Food and Agriculture Organization of the United Nations

UNECE

Forests and Water

Valuation and payments for forest ecosystem services

UNITED NATIONS

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ABSTRACT

The objectives of this study are to further improve our understanding about the ways in which payments for ecosystem services schemes can be applied to forests, in particular focusing on forest's hydrological functions for the mutual benefit of both humans and the environment. In addition, the study covers advances and challenges facing these schemes and provides practical guidance for policymakers and practitioners. This study contains the most comprehensive currently available database of case studies on water-related payment for forest ecosystem services schemes in the UNECE region.

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FOREWORD

Ecosystems are complex and are extremely difficult to restore once their functions have been exhausted. They are priceless. However, without adequately assessing their value for economic decision-making, many of them may be lost forever.

If all ecosystem services were managed under adequately funded government structures, maintaining ecosystem services could be more straightforward, as the cost of maintaining these natural assets would most likely be shouldered by national operating budgets, with some funds generated from user fees or taxes. However, the sustainable supply of ecosystem services is often dependent on the stewardship of private property owners, businesses or, in some cases, governments, many of whom have insufficient resources.

Payment for ecosystem services (PES) can be an incentive for valuation and, when appropriate, can serve to compensate those that have to bear the cost and efforts of maintaining services that are not typically considered in conventional market transactions. This publication draws on the analysis of many experts and national, local and private sector experiences to illustrate various existing options for forest and water resources to benefit from appropriate stewardship and strong support. Furthermore, the most comprehensive currently available database of case studies on the topics in the UNECE region is annexed to this publication.

The Sustainable Development Goals related to water (SDG 6) and land (SDG 15) explicitly acknowledge the linkages between forests and water. Payments for ecosystem services are not only highlighted in all relevant UN literature since the Millennium Ecosystem Assessment, but they are also mentioned in the context of the 2030 Agenda. The sustainable management of forests and water supplies and the many other benefits they provide are crucial for the long-term success of all SDGs. UNECE and FAO support the sharing of knowledge and best practices on forest-water related payments for ecosystem services, with the goal of mainstreaming this approach in the UNECE region.

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ACRONYMS, ABBREVIATIONS AND SYMBOLS

(Infrequently used abbreviations spelled out in the text may not be listed again here)

AES	Agri-Environment Schemes
CAP	Common Agricultural Policy
CBD	Convention on Biological Diversity
CICES	Common International Classification of Ecosystem Services
CoP	Cost of Provision
CSO	Civil society organization
CSR	Corporate Social Responsability
EC	European Commission
EFC	European Forestry Commission
EPA	Environmental Protection Agency
ES	Ecosystem service
ET	Evapotranspiration
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FPWS	Forest Payments for Watershed Services
FRA	Global Forest Resources Assessment
IUCN	International Union for Conservation of Nature
IWMI	International Water Management Institute
MEA	Millennium Ecosystem Assessment
PES	Payment for Ecosystem Services
SDGs	Sustainable Development Goals
TEEB	Economics of Ecosystems and Biodiversity
TEV	Total economic value
TIMOs	Timberland investment management organizations
UKFS	United Kingdom Forestry Standard
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
WPMMW	Working Party on the Management of Mountain Watersheds
WFD	Water Framework Directive
WUA	Water Users Association

EXECUTIVE SUMMARY

Forests play an important role in producing and regulating freshwater flows, and forested watersheds are essential for sustaining freshwater supply. The SDGs related to water (SDG 6) and land (SDG 15) explicitly acknowledge the linkages between forests and water. Forest management and planning will increasingly need to allow for the consideration of water-related issues, as well as to strategically implement these issues to optimize watershed services, such as water purification, surface flow regulation and erosion control. Such innovations require an enabling legislative framework, as well as decision makers who understand the functioning of payment for ecosystem services (PES) schemes in the context of forests and water.

