum of one) ES buyer from a (minimum of one) ES provider if and only if the ES provider secures ES provision (conditionality)." Pure PES, according to this definition, are only possible when agreements are made between private entities. In some cases, however, inclusion of government institutions leads to the development of a mixed agreement, a PES-like scheme (Wunder et al. 2008) characterised by inclusion of a mediator, a guarantor, a seller and a buyer. PES schemes are also characterised by the duration of the contract and presence of a monitoring system that secures ES provision (Gaglioppa and Marino, 2016).

PES schemes which have emerged in recent decades, mainly in developing countries, market-based mechanisms encourage the conservation of natural and forest resources. Most of the time, the provider (e.g. forest owners and managers) get paid by the buyer of services (e.g. water users or a hydropower company) to maintain forest ecosystem services with the state often acting as an intermediary between the two parties or paying on behalf of its citizens, who are the indirect beneficiaries (Chaudhary, 2017). The payment may be monetary or exchange and is intended to cover or compensate the costs of service provision (Salzman, 2010).

The PES design challenge is how most efficiently to transfer both types of information—

(1) willingness to pay/accept, and

(2) service provision resulting from a land use change—from one party to another in a mutually rein- forcing fashion.

Not all of forest ecosystem services are subject to PES and payments focus around four types of forest ecosystem services (Salzman 2010).

- ✓ watershed protection

- ✓ carbon sequestration
- ✓ biodiversity conservation
- ✓ landscape amenities

Most commonly PES is involved in water related services (Landell-Mills and Porras 2002).

The strengths of involving PES for water services are (Salzman 2009):

- easy identification of providers and the users
- The users are discrete (e.g., private operations such as hydroelectric facilities and industrial users) or institutions that represent groups of users such as municipal water authorities (who act on behalf of the public) or irrigation districts (who act on behalf of the irrigation farmers).
- All of these parties have an obvious and direct interest in service provision.
- The beneficiaries, particularly water users, are used to pay for such services already (Landell-Mills and Porras 2002).

Different stakeholders involved by PES on water can be discriminated based on the demand and provision of the water service (CRPF PACA, 2012):

The users of water-related forest ecosystem services include:

- Public bodies which are responsible to supply the water;
- Clear-water consumers (families, etc);
- Irrigation related;
- Water companies;
- Dam managers;
- Other industrial companies using water;
- People from areas threatened by floods (neighbourhoods associations, municipalities);

The providers of the water service (those who are likely to receive compensation or a payment include:

- Owners of forest areas
- Managers of forest areas

3.1.5 Water funds

Water funds are innovative benefit-sharing mechanisms in which water users such as hydropower, municipal water companies, and private industries provide funding and payments to be invested in forest ecosystem service maintenance and improvement. Benefit-sharing mechanisms go beyond payments for ecosystem services since they can include any form of better sharing the benefits of ecosystem services, which may or may not include a return payment.

Water funds have an institutional framework composed of key stakeholders who prioritize the use of payments that, at least in part, go towards conservation management of the watershed. The trust fund of a water fund acts as both a means to finance conservation projects and as reserve fund. The trust is a long-term, sustainable investment (Goldman-Benner et al., 2012). Water funds accumulate money in a trust fund, the interest from which finances conservation.

3.1.6 *Economic assessment of the water-related forest ecosystem services provided by the forest*

Within the framework of TEV (Figure 3) and the methods presented in the previous section some diverse methods, used to assess the value of the services offered to the water by forest could be highlighted (CRPF PACA, 2012)..

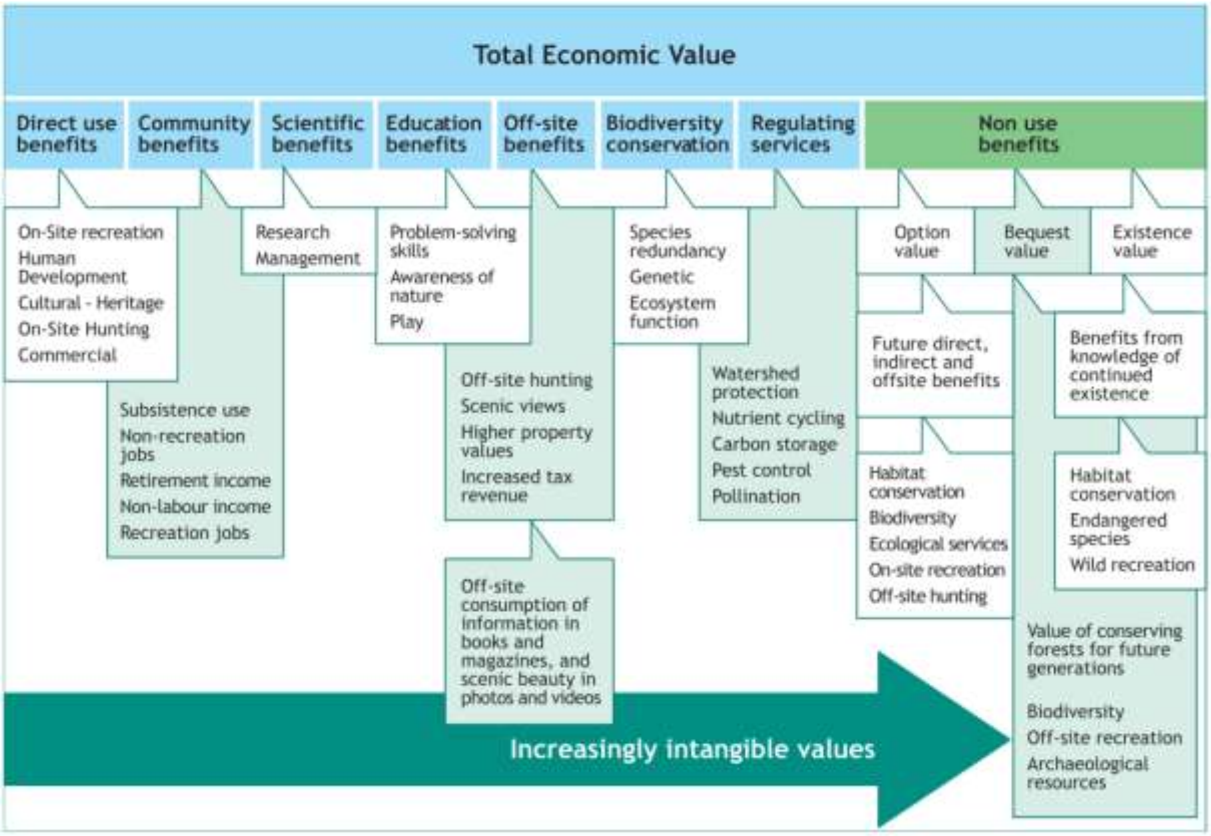

Figure 3 The components of the total economic value of a forest. Source: Value (Eustafor and Patterson, 2011)

1. **Protection costs method**: use for prevention or repair of an environmental damage.
2. **Opportunity cost**: use of water rather than some other economic activity (CRPF PACA, 2012).
3. **Replacement costs**: the cost to develop alternative water sources.
4. **Willingness-to-pay** for marginal increases in security of supply, enhanced water quality, reductions in interruptions to supply, etc. due to forests.

3.2 Actions, plans and mechanisms ensuring sustainability of regulating services related to water

3.2.1 *Protective effect of forest vegetation*

The protective effect of the forest depends mainly on the forest species and the forest silvicultural management form.

The protective significance of the evergreen forests is higher than that of deciduous forests. This is because the leaves keep rainwater in their canopy throughout the year and thus permanently prevent the rains from reaching the ground immediately and causing erosion. In the Mediterranean countries, (i.e. Greece), where rainfall occurs mainly in the autumn, winter and spring, while in the summer usually is characterized by drought, evergreen forests have a very good protective effect. In contrast, in Middle Europe, where the main volume of rain falls during the summer, the deciduous species offer a fairly good protective effect (Kotoulas 2001).

Coppice forests, such as the chestnut tree, the oak, etc. have little protective effect. The reasons are as follows:

- ✓ they have a moderate overground volume, so they retain a small amount of water, which is intensified, especially when they are composed of deciduous species
- ✓ their soil is exposed due to short rotation time (8 to 25 years), therefore, it can not acquire significant porocity volume and high permeability,
- ✓ and the voids in the soil they cause is limited to the surface soil layers.

High, even-aged forests have a greater protective effect compared to the corresponding coppice because they are more bulky and never leave the underlying soil uncovered. But these offer a relatively limited protective effect, because they cannot eliminate the impact force of the floodplains falling from their canopy, which is usually located at a considerable height.

High forests and in particular of uneven age, resulting from single-tree selection, have the greatest possible protective effect. This is because the thickness of their canopy is greater than that of all other forms of forest. The mass of the trees occupies all the space from the ground where the tree saplings and seedlings are located to the top of the highest trees. The amount of water retained by their canopy is greater than that of any other form. Rain drops can never reach the ground directly, especially if the forest is properly managed, and the compaction and clogging of the soil from their fall is limited because they fall from a low height and at a reduced speed(Kotoulas 2001)..

High forest also ensures the existence of a sufficient canopy leaf areas, which with its elasticity neutralizes the impact of the drops. Thus, the surface soil of normal, high forests has larger pores than other types of forest managment. The protective role of forestry species is determined, among other factors, by their botanical and forestry properties. In general, more advantages exist(Kotoulas 2001).:

- evergreen in contrast to deciduous species, especially in the Mediterranean countries, because the rain falls on them in the autumn, winter and spring,
- shade tolerant in contrast to the light-demanding species, because the latter form a sparse canopy, therefore it is characterized of many gaps and does not maintain/protect the soil permanently
- deep rooted in contrast to shallow rooted species because they contributed in larger porous and well-aerated root zones densely and deeply, especially when mixed with shallow rooted species species and
- -needle-like (conifers) in contrast to broadleaves species because they retain more water in their canopy.

The broadleaves canopy is more compact, not facilitating the movement of water inside it, as is the case with the coniferous canopy. However, needle-like forests also sustain a higher risk of fires. For this reason, mixed needle-like and broad-leaved forests, especially deciduous, with a ratio of the latter in the mix to 0.2 to 0.3, are better, because they improve soil and are less flammable(Kotoulas 2001)..

Hydrogeonomic vegetation types

The hydrogeonomic effect of the natural and anthropogenic vegetation (crops) in the mountainous watersheds currents varies according to the species, structure and structure of the vegetation cover.

To estimate its hydrogeonomic value, vegetation can be classified into hydrogeonomic types, which are evaluated using the hydrogeonomic coefficient. Hydrogeonomic types provide a general assessment of the hydrogeonomic status prevailing in drainage basins. The assessment provided with this classification is certainly broad, but it provides sufficient guidelines both for detecting torrents generating sediments and flooding, as well as in estimating deviation in the basin runoff from normal hydrogeonomic conditions (Kotoulas 2001).

Table 3 provides the predominant hydrogeonomic types and their respective hydrogeonomic coefficients, as given by Greek Ministry of Agriculture's (1978).

Table 3 Redominant hydrogeonomic types and their respective hydrogeonomic coefficients. Source: Greek Ministry of Agriculture's (1978).

	Characteristics of vegetation type	Hydrogeonomic coefficient
1	**Forests (Irrespective of soil or slope)**	
	Forests densely vegetated (crown closure more than 0.7, no indication of soil erosion)	0,9-1,0
	Forests sparsely vegetated (crown closure 0.3-0.7, with full density of shrubs or grassland understory with a slight indication of erosion or no soil erosion)	0,7-0,8
	Forests sparsely vegetated (with sparse, shrubs or grassland understory and erosion moderate to intense, i.e. loss of surface soil horizon 25-50%)	0,4-0,6
2	Shrublands (Irrespective of soil or slope)	
	Shrubs Dense (Evergreen broadleaves without soil erosion)	0,8-0,9
	Shrubs Sparse with moderate (25%) to intense (50%) erosion and loss of surface area horizon	0,4-0,6
3	**Grasslands**	
	Grasslands with normal density (no indication of soil erosion)	0,8-0,9
	Grasslands with sparse density (0.3 - 0.7) with moderate to intense erosion and loss (25-75%) of surface horizon.	0,3-0,6
4	Areas fully deforested which are wide erosion generating surfaces with loss of surface soil.	0,0
5	**Non-natural vegetation (agricultural crops).** To determine the hydrogeonomic factor the slope of the surface should be considered	
	Horizontal or almost horizontal terrain	1,0

All kinds of crops with terrace	0,6-0,9
Fields covered with perrenial crops (regardless of inclination)	0,8-0,9
Fields of grains without soil gradient	0,2-0,5
Tree cultivations with no terrace	0,4-0,6

3.2.2 Water regulation through forest vegetation

Forests ecosystems have the potential to regulate water flow, safeguarding the supply of a sufficient water quantity whilst avoiding extreme fluctuations in water flow (Burkhard and Maes, 2017).

Water regulation has various components:

1. The forest landscape should naturally retain and store an adequate amount of water for its needs, limiting also amount. Excess surface run- off of may result to flooding.
2. Several parameters (Figure 4) contribute to water regulation within forest ecosystems (Burkhard and Maes, 2017) can be characterized as forest landscape storage factors
   - interception by vegetation,
   - storage in surface water bodies,
   - infiltration and retention in soil and
   - percolation to groundwater stores.
3. Also water regulation will also be affected by parameters that can be characterized as physical factors (Figure 4):
   - the slope of the landscape
   - the degree of permeability of the soil.

Steeper slopes will promote faster surface runoff, whilst flatter areas allow greater time for infiltration of water. Impermeable surfaces (e.g. artificial infrastructure such as roads and buildings) represent a barrier to the infiltration and retention of water, thus promoting surface runoff (Burkhard and Maes, 2017).

The above parameters are combined to an indicator representing relative landscape water retention (capacity of the ecosystem to provide water regulation) (Burkhard and Maes, 2017).

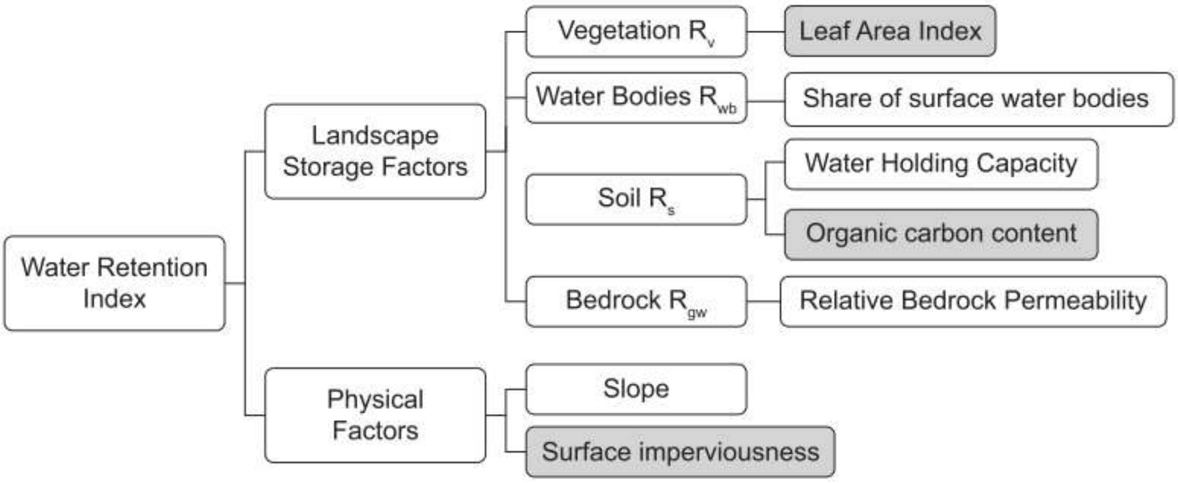

Figure 4 Schematic overview of the structure of the indicator for mapping water retention. Parameters in grey are dynamic and thus change over time. Source (Burkhard and Maes, 2017)

3.2.2.1 *Roles of forest in maintaining water cycle*

The role of forests in the water cycle is to add water to the atmosphere through the process of transpiration (in which plants release water from their leaves during photosynthesis). This moisture contributes to the formation of rain clouds, which release the water back into the forest (Figure 6). When forests are cut down, less moisture goes into the atmosphere and rainfall declines, sometimes leading to drought. Forests are a vital constituent of the global water cycle, as they have a high evaporation rate, contributing to atmospheric moisture circulation. Aragão (2012) reported that the forest canopy recycles water more efficiently through evapotranspiration than sparsely vegetated surfaces such as crop fields. Evapotranspiration is the combination of evaporation and transpiration from vegetation to the atmosphere.

Direct evaporation occurs from water standing on the soil surface or in the interstices of the soil. Rates of evaporation are greatest at or near the surface and decrease rapidly with depth, (www.fao.org). The total volume of water removed by transpiration depends upon several inter related factors: the volume of water available in soil storage, the depth and completeness of root systems, and the hydrologic depth of the soil. Transpiration may be decidedly limited if the root systems are restricted by low density of vegetation, or by a shallow hydrologic depth of the soil (www.fao.org).

Transpiration naturally decreases with reductions in vegetation density, and evaporation tends to increase. Wilm and Dunford in Colorado (U.S.A., 1948) observed that in shallow soils the sum of evaporation and transpiration tend to remain constant even with variations in the density of vegetation. Moreover, the removal of vegetation reduces evapotranspiration and increases water yield to a pronounced degree (Hoover, 1944).

Polster (1950) pointed out, the species with highest transpiration rates are those with the least dense canopies, and the combination of transpiration per unit leaf weight with canopy weight per unit forest area gives estimates of the transpiration of forest stands that do not vary mush between species, except that *Pinus Silvestris* is lower than the other species (Koziowski 1969)

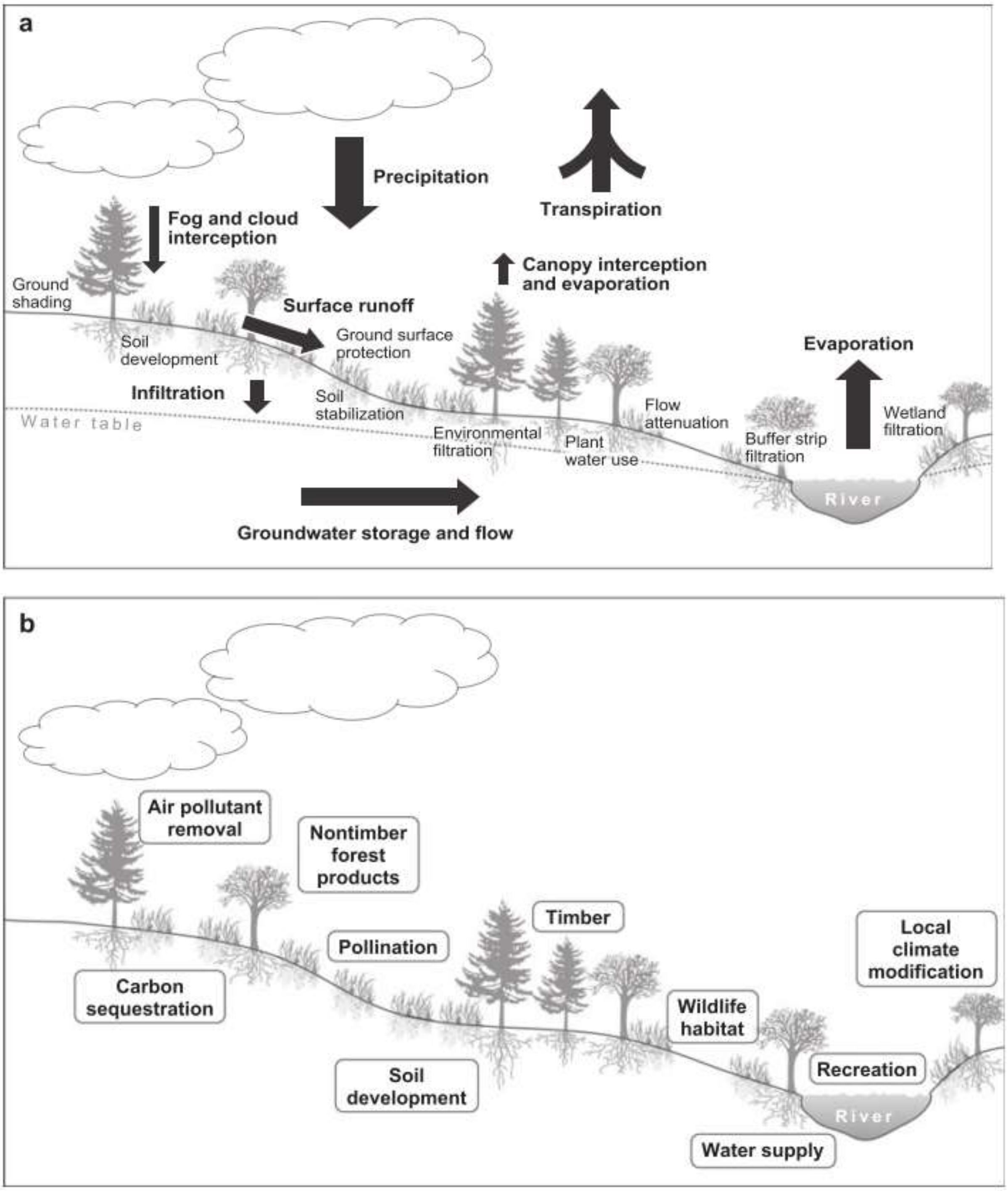

Figure 5 Water cycle-ecosystem interactions Source: (Brauman et al., 2007)

Figure 5 present water cycle ecosystem interaction (Brauman et al., 2007):

1.Local climate interactions, water use by plants, ground surface modification, and water quality modification are all influences of ecosystems to water cycle.