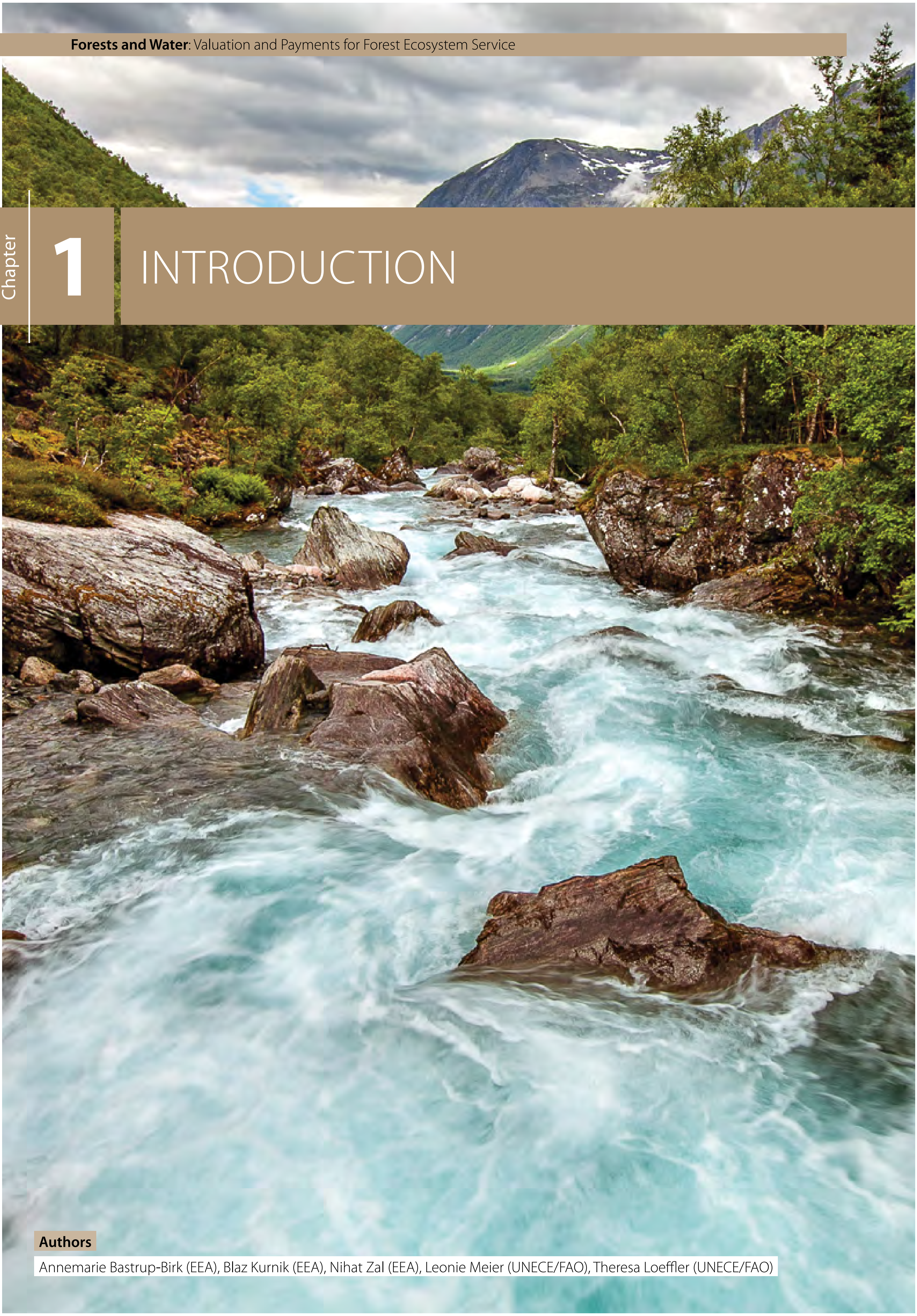
By analysing enabling frameworks at the international, regional and national level, this study shows that countries can build on cross-cutting initiatives and replicate local best practices to counter the sporadic and weak integration of PES legislation at the national level. The amendment and/or integration of existing legislation on ecosystems services and natural resources might be an alternative solution to the development of brand new PES-specific legislation. For instance, the protection and enhancement of freshwater resources can be directly linked to forest management objectives.

Besides promoting an understanding of the wide range of values related to watershed services of forests, the study assesses the governance, design and funding sources of various payments for watershed services (PWS) schemes.

Analysis shows that PWS schemes based on a partnership model are more successful in accessing multiple sources of funding, increasing organizational resilience to changing political support, and ensuring that forest owners and managers engage in these schemes over the long term. Recommendations to make PWS more cost-effective include focusing on a single ecosystem, such as forests, delivering multiple services, such as watershed services, that are sold together or combined in a single credit. Analysis of diverse case studies show that PWS schemes can provide important co-benefits, such as carbon mitigation, biodiversity conservation and social benefits.

Key recommendations:

- Establish platforms for mutual understanding of PES principles and practices to ensure that key authorities responsible for policy-making – including finance and tax authorities – are more forcefully engaged in the dialogue on the development of new forest-related PWS schemes.
- Promote a legal framework that provides guidance and support for forest-related PWS scheme designs that are adapted and appropriate for the local level.
- Strengthen appropriate scientific knowledge, technical competencies and skills, as well as foster stakeholder consultation and participation to overcome limitations in defining, measuring and economically assessing forest-related watershed services.
- Define sound monitoring systems by identifying clear proxy indicators and ecosystem service metrics.
- Focus on ecosystem service bundling for cost-effectiveness, recognizing that forests are a single ecosystem that provide multiple related services that can be combined in a single credit.
- Incorporate measures that fully recognize the potential limitations and challenges inherent in economic valuation, taking account of the multiplicity of values and the potential exclusion of local communities. Equally, the structural factors influencing PES outcomes need to be taken into consideration.



Chapter

1 INTRODUCTION

Authors

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1. Introduction

Overharvesting, habitat degradation, climate change and pollution all pose major threats to forests and the ecosystem services they provide. Forests provide important watershed services, such as water purification, surface flow regulation and erosion control, as reflected in targets 6.6 and 15.1 for SDG 6 (clean water and sanitation) and SDG 15 (life on land).