2.Sun provides energy for the hydrologic cycle

3. Evaporated water vapor forms clouds. Then it falls on earth as rain or snow.

4. Subsequently, water infiltrates into ground or flows over the soil.

5. Water (ground or surface) discharge into the water bodies.

6. Then step (3) is once again active.

7. Meanwhile ecosystem services are provided (Figure 5b)

Table 4 Daily transpiration of leaves and stands Source: (Koziowski 1969)

Forest species	Weight of foliage (kgr/ha $^{-1}$)	Daily transpiration of leaves (gm/gm $^{-1}$ fresh wt)	Daily transpiration of stands (mm)
Birch	4.94	9.5	4.7
Beech	7.9	4.83	3.8
Larch	13.95	3.24	4.7
Pine	12.55	1.88	2.35
Spruce	31.00	1.39	4.3
Douglas fir	40.00	1.33	5.3

3.2.2.2 Water flow regulation

- Water flow regulation involves the influence of natural systems and in particular of forests on the regulation of hydrological flows at the earth's surface (de Groot et al., 2002). Forest areas can regulate in various ways surface and groundwater flow.
- Flooding and landslides have been widely linked to deforestation followed and urban development (Johnson et al., 2001).
- Forest vegetation takes up water and delays the time to soil saturation.
- Forest soils also usually have a higher water storage capacity than non-forest soils (Falkenmark et al. 1999).
- Forests slow the rate of runoff, minimizing flooding and increasing minimum stream flows during the dry periods (Johnson et al., 2001).
- Forests reduce the total annual water flow in a watershed and reduce the total annual stream-flow (Calder 1998).
- Trees consume more water than other types of vegetation, including grasses and annual crops.
- The degree to which forests reduce stream-flow, however, depends on various factors such as age and depth of the root. For example, shallow-rooted trees tend to use less water than deep-rooted trees. Young regenerating forests tend to use much more water than mature and old growth forests (Johnson et al., 2001).

The ability of a catchment to regulate the flow is directly related to the volume of water that is retained or stored in the soil and groundwater (Onaindia et al., 2013).

The water flow regulation service (WC) is calculated as follows (Onaindia et al., 2013)

$$WC = {}^{Hu}/_{R}$$

$$R = P - ETc$$

where WC is the water flow regulation, Hu is the water storage in the soil (mm year^{-1}), R is the annual water flow (mm year^{-1}), P is the annual rainfall (mm year^{-1}), and ETc. is the corrected annual potential evapotranspiration (mm year^{-1}).

3.2.2.3 Regulation of the chemical condition of freshwaters

In comparison with the other uses, the forest environment is the best one for water quapurification. The concept of this service is straight forward: water that runs off or seeps through forests and other natural ecosystems tends to be less contaminated than water discharged by agricultural, urban, or industrial landscapes; hence, it requires less costly treatment before it is fit to drink. http://water.epa.gov/learn/kids/ drinkingwater/watertreatmentplant_index.cfm) (Vincent et al., 2016). Run-off from city streets and agricultural fields contain various pollutants such as oil, pesticides, and fertilizer as well as excess soil. Forest soils are more waterlogged than other soils (except wetlands) and contain more nutrients, allowing them to filter out pollutants (Falkenmark et al. 1999). The pollutants are absorbed by the plants and broken down by plants and bacteria to less harmful substances. Pollutants attached to suspended soil particles are filtered out by grasses and other plants and deposited in lakes. This process helps improve water quality (Reynaud et al., 2010). Different forest parameters can influence water quality (CRPF PACA, 2012). In example there is evidence that broad-leaved stands are more efficient for lower nitrate concentration. This is likely due to the lower leaves surface of deciduous leaves and the lower filtration of atmospheric pollutions, thw lower interception of deciduous stands, the highest capacity of azotes in the humus for deciduous stands and the larger roots network absorbing more chemical elements (CRPF PACA, 2012). Also older trees have a slow growth, implying lower absorption from roots and ionic exchanges and thus less filtering (Hegg, 2006*).* Of course the impact of the forest stands and the response ability depends on water depth since surface water are more prone to pollution compared to underground water (Charnet, 2010)

3.2.2.4 Attenuation of mass movement

Forests reduce soil erosion and sedimentation of waterways. Interception of rain and snowfall by forest canopies means that less water falls on the ground compared to a deforested watershed, reducing soil disturbance. Leaves and natural debris on the forest floor can slow the rate of water runoff and trap soil washing away from nearby fields. Understory forest vegetation and leaf litter protect the soil from the impact of rain that does fall through the canopy (Falkenmark et al. 1999).

Extensive root systems help hold soil more firmly in place and resist landslides compared to clear-cut or heavily disturbed watersheds. Its roots deepen and improve the soil, and the shade it provides facilitates ecosystem metabolism. These functions are essential for ensuring the soil stability and the continuity of agricultural activities.

Sedimentation levels in waterways of forested watersheds are generally lower than in nearby agricultural or urbanized watersheds, but the degree depends on soil types, topography, and climate (Falkenmark et al. 1999).

Gray and Leiser (1982) provide a summary of the major effects of herbaceous, and to a lesser extent woody vegetation in minimizing erosion of surficial soils. They include (CRPF PACA, 2012):

- Interception – foliage and plant residues absorb rain fall energy and prevent soil compaction. Rainfall interception depends on season, environmental parameters such as rainfall intensity and duration, precipitation viscosity, and mechanical activity and plant specific characteristics such as leaf area and configuration (Ekhuemelo, 2016).
- Restraint – root systems physically bind or restrain soil particles while above-ground residues filter sediment out of run-off.
- Retardation – above-ground residues increase surface roughness and slows run-off velocity.
- Infiltration – roots and plant residues help maintain soil porosity and permeability.
- Transpiration – depletion of soil moisture by plants delays onset of saturation and run-off.

3.2.2.5 Climate regulation service

Forests play an essential role in regulating fluxes of atmospheric moisture and rainfall patterns. The process of Earth's land releasing water vapor to the atmosphere is aided by forests and other vegetation through evapotranspiration. The resulting atmospheric moisture through the "precipitation recycling" can under the appropriate circumstances, promote and intensify the redistribution of water across terrestrial surfaces.

- Forest vegetation is known to affect local climate.
- The fluctuations of temperature are smaller (i.e. max is lowered and minimum is raised).
- Relative humidity is slightly increased.
- Wind velocities are usually reduced.

These are generally beneficial influences, especially in and regions. But of greater interest to the watershed land manager is the influence of forests upon local precipitation, runoff, soil movement, and water losses (www.fao.org).

While few studies provide evidence that extended deforestation can reduce rainfall (i.e. in China) and lead to a drier climate (i.e. in Amazonia and Central Africa) (Xue 1994), afforestation should not be considered as an effective strategy to increase rainfall and affect climate regional and national climate patterns (Kaimowitz 2000).

3.2.2.6 Water Supply

In general, in forests rainfall is intercepted and absorbed into the ground. Only a relatively small amount of water flows from the surface especially in times of heavy rainfall. Some studies have shown that tree growth can reduce the ground water available for agricultural irrigation but in general, forest cover is beneficial to ground and surface water (EUSTAFOR and Patterson, 2011).

Forests with different types of trees vary in their capacity for water interception and transpiration.

- Deciduous trees are species that shed their leaves when conditions are unfavorable (such as too cold, not enough water, etc.). Deciduous trees (i.e oak, beech) allow more rain to percolate into the soil (rather than into roots and through the leaves into the air) and eventually flow downstream because deciduous trees transpire much less during their dormant seasons.

- Evergreen trees (like pines) have been shown to have higher annual evapotranspiration and therefore reduce stream flows.

3.2.2.7 Aquatic Productivity

Forest plays an important and complex role in sustaining aquatic productivity. Trees shade waterways and moderate water temperatures. Woody debris provides fish with habitat while leaves and decaying wood provide nutrients to a wide array of aquatic organisms (Johnson et al., 2001)

Riparian forests have many influences on streams. They vary widely in species composition and stand structure They provide organic matter to streams, including nutritious detritus and decomposition products that partially support the aquatic food chain. They provide large wood that creates cover from predators and dams that reduce water velocity while creating pool habitat. One of the major functions of riparian forests is to minimize temperature fluctuations and increases in streams by providing shade (Bennett and Leonardi, 2017).

3.2.3 Forest management and water recourses

3.2.3.1 The role of forests in water ecosystem services

Forests play a pivotal role in the hydrological cycle by affecting rates of transpiration and evaporation, and influencing how water is routed and stored in a watershed." (Blumenfeld et all., 2009)

Forest management through the inherent multi-functional principles, has the ability to deliver water ecosystem services in a sustainable way. Forests and forest management play a vital role in protecting water quality, managing water resources for the quantity of all waters, flood alleviation, combating desertification and soil protection (CRPF PACA, 2012).

The role of forests in water ecosystem services mainly depends on:

(1) anaglyph and climate

(2) forest type

(3) LULC and forest management

(4) Demand from the beneficiaries (i.e. people).

Important is also the area of the forest in comparison to other LU and its location in relation to spatial heterogeneity of the other environmental factors (Martin-Ortega et al., 2015).

3.2.3.2 Forest management and water regulation

Established links in the literature between water and forests suggests that forest ecosystems can be managed to improve water provision. Many previous research in forest hydrology dealt with influence of various natural and anthropogenic practices to water quantity and quality (Bales et al., 2011).

Forest management (modifying composition and structure of the forest stands), can have a large impact on water regulation. Intact or well-managed natural forest cover can regulate permanent or seasonal stream flow, protect soil and lower stream sediment loads.

Forest vegetation can be managed to maximize sustainably provision of water-related forest ecosystem services, particularly in well-managed forests. In example when high net primary productivity, also increases evapotranspiration (causing water loss). Treatments reducing productivity (selective logging) reduces evapotranspiration and increase water availability (Bales et al., 2011).

Moreover, water consumption by forests varies among tree species (Figure 5). Previous studies have indicated that depending on forest tree species composition, vertical structure and biogeographical region of forests, coniferous usually consume more water compared to broadleaved forests due to higher interception and transpiration values (EEA, 2015).

Figure 6 Seasonal run-off coefficient vs. forest types by biogeographical region. Source (EEA, 2015).

Coniferous and broadleaved forests also differ in the net groundwater recharge. Forest management may enhance or reduce the quantity of groundwater recharge since replacement of conifer stands with mixed or broadleaved trees improves rainfall absorption and storage (EUSTAFOR and Patterson, 2011).

3.2.3.3 Afforestation Strategies with Respect to Forest–Water Interactions

Afforestation and reforestation are two forms of direct human-induced conversions of non-forest to forest land through planting, seeding, and/or anthropogenic dispersal of natural seed sources. (Bredemeier et al., 2011). Afforestation can improve regional water cycle by reducing run-off, flooding, and by increasing the control of groundwater recharge and watersheds protection. Nevertheless afforestation of grassland areas may reduce water flow and affect aquifer water level and recharge, (Jackson et al. 2005).

Water Yields

Following afforestation, flow reduction has been demonstrated (Farley et al. 2005; Jackson et al. 2005) (i.e. afforestation of grasslands and shrublands can result to one third loss of streamflow (Farley et al. 2005). Forest growth leads to an increase in the rates of interception and transpiration which results in a decreased recharge to the soils and decreased flows (Johnson 1998). In drier areas as such in the Mediterranean areas, low water flows are important for river flow regime in order to ensure water supplies for yearly services provision.

Main recommendations for good practices in forest management actions and measures close to water catchment in respect to water availability (CRPF PACA, 2012)

- Thinning can increase water yield
- Water consumption is also related to forest stand age, related to tree height, LAI, crown structure (Vanclay., 2009). Forest management can modify these parameters.
- Broad-leaved trees during winter characterized by frequent rains intercept less precipitation.
- Internal 'windbreaks' within a plantation could simulate the behavior of natural old-growth forest in respect to water yield.
- Water use of forest can be modified through the structure of the canopy and especially the upper canopy stratum that influences air exchange of trees with atmosphere. Even-aged plantations have a very different boundary layer than mixed-species and old-growth forests, and this is reflected in their water use.
- For afforestation species with less water consumption but equal productivity should be selected (Vanclay. 2010).

Water Quality

Dense, properly managed canopy cover contribute positively on water quality (Calder 2007). Water quality can be improved by afforestation as pollutants and erosion runoff from crop production are reduced (Pattanayak et al. 2005). Tree belts intercept and absorb surface runoff before it flows streams (Ellis et al. 2006).

Main recommendations for good practices in forest management actions and measures close to water catchment in respect to water quality (CRPF PACA, 2012):

- Reduce inputs of pollutants avoiding the use of fertilizer
- Avoid use of herbicide, preferring manual or mechanic treatments. - In case of pest, preferring biologic fight
- Favour the mixed stands
- Avoid log treatments with pesticides (Combe, 2006).
- Enforce biodegradable chain oils
- Avoid disturbing the soil with logging machine.
- Minimize thinning cuts on abrupt relief and avoid them on extended areas
- Use progressive logging of forest stands (bi-temporal for example)
- Favour species which have extended exploitability age (i.e. oak or beech) so that to reduce frequency of harvesting
- Favour natural regeneration so that to avoid exposed, bare areas

- Favour irregular diverse forest stands than a regular one. The more recommended forest type is the irregular one with quarters so that the cut surfaces are reduced and the forest covering is maintained.
- Avoid excessive road opening since it is a source of erosion. Special care should be taken close to rivers, wetlands or water catchments.
- Road tracks with a light slope and lined with a forestry covering are reducing the erosion risks.
- Organize well logging machine traffic on the site
- Limit thinning cut to reduce risks of a temporary raising of nitrates
- Avoid the soil working to reduce risks of a temporary raising of nitrates ϖ To maintain the forestry covering
- Limit the draining works to favor the filter role of the forest against pollutions
- Manage to maintain undergrowth which are good filters and good for nitrogen fixation,
- Regenerate regularly stands in order to increase filter role
- Avoid the use of logging machine to minimize soil compaction

3.2.3.4 Deforestation and flood mitigation

Deforestation alters the local hydrological cycle reducing evapotranspiration and likely decreasing rainfall (Spracklen et al., 2012). Deforestation also effect local climate, resulting in a decrease in heat released to the atmosphere. This impacts atmospheric circulation and its associated rainfall (Werth and Avissar 2005). Changes in rainfall patterns could result in droughts, especially in the dry season, negatively impacting agriculture and water availability (Ekhuemelo, 2016)

Main recommendations for good practices in forest management actions and measures close to water catchment in respect to flood mitigation (CRPF PACA, 2012)

- Favor stands which have higher LAI.
- Restrict practices that reduce forest soils ability f to infiltrate: such as grazing and road compaction.

3.2.4 Quantifying water services

3.2.4.1 Hydrologic models

To assess benefits of water related forest ecosystem services, these services need to be quantified and valued in way allowing monitoring of quantities or qualities of the ecosystem services (Thorsen et al., 2014). A major challenge in the valuation of water-related ecosystem services is that hydrologic knowledge should be incorporated. To support the ecosystem-service framework, such models are tools for providing hydrologic understanding. Hydrologic models incorporate and produce relevant information for decision makers at multiple spatial and temporal scales. Within the framework of ecosystem services, consider LULC and LUCC providing service valuation, based on biophysical response (Guswa et al., 2014).

3.2.4.2 Soil and Water Assessment Tool

The Soil Water Assessment Tool (SWAT) is a watershed-scale model developed to predict the impact of management on water, sediment, and agricultural chemical yields (Gassman et al. 2007). SWAT requires detailed spatial information on various environmental variables. The hydrological processes can be calibrated per sub- basin. The model inputs (Arnold et al., 1998) include the digital elevation model (DEM), land use, land cover, soil type, soil hydrological properties, time series of climate data, reservoirs, and land management. For calibration, the model requires a time series of water discharge and water quality data. Among the outputs, SWAT provides average daily flow, groundwater recharge, surface runoff, subsurface flow, concentration of sediments, and the amount of nitrogen, phosphorus and pesticides transported with water in each time step (day, month or year) (Arnold et al., 1998)

Overall, SWAT published model applications results indicated that SWAT can provide reasonable predictions of annual, monthly, and daily streamflow from forested watersheds (Beckers et al., 2009; Francesconi et al., 2016)

3.2.4.3 Integrated Valuation of Ecosystem Services and Tradeoffs

The Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model is applied in two initiatives (Natural Capital project and WAVES). InVEST is a spatially explicit tool consisting of a suite of models that use biophysical and economic data and relationships to estimate biophysical levels and economic values of ecosystem services (Acuna et al., 2014). The model runs in a gridded map at an annual average time step, and results can be reported in either biophysical or monetary terms, depending on the needs and the availability of data. Two kinds of outputs were obtained: rasters, providing information per cell, and tables, containing information at the basin or sub-basin level. InVEST user's guide can be consulted for further detail (Tallis et al., 2011)

3.2.4.4 Geospatial Regression Equation for European Nutrient losses

The Geospatial Regression Equation for European Nutrient losses (GREEN) model is a statistical model developed to estimate nitrogen and phosphorus fluxes to surface water in large river basins. The model was developed and used in European basins with different climatic and nutrient pressure conditions (Grizzetti et al., 2005) and was successfully applied to several European river basins (Grizzetti et al., 2008; Bouraoui et al., 2009a, 2009b). A description of the model GREEN is also provided in the La Notte et al., (2015) study.

GREEN considers two different pathways of nutrient transfer from sources to the catchment outlet. Diffuse sources (DS) that include fertilizers (artificial and manure), atmospheric deposition, and scattered dwellings, are first reduced in the soil and then partially retained in the streams. Point sources (PS), which include discharges from sewers, wastewater treatment plants, industries, and paved areas, are retained only in the streams (Grizzetti et al., 2008)

3.2.4.5 WaterWorld

WaterWorld (http://www.policysupport.org/waterworld) is a software tool that details process-based modelling of selected provisioning and regulating hydrological services. It incorporates high resolution spatial datasets for the entire world, spatial models for biophysical and socio-economic processes along with scenarios for climate, land use and economic change. The web-based tool examines the consequences of development actions through computer simulation, by highlighting their effectiveness and unintended consequences, both locally and downstream, before the options are tested on the ground. Typical applications include water resources assessment, water security analysis, land and water management, climate and land use change impact analysis, and hydrological ecosystem services accounting.

3.3 Policies for ecosystem services and capitalization

3.3.1 Water policies

3.3.1.1 Water Framework Directive 2000/60/EC

The **Water Framework Directive 2000/60/EC** (WFD) was adopted in the year 2000 and is an important piece of EU environmental legislation which aims at improving our water environment. It requires governments to take a new holistic approach to managing their waters which include rivers, lakes, groundwater, estuaries and coastal waters. Member States must aim to achieve Good Ecological Status in all waters by 2015 and must ensure that status does not deteriorate in any waters.