Payments for ecosystem services (PES) schemes in general, and payments for watershed services (PWS) schemes in particular, provide a mechanism for enhancing the services that forests provide. PES rely on an economic valuation of non-marketed services, such as carbon sequestration and water provision by forests. These schemes make us aware of what is at stake when ecosystems are degraded, and of the costs associated with replacing those services. While the importance of ecosystem services provided by forests are often acknowledged, the economic values of these services remain hard to assess and difficult to monetize. Consequently, their values are often overlooked in economic and political decisions, despite their importance to human well-being and environmental sustainability. The challenge we now face is how to value and properly consider these services in decision-making and ensure sustainable forest management.

Considering the need for establishing an enabling policy environment for the implementation of PES schemes in the UNECE region, the 2015 joint session of the FAO European Forestry Commission (EFC) and the ECE Committee on Forests and the Forest Industry (COFFI) provided a mandate for the FAO and UNECE to undertake this study[1] with the following objectives:

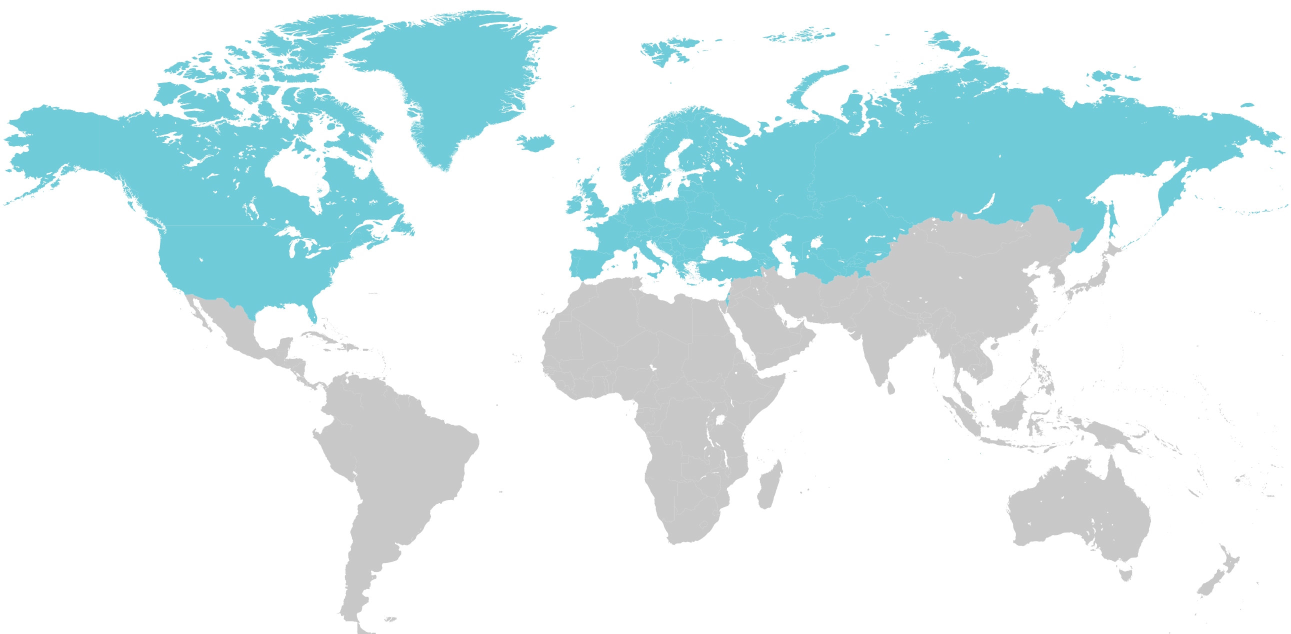
a. Further improve our understanding about the ways in which PES can be applied to forests, in particular focusing on forest's hydrological functions for the mutual benefit of both humans and the environment;
b. Inform readers on the advances and challenges facing PES;
c. Provide practical guidance for policymakers and practitioners to encourage entrepreneurship in this important area.

This study focuses on the 56 member States of the United Nations Economic Commission for Europe (UNECE), which includes States from Europe, North America, the Caucasus and Central Asia, and the Russian Federation (Figure 1.1).

1 Further information on this joint EFC/COFFI sessiom can be found at: http://www.unece.org/forests/silva2015-engelberg.html

FIGURE 1.1

Member States of the United Nations Economic Commission for Europe



EU: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom of Great Britain and Northern Ireland

North America: United States of America, Canada

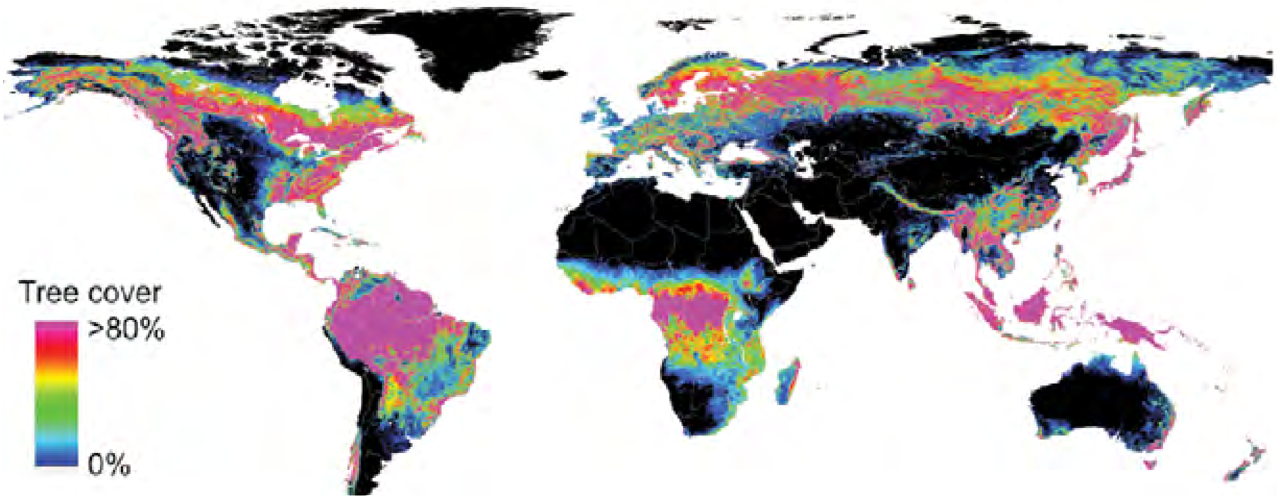
Russian Federation: Russia

Caucasus & Central Asia: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

Other: Albania, Andorra, Belarus, Bosnia and Herzegovina, Iceland, Israel, Liechtenstein, Monaco, Montenegro, Norway, Portugal, Republic of Moldova, San Marino, Serbia, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, Ukraine

FIGURE 1.2

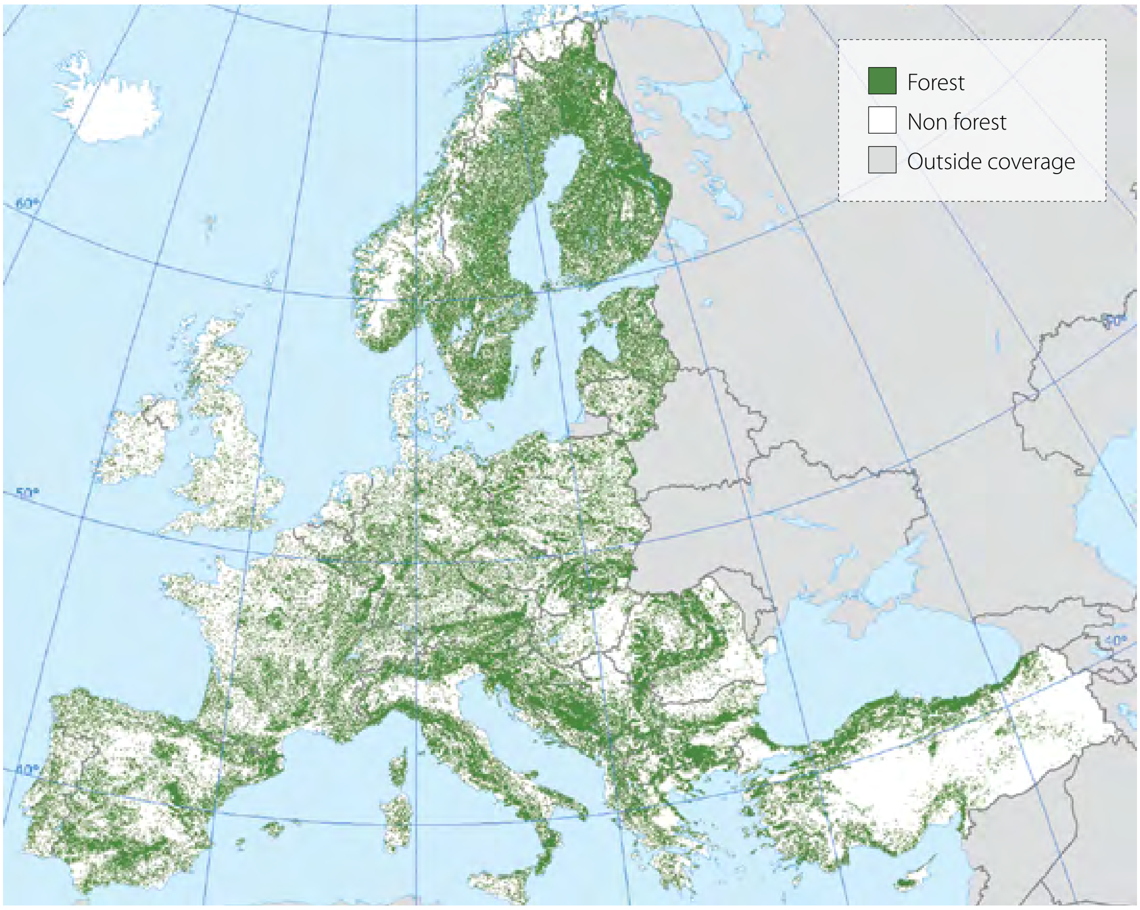
Global tree cover density



Source: Hansen *et al.* (2013).

FIGURE 1.3

Detailed map of forest area distribution in Europe



Source: EEA (2016a).