Water bodies are at risk from a number of different human activities such as discharges from waste water treatment plants, agriculture, urban development, abstraction, etc. Forestry has been identified as one of the key pressures on water bodies. Although contributing to the overall nutrient load in waters the amounts are low in comparison with other land uses. For example, agriculture contributes 33% to the phosphate load while forestry only 5%. Never-the-less, the fact that forestry is a potential risk to water bodies requires that it be taken into consideration in the management of catchments. In achieving Good Ecological Status water quality management will be centred on river basins, which are natural geographical areas that occur in the landscape. Management of these basins will be achieved through management plans, a plan being created for each River Basin District (www.forestryfocus.ie).

3.3.1.2 Water Floods Directive 2007/60/EC

The Water Floods Directive (WFD) does not only manage and protect water nationally, but goes beyond political boarders to ensure good water quality in cooperation with neighbouring countries, which share rivers. Member countries were asked to draw up river basin management plans (RBMPs) for the currently 110 river basin districts. Furthermore, other goals include reaching a good ecological and chemical status of the bodies of surface water as well as a good status of the groundwater (good chemical and quantitative status). The WFD classification system for surface water includes five categories (high, good, moderate, poor, bad) which member countries have to assess. For assessing the chemical status, quality standards were drawn up. Public participation of citizens is also being asked for to achieve public support. The Commission monitors the implementation progress through drafting implementation reports and progress reviews. Since flood risks, but also water scarcity and droughts occur more often, the EU Floods Directive 2007/60/EC required member states to prepare flood risk assessments for all its river basins as well as flood hazard maps. The first management cycle for the WFD ended 2015. The next one will end in 2021 respectively 2027 for meeting all remaining policy objectives. A large number of guidance documents exist that shall support member countries but also candidate countries in the implementation of the related legislation to meet all policy objectives (http:// ec.EURpa.eu/environment/water/water-framework/facts_figures/guidance_docs_en.htm).

3.3.1.3 Nitrates Directive 91/676/EEC

The **Nitrates Directive 91/676/EEC** aims to prevent water quality through avoiding the pollution of ground and surface waters by nitrated from agricultural sources. The aims is to promote good farming practices. Also the Nitrates Directive forms part of the WFD.

3.3.1.4 Drinking Water Directive 98/83/EC

The **Drinking Water Directive 98/83/EC** relates to the quality of water intended for human consumption to protect human health. Based on this legislation currently 48 microbiological, chemical and indicator parameters are monitored and tested on a regular basis. Member states as well as candidate countries can put in place more severe requirements, but not adopt lower standards. A revision of the Drinking Water Directive has been put in place and a Commission proposal is expected for the end of 2017.

3.3.1.5 Urban Wastewater Council Directive 91/271/EEC

The **Urban Wastewater Council Directive 91/271/EEC** was adopted in the beginning of 1990s to protect the environment from urban waste water discharges as well as discharges from certain industrial sectors. It regulates the collection, treatment and discharge of domestic waste water, the mixture of waste water and the waste water from certain industrial sectors included in the annex III of the Directive (Dragovic et al., 2017).

3.3.2 Forests and water in Europe

The Ministerial Conference on the Protection of Forests in Europe (MCPFE or Forest Europe) includes a specific Resolution on Forests and water.

The 2007 Resolution commits signatory states, including the UK, to:

- Maintaining and enhancing the protective functions of forests for water and soil, as well as for mitigating local water-related natural disasters through sustainable forest management, including through public and private partnerships.
- Assessing afforestation and reforestation programmes in terms of their effects on the quality and quantity of water resources, flood alleviation and soil.
- Promoting the restoration of degraded forests, particularly in floodplains and upper watershed areas for the benefit of the water environment, flood reduction, conservation of biodiversity and soil protection. There is also a commitment to better co-ordinate policies on forests and water, to address the impacts of climate change, and to undertake an economic valuation of water-related forest services (https://www.forestry.gov.uk/).

3.3.2.1 Natural Water-Retention Measures (NWRMs)

Concerning measures for water retention European and international policy instruments have been proposed. Water retention is a regulatory ecosystem service. Water stays in the environment and is available for human well-being and for other ecosystems for a longer time. This helps to improve the capacity of other ecosystems to provide ecosystem services.

European Commission (2012) define NWRMs as intervention techniques over water related ecosystems that are designed to replicate nature's capacity of adaptation. Their principal objective in terms of water management is to regulate water flow so that hydrologic extremes such as floods, droughts or desertification can be mitigated as well as achieving better water storage. NWRMs can be categorized broadly under 2 key headings: 1) restoration measures (e.g. rivers and wetlands); 2) changing land use practices (e.g. agricultural and forestry practices) including a range of agronomic practices to slow down the rate of water flow from arable cropping areas

NWRMs include actions such as growing forests, restoring wetlands and lakes, removing dams, and reducing tillage in agriculture. The main focus is to enhance and preserve the water retention capacity of aquifers, soil and ecosystems and improve their status.

The Commission's study on Natural Water Retention Measures classifies 53 different NWRMs suggested for implementation in four different areas: agriculture, forests, urban areas, and hydromorphology (EEA-European Environment Agency, 2015)

There are 14 different types of forest-related measures (http://en.klimatilpasning.dk/):

- F01 Forest riparian buffers
- F02 Maintenance of forest covers in headwater areas
- F03 Afforestation of reservoir catchments
- F04 Targeted planting for 'catching' precipitation
- F05 Land-use conversion
- F06 Continuous cover forestry
- F07 'Water sensitive' driving
- F08 Appropriate design of roads and stream crossings
- F09 Sediment capture ponds
- F10 Coarse woody debris
- F11 Urban forest parks
- F12 Trees in urban areas
- F13 Peak flow-control structures
- F14 Overland flow areas in peat-land forests

3.3.2.2 EU Biodiversity Strategy

The Biodiversity Strategy 2020 lists as one of its six targets the aim of encouraging forest managers to protect and enhance forest biodiversity and to integrate biodiversity measures in forest management plans. Therefore there is a need to balance the different possible ecosystem services forests can provide. It is also necessary to find relevant solutions at regional and local scale that support each of the possible services and targets.

The EU Biodiversity Strategy to 2020 emphasises the importance of NWRMs to ensure the provision of ecosystem services (Europäische Kommission 2011). The EU Forest Strategy encourages NWRMs and recommends that forest cover is maintained and increased to protect soils, and to regulate the quality and quantity of water (European Commission, 2013). The Strategy also recommends that sustainable forest management practices are to be integrated into Rural Development Programmes and the Programmes of Measures.

3.3.2.3 FOREST EUROPE

FOREST EUROPE (The brand name of the Ministerial Conference on the Protection of Forests in Europe) is the pan-European voluntary high-level political process for dialogue and cooperation on forest policies in Europe. FOREST EUROPE develops common strategies for its 47 signatories (46 European countries and the European Union) on how to protect and sustainably manage their forests. with the aim of maintaining the multiple functions of forests crucial to society

FOREST EUROPE is a unique forest policy process addressing and developing common decisions on issues of highest political relevance. The preservation of drinking water resources, the stabilization of stream banks or sand dunes are among key protective functions of forests. Protective functions are very important when assessing sustainability in forests. Therefore, the pan-European Criterion 5 "C5: Maintenance and Appropriate Enhancement of Protective Functions in Forest Management (notably soil and water)" has the indicator of designated forest and other wooded land for preserving water resources, among other protective functions.

Criteria and indicators are the basic tools in implementing and promoting sustainable forest management by providing relevant information for forest policy development and evaluation, national forest policies, plans and programmes and as a basis for cross-sectoral communication. FOREST EUROPE was one of the first regional policy processes to develop and endorse criteria and indicators. All documents can be found at www.foresteurope.org.

3.3.3 Capitalisation policies and projects

3.3.3.1 System of Environmental-Economic Accounting (SEEA)

The 7th Environment Action Programme and the EU Biodiversity Strategy includes objectives to develop natural capital accounting (NCA) in the EU, with a focus on ecosystems and their services. Ecosystem accounting complements the system of national accounts (SNA). It builds on the System of Environmental-Economic Accounting – Central Framework (SEEA CF) which provides methodological guidelines for setting up accounts for environmental assets as individual resources such as timber resources or water resources. The UN SEEA EEA (Experimental Ecosystem Accounting) goes beyond the central framework to give guidance on setting up accounts that reflect the role of ecosystems and their services.

3.3.3.2 The Economics of Ecosystems and Biodiversity (TEEB)

In 2007, a study on the economics of ecosystems and biodiversity (TEEB) was launched in response to a proposal by the Environment Ministers from the G8 states and five major developing countries3 to develop a global study on the economics of biodiversity loss. Over time, the study developed into an initiative involving regular publications on work done on various aspects of the economic valuation of ecosystems.

The valuation process defined by TEEB involves three levels:

1. recognizing value, i.e. identifying the wide range of benefits in ecosystems, landscapes, species and other biodiversity-linked aspects;

2. demonstrating value, i.e. using economic tools and methods to make nature's services economically visible;

3. capturing value, i.e. incorporating ecosystem and biodiversity benefits into decision-making through incentives and price signals.

In this process, valuation is not seen as an end in itself; it is rather meant to provide a framework for better-informed decision-making (Chaudhary, 2017).

The TEEB Report for Local and Regional Policy Makers and the TEEB Report for Business provide useful reference points for EUSTAFOR members as they outline the value of nature for local well-being and regional development. Maintaining and enhancing functioning natural systems are often the most robust and cost-effective solutions for local economy, food and energy security, and environmental sustainability, but these systems are often the first to degrade because their benefits are often unaccounted in traditional cost- benefit analysis (EUSTAFOR and Patterson, 2011).

3.3.3.3 NEWFOREX

NEWFOREX is a four-year research project (2009-2013), funded by the European Commission under the 7th Framework Programme for Research and Technological Development.

The NEWFOREX project seeks to accomplish the following objectives:

1. To provide new methods for valuing forest externalities that enable to handle join produced externalities in an integrated way. Specific attention will be given to the question: Who benefits from the provision of externalities?

2. To develop a methodology for assessing the cost of providing externalities. This approach will account for the costs of the trans-boundary effects of forest management, as well as the transaction and opportunity costs of selling/buying these externalities.

3. To assess several market-based methods for enhancing the provision of forest externalities, like payment schemes, certification, or (re-)definition of property rights. The project will also develop a methodology to help select and design the most appropriate market-based mechanism, by taking into account the type of externality, the values, the cost of provision, and the relevant stakeholders.