Globally, forests cover more than 4 billion hectares (ha), which corresponds to 31 per cent of the Earth's surface (Keenan *et al.*, 2015). With 1.9 billion ha, corresponding to more than 40 per cent of the total forest area, the UNECE region has more forests than any other region of the world (UNECE and FAO, 2015). In the UNECE region, three countries, the Russian Federation, Canada and the United States of America account for more than 80 per cent of the region's forest and other wooded land (see Figure 1.2). In Europe, high forest cover is mostly to be found in the less populated northern regions as well as in mountainous alpine regions, such as the Alps and the Carpathians (see Figure 1.3). The dominant forest type in the UNECE region is the boreal coniferous forest. Boreal forests encompass 30 per cent of the global forest area and contain more freshwater than any other biome (Gauthier *et al.*, 2015). The UNECE region also hosts the northern temperate forests located between the boreal forests to the north and the Mediterranean vegetation to the south. A large extent of the northern temperate forests is located in North America and Europe (Frelich *et al.*, 2015).

Governments and societies are increasingly aware of the role that forests play in protecting watersheds, regulating stream temperature, filtering water, preventing erosion and mitigating destructive events, and have thus improved regulation and management of forests. Society as a whole can reap the benefits of forest ecosystem services, but it is often more lucrative to exploit forests in unsustainable ways. Forest owners and managers may not have the resources needed to sustainably manage the supply of ecosystem services – and even when they do have the resources – it may be unfair to expect them to bear the cost and responsibility without support since so many people benefit from these services. PES schemes, however, could support in maintaining or improving ecosystem services.

This report is targeted at policymakers, academics, practitioners and interested individuals, and is structured as follows:

- **Chapter 1** provides an overview of forests and water interaction and maps out ecosystem services. In addition, it provides a brief review of the forest-water regulatory frameworks at the global, regional, and national level, as well as a risk management approach;
- **Chapter 2** follows with a theoretical discussion of economic valuation techniques for water-related ecosystem services, and presents some challenges of valuation;
- **Chapter 3** describes how to overcome some of the challenges of economic valuation and proposes avenues for integrating market-based tools into traditional regulatory frameworks and governance. It also provides a classification for the case studies presented in the following chapter;
- **Chapter 4** introduces a database on PES schemes in the UNECE region, and provides detailed case study applications of forest-water-related PES schemes in the different UNECE sub-regions;
- **Chapter 5** concludes with the challenges and recommendations that will enable policymakers and practitioners across the UNECE region to identify and promote different types of forest-water ecosystem service payment schemes.

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Chapter 2

FOREST AND WATER INTERACTIONS

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2. Forest and water interactions

Water and forests are important natural resources providing food, energy, habitats and many other biological and socio-economic functions. Forests provide a wide range of ecosystem services, which benefit society as a whole and in communities in which they are to be found. Of these, the provision of water services is among the most vital for human welfare (Birgé *et al.*, 2016; M.E.A., 2005; Furniss, 2010). Forests influence stream discharge, precipitation, evapotranspiration (ET), infiltration, groundwater recharge, runoff and water discharge to streams, which are main components of the hydrological cycle (Box 2.1).

Box 2.1

Water retention as example of forest and water ecosystem functions

A correlation exists between forest cover and water availability in watersheds. An example of this interaction is water retention from forests. The European Environment Agency's (EEA) water account database contains 287 sub-basins hosting more than 65,000 catchments; these sub-basins and catchments were selected to assess how forest cover and type affects the amount of water retained by forest ecosystems. Forests retain a relatively high amount of water that is normally less polluted due to natural purification processes and the limited use of pesticides and fertilizers in forested areas. The analysis showed that forested water sub-basins with a forest cover of more than 30 per cent retained 25 per cent more water than sub-basins with lower forest coverage. In sub-basins where forest cover is 70 per cent, water retention is 50 per cent greater than in sub-basins where the forest cover is only 10 per cent. The EEA study found that forest type has an impact on the degree of water retention, *e.g.* coniferous forests retain 10 per cent more water than broadleaved or mixed forests due to higher retention of water by canopy (EEA (2015).

Water and forests are interdependent. For example, forests play an important role in producing and regulating temperature and freshwater flows (Ellison *et al.*, 2017) as they intercept sunlight and regulate temperature, retain water in the forest ecosystem and reduce floods. Moreover, forested watersheds are essential for sustaining freshwater supply. In the United States of America, more than 50 per cent of freshwater supply originates from forests (Johnson and Spildie, 2014; USFS, 2017), and one-third of the world's largest cities depend on protected areas for their drinking water supply (Dudley and Stolton, 2013) (Box 2.2).

Box 2.2

Examples of large cities in UNECE regions that rely on forests for their water supply

Many cities in the UNECE region rely on forests that have been designated for water supply, for instance about 85 per cent of San Francisco's drinking water comes from the Hetch Hetchy watershed in the Yosemite National Park (FAO, 2008). A significant source of water supply for the city of Vienna is located in the Donau-Auen National Park; the remainder is piped from mountain areas, which include protected forests. The city of Sofia relies for much of its water supply on sources originating from two protected mountain areas: the Rila and Vitosha National Park, which comprise protected coniferous forests and deciduous forests of beech. Similarly, the city of Madrid relies on forested mountain areas for the quality and quantity of their water supply. The 15,000 ha natural park of Peñalara provides protection to Madrid's only glacier lake, as well as to the area's wildlife. Despite providing clean water, water-forest interactions have a number of recreational benefits for social health and regulate streamflow and floods. In New Jersey, urban trees and green areas are developed for their storm water retention capabilities (UNECE and FAO, 2015). In addition, many European cities have created green rooftops and walls, improvements to green spaces and storm water systems (Chocat *et al.*, 2001; Stovin, 2010).