These efforts are undertaken across a set of regional case studies in Europe targeting four key externalities: carbon sequestration, biodiversity protection, water- shed services, and recreation. The project aims to ex- tend the state-of-the-art theory and methods with new empirical insights. The gains in knowledge are communicated using seminars, popular articles, guide- lines, and best practice examples from across Europe. An easy-access guiding tool for analysts, policy-makers, and decision-makers will be compiled and widely distributed (EUSTAFOR and Patterson, 2011).

3.3.3.4 EU Biodiversity Strategy

One of the measures of the EU Biodiversity Strategy directly related to FES (Target 2 -Action 5) requires improving knowledge of ecosystems and their services in the EU. Member States are asked to map and assess state of ecosystems and their services by 2014, to assess their economic value and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.

Target 3 “Increase the contribution of agriculture and forestry to maintaining and enhancing biodiversity”. By 2020, Forest Management Plans or equivalent instruments, in line with Sustainable Forest Management (SFM), are in place for all forests that are publicly owned and for forest holdings above a certain size (to be defined by the Member States or regions and communicated in their Rural Development Programmes) that receive funding under the EU Rural Development Policy so as to bring about a measurable improvement in the conservation status of species and habitats that depend on or are affected by forestry and in the provision of related ecosystem services as compared to the EU 2010 Baseline. Action 11 Encourage forest holders to protect and enhance forest biodiversity. Member States and the Commission will foster innovative mechanisms (e.g. Payments for Ecosystem Services) to finance the maintenance and restoration of ecosystem services provided by multifunctional forests (European Union, 2011).

3.4 Links among conservation drivers, pressures, ecosystem services and economic importance

3.4.1 Ecosystem services and economics

The cycle (Figure 7) that links human societies and their well-being with the environment is building on the framework used by the Millennium Ecosystem Assessment (MEA). The framework emphasises the role of ecosystems in providing services that benefit people. Ecosystem services are the outputs of ecosystems from which people derive benefits including goods and services (e.g. food and water purification, with economical value) and other values (e.g. spiritual experiences, which have a non-economic value). The combination of these goods, services and values provides our overall human well-being (expressed in society as health, wealth and happiness). The values that people derive from ecosystems may alter the way that they choose to use and manage the environment (Silvis and Van der Heide, 2013).

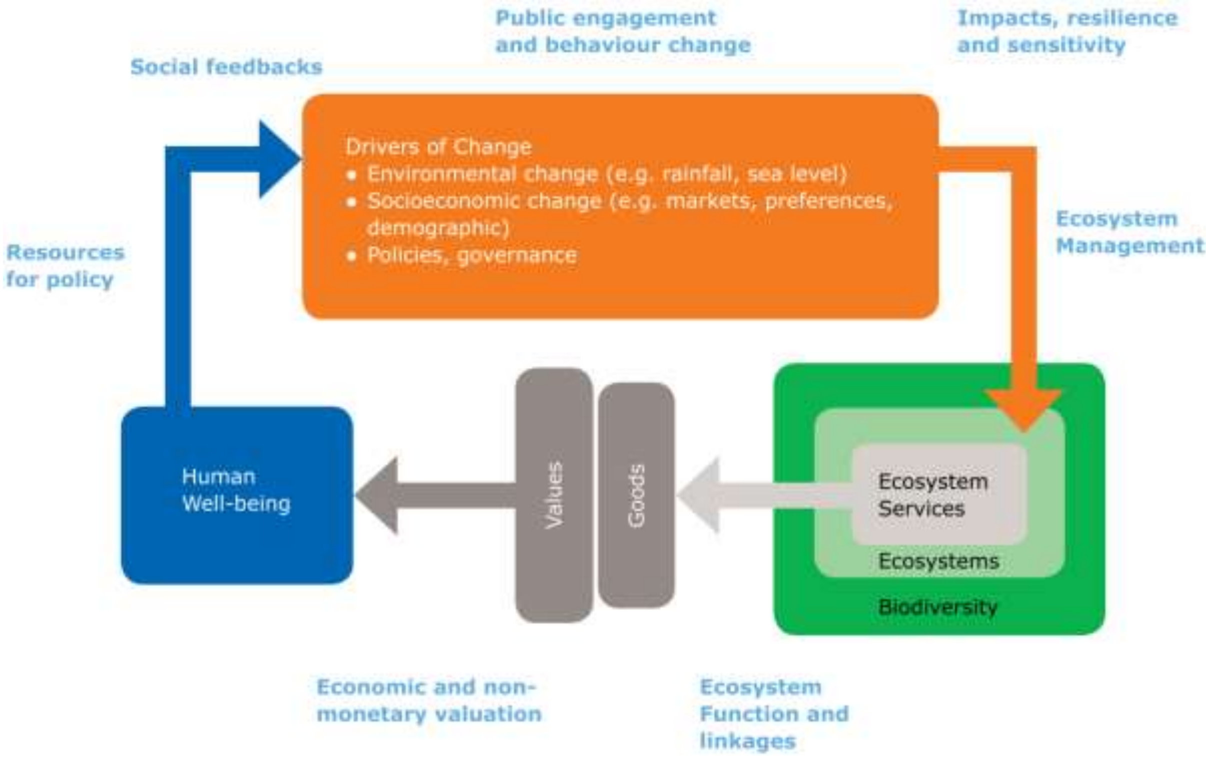

Figure 7 Ecosystem services in the policy sphere. Source: DEFRA, 2010

Production and consumption of good and services for the ultimate sales of human wants are involved in economic activity concerning economics. Man performs economic activities as well as non-economic activities. An economic activity is one for which he earns an income for whatever effort he puts in production. However, an activity which a man performs for pleasure or out of love or pity is a non- economic activity as it is not measured in terms of money but in terms of social help.

ES conservation supports natural, cultural and social capital, yielding flows of economically valuable goods and services that benefit society. Researchers created an economic model of the Amazonian Brazilian economy to examine how investments in conservation such as protected areas would provide quantifiable economic benefits in the form of improved human health. This demonstrates how large-scale investments in conservation also support economic growth by improving human health (Mulongoy and Gidda, 2008).

3.4.2 The drivers and pressures affecting the water related forest regulative services

For the sustainable capitalization of regulative services related to water resources management, it is necessary to consider the complex links between conservation drivers, pressures, status and economic importance of ecosystems (Teichert et al., 2016; Brown et al., 2013; Halpern et al., 2008). Overall, the main pressures affecting the water related forest regulative services can be summarized as alterations of water quantity and quality, and changes in the physical habitat and the biological components, as shown in Table 5 (Grizzetti et al., 2016)

Table 5 Pressures on water related forest regulative services (Source: Grizzetti et al., 2016)

Water quantity
Flow modifications (hydrological alterations): Quantity and frequency (dams, water abstractions, irrigation, transfers) Groundwater abstractions Changes in precipitation and temperature Changes in runoff
Water Quality
Diffuse and point pollution: Nutrients Chemicals (pesticides, endocrine disrupting compounds, nanoparticles, etc.) Metals Pathogens Litter Litter Groundwater salinization Sediments, increased turbidity and brownification
Habitat
Hydromorphological alterations (physical alteration of channels, bed disruption, dams)
Biota and biological communities
Alien species, other changes in biological communities

Drivers of changes can directly or not affect the status, current management and future trajectories of ecosystems and ESs (Figure 9). Figure 9 present a list of drivers and pressures; the arrows describing the relationships are not exhaustive, the users are invited to develop the specific relationships at stake in their case study (Grizzetti et al., 2016).

Indirect drivers of ecosystem change include

- demographic shifts,
- technology innovations,
- economic development,
- legal and institutional frameworks,
- loss of traditional knowledge and cultural diversity (OECD 2003; MA 2005b; OECD 2008).

These drivers affect the use and manage ecosystems and services (De Groot Rudolf et al., 2010).

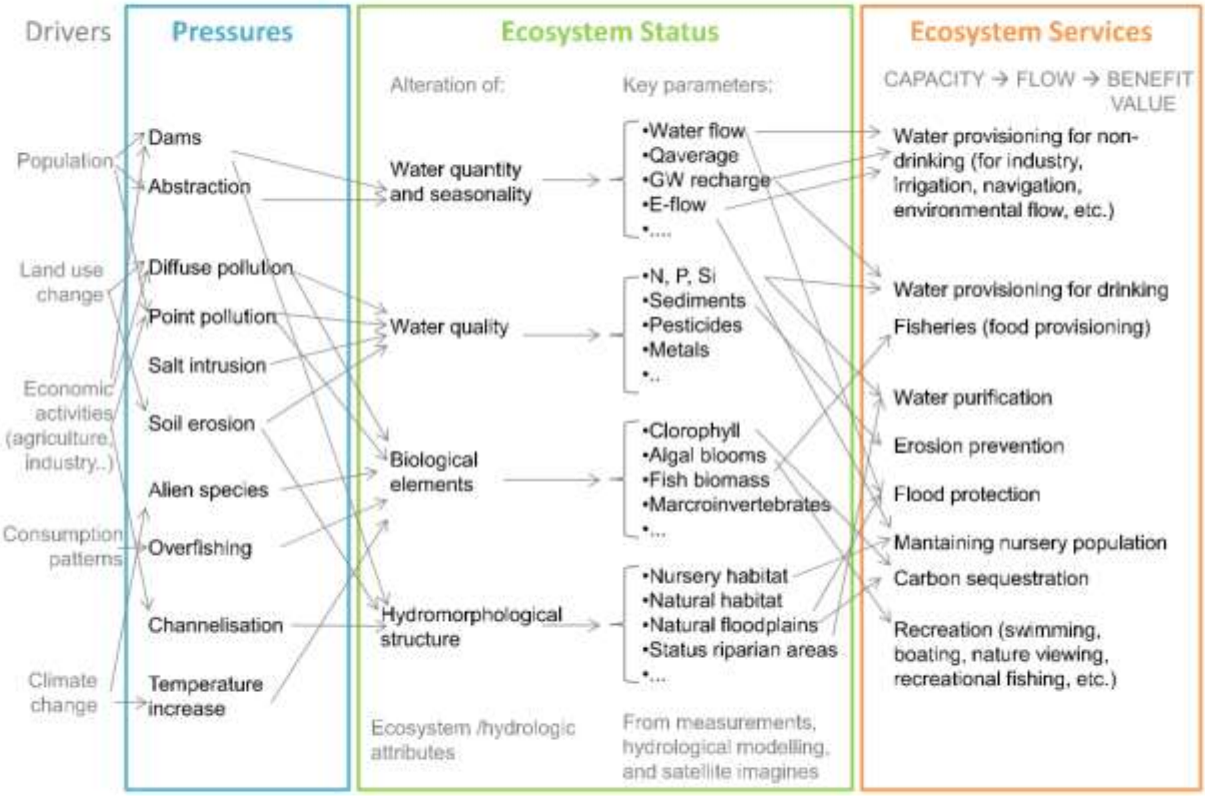

Figure 8 Integrated assessment framework for analyzing the links between pressures, ecosystem status and ecosystem services (Source: Grizzetti et al., 2016).