It is estimated that the average precipitation for the pan-European[2] region is about 4.1 billion m^3 of water. Almost 64 per cent of this precipitation falls over forested catchments, and about 85 per cent of the river network discharge (1.7 million km of the river network) from 287 major river basins, flow through European forests. In addition, the study assessed that forests accommodate more than half of all lakes (96 000 km^2 out of 185 000 km^2), providing water storage and high recreational values (EEA, 2015).

Climatic variability and land cover/land use controls water supply and flow regimes (Zhou *et al.*, 2015). The UNECE region covers a huge land area, more than 47 million km^2 and comprises boreal, temperate and subtropical climate zones (FAO, 2012). The variety of climate zones, as well as variations in topography, natural ecosystems and how natural resources, including forests, are managed, is reflected in wide temperature spans and in a high diversity of precipitation and temperature regimes. For example, the annual average temperature in the northern hemisphere is about 15.2 °C, in the cold and boreal zone it ranges from +5 to -5 °C, and rises to more than 20 to 35 °C in subtropical climate zones. The UNECE region comprises mainly boreal and the temperate forests. Nevertheless, forests also play a major environmental,

2 Spatial cover of Europe in this analysis is limited by the high resolution layer forest coverage. The HRL forest covers the EU and western Balkans countries. The latter country grouping includes Turkey but not Russia, Ukraine, Belorussia and Moldova.

economic and social role in the Mediterranean regions of the UNECE.

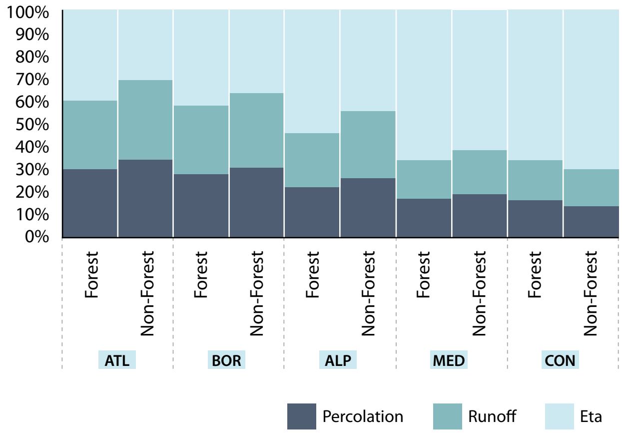
These variations have a large impact in regulating the water cycle. On average, at least 40 per cent of rainfall over land originates from ET and forests play an important role in regulating fluxes of atmospheric moisture and rainfall patterns over land. Transpiration contributes a large share of terrestrial ET, and produces some of the water vapour available for rainfall (Jasechko *et al.*, 2013; Schlesinger and Jasechko, 2014). Figure 2.1 illustrates the relation between yearly average actual ET, percolation and surface runoff for the period 1951-2014 for forests and non-forested land cover. The study was applied on a wide variety of biogeographical regions[3] across Europe. The results show that forest catchments with a forest cover exceeding 70 per cent have a significant impact on actual ET, runoff and deep percolation compared with non-forested catchments at the biogeographical region level. Forest cover provides 4 per cent higher percolation of water into the soil than to non-forests areas, resulting in higher levels of groundwater recharge, which is the main source of drinking water supply in Europe.

Forests slow down surface runoff; forested areas retain 76 per cent of total precipitation from surface runoff, as compared to 28 per cent in the case of non-forested areas (EEA, 2015). Similar results have been achieved for other watersheds in the UNECE region (*e.g.* Zhou *et al.*, 2015). In general, watershed runoff coefficients and flushing ratios correlate highly with forest coverage and watershed slope and area. By means of lower runoff and higher ET, forests regulate the river runoff. Mountain forests level extreme runoff events due to *e.g.* sudden snowmelt by more than 30 per cent in those catchments where forests cover more than 50 per cent of the total catchment area (EEA, 2015). A comparison of the relationship between the runoff and the forest cover indicates that once forest cover exceeds 30 per cent of the area of the sub-basin, forests have an impact on runoff conditions. Each additional increase of 10 per cent in forest cover decreases runoff by 2-5 per cent and thus increases water retention by forests. In addition, when forest cover exceeds 70 per cent of the sub-basin's area, forests retain 50 per cent more water than sub-basins where forest cover is only 10 per cent (EEA, 2015).

The role of forest in the overall availability of water resources and the water balance still requires further research. In general, most forests provide a smaller amount of surface water compared to non-forest lands. However, the impact of a forest on water balance largely depends on the age of the forest, species composition, soil properties, slope, forest

FIGURE 2.1

Water balance of forested vs non-forested catchments in biogeographical regions



Source: EEA (2015).