Direct drivers can be organized in negative, neutral and positive categories(De Groot Rudolf et al., 2010).

Negative drivers include:

- habitat loss,
- over-exploitation of resources.

Neutral drivers include:

- land use change.

Positive drivers include:

- ecosystem conservation and restoration,
- sustainable management regimes
- use of environmental-friendly to reduce human pressures (e.g. organic farming, eco-tourism, renewable energy, etc).

Clearly, even “positive drivers‟ can have negative impacts on ecosystems and biodiversity, when applied in the wrong place or context, so the effects of any direct driver on ecosystems need to be carefully analyzed through the TEEB framework (De Groot Rudolf et al., 2010).

4 CASE STUDIES

4.1 Case interventions for sustainability of forest regulating services related to water

In **Catalonia**, the river basin management plan consider forests and forestry in measures related to "recovering the natural state of riparian forests" and "recovering wetlands", it is also referred that temporary deterioration of water bodies" linked to forest fires or droughts. Regarding wildfires it is established a threshold beyond which water can be deteriorated.. In relation to forest management guidelines to improve the water-related services of forests, the river basin management plan of Catalonia includes a specific requirement for the riparian forests, which have to be managed following the guideline: "Indications and guidelines for the treatment of riparian forests" (Agència Catalana de l'Aigua (ACA), 2008). Regarding the use of PES-like schemes, the River basin Management Plan of Catalonia (Agència Catalana de l'Aigua (ACA), 2010) foresees the measures of "land acquisition" and "land stewardship agreements" for the recovering of wetlands and riparian forests (CRPF PACA, 2012).

In **Catalonia** regarding water quantity, some protected areas are starting to implement a program of "open spaces" (transformation of treed areas into pasture land) close to the riverbed, to increase water runoff. In both cases the works are carried out with public money investments (CRPF PACA, 2012)

Slowing the Flow at Pickering is a project that seeks to demonstrate how better land management can help to tackle the flooding problem faced by Pickering **in North Yorkshire** and deliver other benefits to water quality, wildlife, and soil protection. The project aims to achieve protection for Pickering for up to 1 in 25 year flooding events through a mixture of land management measures (including flood storage bunds and debris dams) and woodland creation. These measures aim to increase the time it takes from rain falling on the upper catchment to flood waters flowing through Pickering. The project began as one of three pilots funded by Defra in response to the Pitt Review of the 2007 floods in England and Wales. This called for Defra to work with partners to deliver flood risk management involving greater working with natural processes. The project also responds to a strong local lobby for action after suffering the consequences of flooding; Pickering has been flooded four times in the last ten years (Defra, 2013).

Tyszka (2009) study demonstrates the importance of efficient water retention activities as well as the importance of integrated water-resources management practices to balance the water demands of tree stands with the needs of external users. Four different river basins were selected across Europe (**Norway, France, Hungary**) representing various forest cover ratios starting from 10% up to 60%. All selected sub‑basins provide quite strong correlations, indicating the regulatory role of forests over run-off regime. An increase of forest cover from 0 to 100% resulted in a decrease of the annual run‑off irregularities (EEA-European Environment Agency, 2015).

In the **Western Cape, South Africa,** there is scientific evidence that forests reduce stream flow in this semi-arid environment. The stream flow reduction resulting from the historical pine afforestation of about 80 000 ha of some of the wetter scrubland (known as fynbos) areas in the province was calculated to be 1.96% of the total run-off in the province's catchments (Scott et al. 1998). Calculations based on the work of Gush et al. (2002) estimate the stream flow reduction as 1.06% of the annual total before afforestation. This number would fall to a value of between 0.8 and 1.3% of the total run-off following deforestation of approximately 30 000 ha of plantation forest (based on work by Scott et al. 1998 and Gush et al. 2002) – i.e. if the Cape conversion process is partially re-versed, thus allowing some 50 000 ha of plantations to remain. So in terms of water-related ecosystem services, plantation forests provide wood production as a major green water service, with stream water reduction as a relevant but regionally limited blue water disservice.

Yurtseven et al., (2018) study focuses on the role of water-related forest services in mitigating the impacts of climate change and in supporting the adaptation capacity of the ecosystem. The impact of two cutting treatments on runoff was analyzed by a paired experimental watershed in the Belgrade Forest, 3 km south of the **Black Sea**. The results showed that in terms of water production, conversion of vegetation and clearcutting are more drastic and effective treatments compared to partial or selective cutting. The reason for this lies in the duration needed by the ecosystem to restore itself.

In **Water-retention potential of Europe's forests** report by EEA-European Environment Agency, (2015) conducted an analysis of the relationships between forest and water retention for the whole of Europe. The report was based on available data at European level from the EEA Water Accounts Production Database, as well as on information on forest land use and cover from forest statistics and Corine The analysis revealed that the impact of forests on water retention is particularly noticeable in small sub-basins. Forest cover greater than 30% results in higher water retention potentials. Regarding forest types, coniferous forests have the largest impact on run-off across Europe with some local exceptions, for instance mixed forests in the Alpine region and broadleaved forests in the Continental region. Medium water-retention areas are mostly represented by coniferous and mixed forests, except for the Mediterranean region.

4.2 Case studies of capitalization of forest regulating services related to water

Numerous efforts have been made in the last 40 years to emphasize the vital importance of water or human beings and for the environment and to draw attention on the urgency of addressing water related issues (Carlos and Mesa-jurado, 2017).

In **France and Poland** there are now arrangements in place where businesses bottling drinking water are paying land managers (farmers and foresters) within the water catchment areas to maintain the water quality. In France the arrangement is for water quality and the beverage manufacturer pays farmers to reduce agricultural chemical inputs on the land above the aquifer. In Poland, beverage manufacturers can buy licences to extract clean freshwater from wells on State forest lands, which is then treated, bottled and sold (EUSTAFOR and Patterson, 2011).

In Latin America, water fund mechanism for protecting watershed services is steadily gaining ground. In the Andes region, a mix of high altitude wetlands and forests provide valuable water supply regulation and erosion and nutrient retention that improves water quality to the millions of people in the mountains and inter- Andean valleys. Water funds are being developed as a means for water users to pay upstream land managers to improve watershed management as a way to regulate water flows and provide natural filtration for water quality. These payments for watershed services are created by a group of users who pay into a trust and then collectively decide how to invest in watershed management changes they believe will meet their water-related objectives (Goldman-Benner et al., 2012).

(Vincent et al., 2016) present an econometric study to estimate directly the effect of tropical forests and land use on water treatment cost, in **Malaysia**. The econometric analysis was guided by the theory of using cost functions to value environmental inputs (land-use variables and rainfall). They suggest as a second way to gauge the magnitude of the service values, to compare them to the opportunity cost of protecting virgin forests from logging or conversion.

La Notte et al., (2015) study presents an approach for assessing ecosystem services in monetary terms to support conservation policies at the **regional and continental** scale. They present and discuss a methodology suitable for associating a monetary cost to ecosystem services when the purpose addresses conservation policies. In order to provide a contribution. They show a practical case study on water purification in the northern Mediterranean region using an indicator based on the in-stream nitrogen retention estimated by the model GREEN. They applied the replacement cost technique.

(Häyhä et al., (2015) study explore biophysical amounts, spatial distribution, and economic value of forest ecosystem services in the **Italian Alpine** region. Replacement cost method was applied to value the ecosystem service of hydrogeological protection.

In **Germany** afforestation of farm land was implemented to reduce water treatment costs. One of the largest drinking water suppliers (OOWV) in Lower Saxony, signed an agreement for higher water quality in the sparsely wooded Weser-Ems region. Over 20 years OOWV has bought 1800 ha of agricultural land near the water abstraction wells and has assigned the land, for water management. More than 1500 ha of the land NLF were afforested, mainly with oak and beech,

These forests had a significant positive effect on the water quality. Purchasing the land has been a barrier (purchases received part public funding). Much of the afforestation was funded by private development seeking nature compensation for construction projects (EUSTAFOR and Patterson, 2011).

In another study where PES for drinking water supply with a private company in Germany that entered into a partnership with an environmental protection agency in order to create over 130 ha of new drinking water forests throughout Germany , thereby generating in a sustainable way 100 million liters additional ground- and drinking water. A better ground water can be best produced in deciduous forests. Modifications of evergreen mono-cultures into natural deciduous forests generates an additional 800.000 lts of clean groundwater per ha (CRPF PACA, 2012).

In France a CNPF-IDF and INRA joint project called “ Forests and Water ”Economic assessment of the services provided by the forest to the water cycle, identified that households are willing to pay up to 50 € a year extra to have, or to keep, tap water from woodland sources (CRPF PACA, 2012)..

The method was based on household surveys, and every extra hectare of woodland saves 15 € a year on household water bills (lowest saving in the range estimated by the economic model). The reseranchers also identified that the impact should be greater in studies on the most sensitive areas producing drinking water. In Portugal where PES for drinking water supply was implemented land owners committed to maintain good forest management practices within the 16.000 ha FSC certified areas. Approximately 600 hectares were considered to be of critical importance for biodiversity and water recharge of the aquifer.

In Denmark two, two forest -groundwater PES schemes have been developed to combat the r groundwater pollution. Both PES schemes aim to have two main effects (Greiber et al., 2009):

- Land-use change from agriculture to forests through afforestation of mainly broadleaved species.
- In existing forest areas, restrictions on the use of fertilizers or pesticides
- Modifications of conifer stands with broadleaf tree species, as the latter increase groundwater recharge.

More specifically, in order to guarantee the quality of the groundwater resources of the region, an agreement has been made between a company providing water and an owner of the forest. Through this voluntary agreement the private forest owner set aside 95 ha of forest with no pesticides use. In addition, the water company was able to buy several hectares of farm land on which broadleaved trees were planted. Afforestation activities were implemented and managed by the state and local municipalities (Greiber et al., 2009).

Another example of a PES scheme is the state policy to double the country's forest area within a sixty to hundred year's time period. Public water companies have entered into a contract with public land owners who change their forest management practices or engage in large scale afforestation projects in watershed areas so that they preserve water quality. One such afforestation project has been initiated, for example, in 2001 where the authorities established more than 2.000 ha of new forest (Greiber et al., 2009)

In a US case study, rather than spending six to eight billions on a new filtration plant, New York City invest in protecting and conserving lands in a watershed. By spending one to two billions on purchasing and managing lands in nearby mountainous areas, the city was able to achieve its water quality goals at only a fraction of the cost of the filtration plant (Chichilnisky and Heal 1998). In addition to New York, a number of US cities have avoided building expensive new filtration plants by investing in watershed protection.

5 GUIDELINES-RECOMMENDATIONS FOR CONSERVATION AND SUSTAINABLE CAPITALIZATION OF FOREST ECOSYSTEM SERVICES UNDER STUDY

5.1 Key stages and processes of sustainable capitalization

The process of economic valuation could begin with a examining step in which the services to be evaluated from a forest ecosystem are identified; this is followed by application of appropriate methods and techniques to collect and analyze data in order to capture ESs use and non-use values. The process of valuation ends with a inputs and recommendations to decision makers clarifying the drivers of change, and identifying the course of action to arrest the degradation and improve the health of the ecosystem. Figure 10 briefly presents the key stages and processes of forest ecosystem services and the corresponding issues and guidelines.

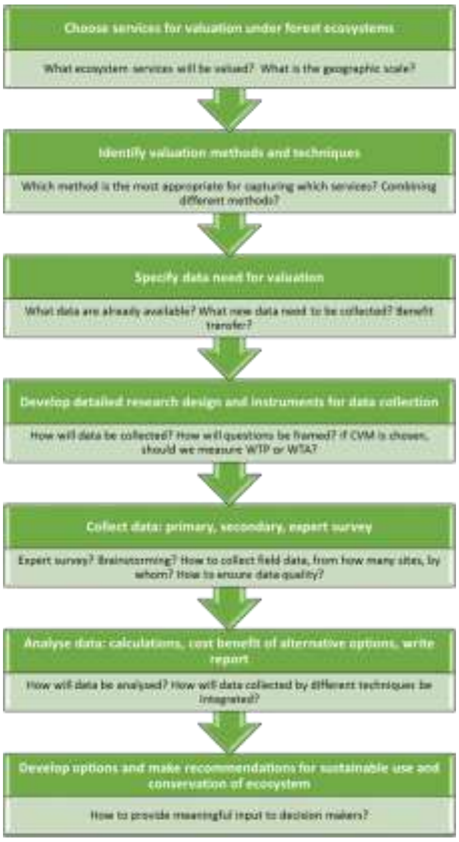

Figure 9 Key stages and processes of sustainable capitalization of FES related to water resources

Economic valuation may help to inform management decisions, but actions for conservation is essential from the part of decision-makers. The aim of the economic valuation should be to identify a more cost effective and efficient course of action for ESs sustainability that will maximise human wellbeing. Valuation, strong institutions and governance mechanisms, group or multi-stakeholder efforts, and sound policy are elements in the effort to improve the management of ecosystems and their services (Rasul et al., 2011).

5.2 Checklist to Guide Economic Valuation of Ecosystem Services

The economic valuation process is context specific and must be customized and adapted to suit the situation at hand. Different methods may need to achieve different goals. Several factors must be considered (Silvis and Van der Heide, 2013) such as the geographic and temporal scale, the extrapolations from one ecosystem to another, the time frame, the temporal, spatial, and inter-personal tradeoffs, the costs of conservation, and the users and providers of the benefits.

The following checklist has been developed by Heal et al. (2005) to guide economic valuation of ecosystem services, and hence in can be applied in the case of water-related forest ecosystem services:

The Policy Frame

1. What is the purpose of the valuation
2. What is the scope of the valuation
3. What is the geographic scale of the valuation
4. How the valuation question framed

The Underlying Ecology

1. How well understood is the (forest) ecosystem of interest

From Ecology to Economic Valuation

1. The output from the biophysical (ecological) models can be used as an input to the economic models
2. Given the services to be valued, what existing valuation methods are available
3. What are the data needs
4. How is aggregation handled

Uncertainty

1. What are the primary sources of scientific uncertainty affecting the valuation estimates
2. What methods will be used to address uncertainty
3. What benefits or values extend over time

5.3 Recommendations for capitalization of water resources through economical schemes such as PES

The following recommendations should be considered when implementing a PES scheme targeting to water resources*(CRPF PACA, 2012)*.

1. Identify solid technical arguments for mapping, assessing, quantifying and valuing regulative services related to water resources management.

This is not straightforward since there are a lot of variability according to the location, the type of the ground, of the soil of the stands, the climate, the aspect, the hydrological conditions etc. The forest is multifunctional, and all these roles should be considered for the valuation of the services offered and not the water-specific

2. Ensure proper management structure and plan

The management should be demonstrating that the services supply will be continued as well as to be improved-as well as that the water will not be privatized. Also, it is important to consider all the interest parties together and not only the water specific. Proper forest management for the water will be also beneficiary for the other stakes. For example, forest thinning (of dense stands) will improve forest growing and wood quality, reduce water consumption, improve fire prevention, improve biodiversity (openings), increase grazing potential and landscape accessibility. Clear differentiation of the beneficiaries (stakes) should be made in order to avoid problem of free-riding as well as payment of bundle services. Water services that are offered by forest areas which are owned by a lot of forest owners (i.e. basin scale), it can be necessary to gather them in an association which will follow a common management plan. Spend ample time in framing and thereafter communicating the need for water resources management to those whose interests are affected by that management. Take the time to understand from stakeholders how they are affected.

3. Ensure preparatory action before PES implementation

Since PES has been scarcely used in Balkan Mediterranean countries, the it is hard to be implement. Reports or policy briefs should inform of tracks, ways, studies already carried-out Since the true definition of a PES is restrictive. Adjustment and soft PES-like schemes could be adopted.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Limitation of Economic Valuation

A major difficulty arising in treating ecosystems as economic assets is in quantifying this form of capital and in measuring the valuable benefits that it produces (Tallis et al., 2012). While the valuation of ecosystem services provides a more systematic approach towards the assessment of environmental effects in policy, considerable challenges still remain if this approach is to be fully incorporated. In practice, there are many uncertainties and missing data and links in each step of the process, as well as a number of issues such as accounting for cumulative effects and environmental limits (Defra, 2007).

Economic valuation cannot value everything; not all benefits provided by ecosystems are fully translatable into economic terms. There are some basic methodological barriers. As yet, there are no generally accepted procedural rules for monetary valuations of FES with would allow for a simple “cookbook approach”. Rather, economic valuation uses a variety of approaches and methods, which have to be specified for each application (Barredo et al., 2015).

Methodological limitations constrain the extent to which economic valuation methods can capture the ecological interdependencies of different ecosystem entities. As a result, valuation analysis often ignores, or does not adequately account for, the internal structure of ecosystems, and the interdependencies and inter-linkages of different ecosystem entities (Silvis and Van der Heide, 2013)..

Some methodological details remain open to debate, for example when non-use values are involved. The methodological complexities of valuation studies can result in widely varying estimates, even when valuation contexts are similar. Bias can often feature in this type of work. (Barredo et al., 2015)

Moreover, by relying on revealed or stated preferences, the economic valuation methods are not able to capture normative and ethical aspects of ecosystems. Thus economic valuation remains an indication of the value of an ecosystem rather than an actual value (Silvis and Van der Heide, 2013).

Estimated values remain. Ecosystem services values are context-specific, approximate estimations based on methods and assumptions, and local conditions. Since studies have only been carried out for a few locations, estimates are often calculated through 'value transfer' approach. The economic valuation of ecosystem services does not necessarily give a full picture, as analyses often concentrate on a few high-profile services (such as water flow regulation) and rarely assess the value of wider economic services (Chaudhary, 2017).

The above arguments do not mean that the valuation of ecosystem services cannot be taken forward now – and indeed the priority is that it should be, to fully take into account all the impacts on ecosystems and their services (Defra, 2007).

6.2 Potential for improvement and remaining challenges

Different forest management activities affect forest ecosystem services in different ways and new tools are needed to describe and evaluate the benefits that result. An ecosystem services approach can help in this by (EUSTAFOR and Patterson, 2011).;

- Offering a more complete account of the range of values that the forest provides
- Providing a better analysis of the relationships between multiple values
- Identifying the benefits of management activities that are relevant to particular stakeholders

Applying a forest ecosystem services-based approach to water management can help give visibility to, and raise awareness of, the multiple values of services provided by forest ecosystems, and hence help society realize that water allocated or left to the forest ecosystem is not wasted (UNESCO 2009). By providing an economic rationale for water related forest ecosystem maintenance, it helps communicate the value of forest ecosystem services in a commonly accessible language. It also helps broaden the constituency in support of conservation and enhancement of forest ecosystem functions (Ingram et al. 2012). Forest ecosystem services-based approaches can be used to establish a consultative and decision-making framework that brings to the fore, and gives voice to, the poor as custodians of these (Martin-Ortega et al., 2015).

An important challenge in forest ecosystem services is to identify who benefits from regulating services and how much the benefit is. This challenge requires an understanding of where regulating services are produced in an area relative to people who might benefits from these services. Tallis et al., (2012), introduced the concept of a “serviceshed.” A serviceshed for an ecosystem service is simply the area where a specific benefit is provided to a specific individual or group of people. For water-related regulating services, servicesheds are related to watersheds. The serviceshed for drinking water quality regulation is the area upstream of a person’s or a community’s water extraction point. For a person or community to benefit from water quality regulation, they must be downstream of an area that has natural capital that can regulate water quality (supply) and have physical access (pipes, foot paths, wells, etc.) and institutional access (legal rights, informal rights) to that water (Tallis et al., 2012).

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