Note: In the above figure, forested basins are adopted as those where forest cover is higher than 10 per cent. ATL: Atlantic region; BOR: boreal region; Alp: Alpine region; MED: Mediterranean region; CON= Continental region.

location within the watershed and meteorological conditions. These factors must be taken into account when comparing the water balance of forested and treeless areas. Therefore, forest area percentage is not, in itself, a very reliable predictor.

The relationship between forests and water quality is less contested. Forests have an extensive root network and a great ability to generate porous and filtering soils. Forests and their soils act as natural filters, reducing erosion and sedimentation of water courses, and filtering many chemicals. Forest management requires different types of operations, such as creating stands, cleanings, successive thinning and timber transport that can cause considerable disturbance to the soil, depending on the precautions taken while the work is carried out. Overall, forest management regimes do not involve reliance on fertilizer or pesticides, and only rare cases of fossil fuel runoffs or outfalls from domestic sewage or industrial processes (FAO, 2008). Recycling, especially of nitrogen, is important. Under forest cover, nitrate levels are low (Jussy *et al.*, 2002) and similar results are also observed for various pollutants (*e.g.*, pesticides). Forest management is not neutral in terms of water quality, but many factors tend to attenuate harmful effects, particularly as human interventions are less frequent in this sector than in agriculture (Fiquepron *et al.*, 2013).

2.1 Forest and water ecosystem services

The concepts of ecosystem service flows and natural capital stocks are increasingly being used to highlight, measure

3 Biogeographical regions as delineated in the EU Habitats Directive (92/43/EEC). Further information can be found at: http://www.eea.europa.eu/data-and-maps/data/biogeographical-regions-europe-3.

and value the degree of interdependence between humans and the rest of nature. According to TEEB (2010), ecosystem services can be split into four categories which are all based on supporting services, such as primary production and biodiversity. Forests have many positive impacts on the hydrological cycle, and also contribute to conservation and recreation through, among others, water vapour and water purification processes, as well as runoff and erosion control. The interactions between forests and water provide an extensive range of products and services that are of vital importance to the functioning of the biosphere, to society and to human well-being. The four categories below include both forest and water ecosystem services:

1. **Provisioning services**: *e.g.* the recharge of groundwater and provision of clean drinking water from forests;
2. **Regulating services**: *e.g.* buffering and filtering of pollutants from surface waters; the regulation of rainfall and snow melt by forests that reduces surface runoff and discharge that reduce soil erosion and the risk of flooding;
3. **Habitat or supporting services**: *e.g.* the provision of habitats for different species; and maintenance of genetic diversity;
4. **Cultural and social services**: *e.g.* the provision of scenic landscape of forests and water bodies for recreation and leisure activities, as well as high biodiversity.

The approach has been applied to support strategies aimed at maintaining and restoring forest and water ecosystems in Europe (European Commission, 2013, 2014). Several initiatives have been carried out to map and assess ecosystem services from both water and forest ecosystems at the pan-European level (USDA, 2017a, b; Maes J, *et al.*, 2013; Maes J, *et al.,* 2014).

The main aim of forest management is the production and delivery of timber, which may reduce the provision of other ecosystem services, *e.g.* water (Bennett *et al.*, 2009). Delivery of the forest and water-related ecosystem services needs to be more integrated into forest management objectives (*e.g.* Egoh *et al.*, 2012; US EPA 2013; Grêt-Regamey *et al.*, 2014). Forest and water resources are closely linked to services from many other land uses and ecosystems such as crop land and nature areas. Forest land provides both market products and services, *e.g.* commercial timber and wood for fuel, resins, honey, fibres, drinking water and recreational opportunities including the scenic combinations of water bodies and forested landscapes. High-elevation forests are

Box 2.3

Case study: floodplain forests

In most floodplains, natural vegetation consists of dense forests growing alongside streams and major rivers. Only a few areas, such as open water, flood channels, silted up areas and gravel banks, are naturally non-wooded. Floodplain forests are thus among the richest and most complex forest ecosystems and host some of the most species-rich and unique plant, bird or invertebrates of forests (Glaeser and Wulf, 2009; Klimo and Hager, 2001; EEA 2015).

Floodplain forests occur on nutrient-rich soils, which have, gradually been deposited by rivers during flooding. Floodplain forests vary considerably in structure and in the species present in different biogeographical regions of Europe. Rapidly growing softwoods, such as willows and poplars, are characteristic of floodplain forests near rivers with sediment-rich soil. They depend on newly deposited sediments and well-timed floods for their natural regeneration by seed, and the absence of these conditions across most European floodplains has resulted in some species, such as the black poplar, becoming rare (Hughes *et al.*, 2008). Floodplain areas further away from rivers tend to have a lower water table and older soil and are often made up of hardwood tree species, *e.g.* oak, ash or elm, but also contain a high diversity of other tree species. Softwood forests can experience between 60 and 180 inundation days annually, whereas hardwood floodplain forests can be flooded between 1 and 60 days per year in the growing season. Because of their nutrient-rich soils, a good water supply and diversely structured forest strata, old hardwood forests host species-rich and unique plant, bird or invertebrate communities. Natural floodplain forests in northern regions that grow on nutrient-poor organic soils (peat) are dominated by pine, spruce, birch and willow.

The extent of temperate floodplain forests has receded, with only 10 per cent now left uncultivated across the United States of America and Europe (Johnson *et al.*, 2016). Flood regulation by dams or water withdrawal has resulted in some species becoming rare (Hughes *et al.* 2008). Floodplain forests contribute to flood risk management, by modifying the river discharge and protecting societies and economic activities from damage.

particularly important because these headwater catchments store vast quantities of water in the form of snow in winter, which are then gradually released in the spring and summer, thus sustaining downstream water supplies during dry seasons. Forested watersheds reduce storm runoff, stabilize streambanks, shade surface water, cycle nutrients, and filter pollutants (Johnson *et al.*, 2014).

Some of the interacting services from forest and water ecosystems, such as ecotourism, are sources of revenue for forest owners. Other services, such as forests cleaning the water and protecting downstream farmers from floods, droughts and sediments, are not. Forests shelter biodiversity and stock large amounts of carbon from the atmosphere. Many of these forest services are attributed to other sectors of the economy, such as agriculture and tourism. This implies that the forest sector and forest owners are not always remunerated for the services delivered by their forests.

2.2 Forest management impacts on water ecosystem services

The management of natural resources for the provision of ecosystem services is vital for human welfare. One of the primary stressors on water quality and quantity is the conversion of forest land (and other land uses) to urban land and agriculture. As urban populations grow, significant amounts of forests are being converted to urban areas. The challenge is to manage natural resources in a sustainable way while, at the same time, maintaining quality of life. Different forests or forestry practices will increasingly be needed to support future quality water supply. Forest management and planning needs to strategically implement plans to optimize water-related ecosystem services, including issues related to quality, quantity and timing. There is a continued need for an enhanced knowledge base on forest and water interactions at multiple scales, including interactions in small and large watersheds. Emphasis must therefore be placed on creating synergies between forests and water management, and on maximizing ecosystem services in forests, while ensuring that water resources are not threatened.

Forests growing on mountain slopes play a significant role in soil and water conservation, and water and climate regulation. The 2011-2015 Aral Sea Basin Programme demonstrates the importance of establishing and managing forests in upstream mountains where the main rivers are formed to increase possibilities for irrigation downstream. In this case, afforestation in the upper catchment has been shown to be efficient in combating land degradation under such climatic and geographic conditions, as well as producing positive effects for the whole basin (Karthe *et al.*, 2016). A similar situation can be found in the South Caucasus region, as it is dependent on a declining forest cover for ecosystem protection and other water services. In this region there is no formal framework relating to the management of mountain forests.

Against this perspective, different forests or forestry practices will increasingly be needed in the future to support water quality and water supply. Forest management should also take into consideration what is now being done versus what should or could be done in the future.

The way forests are managed, including the selection of tree species, has an important impact on the magnitude of water balance components. There is less water discharge from catchments with forests with fast growing tree species used for commercial timber or bioenergy production than in forests with older plantations and slower growing species (Neary *et al.*, 2009). Plantation management plans must therefore consider this water use through a careful selection of tree species and planting sites to minimize competition between water consumption and forests.

It is usually recommended to manage water resources according to a natural hydrological pattern and processes to avoid any negative hydrological developments impacts that may occur as a result of climate change. This calls for multi-sectoral collaboration between forestry, land management and water resource management to develop adaptive management strategies which address forest, water and land resources.

2.3 Climate change impacts on forests and water interactions

Globally averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of 0.85 °C in the period 1880 to 2012 (IPCC, 2013). Likewise, the average precipitation over mid-latitude land areas of the Northern Hemisphere has increased since 1901. For other latitudes, area-averaged long-term positive or negative trends have low confidence (IPCC, 2013).

Climate change has directly affected, and is predicted to continue to affect, the hydrologic cycle. Its impact is likely to impact forest and water interactions in the UNECE region, such as the quality, the quantity and the timing of streamflows from forests (Furniss *et al.*, 2010; EEA, 2016b). The order of magnitude of future changes might be beyond the adaptive capacity of forests (Keenan, 2015). For instance, the average temperature in many parts of the UNECE region is expected to rise between 1.0 and 3.7°C by the end of the 21st century (IPCC, 2013). Average precipitation rates are projected to decrease in southern parts of the UNECE region but increase in northern parts of the region. In addition to increased temperature, climate change models predict changes in the timing, amount, inter-annual variability of precipitation (snowfall included), and the occurrence of extreme events, including the extent, frequency and magnitude of floods, forest mortality and fire. Changes in hydrology regimes will have impacts on forests and the watershed services they provide and affect water quality, aquatic habitats and species and soil resources (Capon *et al.*, 2013; Sun and Vose, 2016).

These effects will be both direct (*e.g.* effects of elevated CO_2 on forest growth and water use) and indirect (*e.g.* altered disturbance regimes), and will differ temporally and spatially according to forest ecosystem and local climatic conditions, as mediated by local management actions across the UNECE region. The interactions between climate, water and forests are complex and difficult to project or foresee (Vose *et al.*, 2012). However, the boreal biome is expected to warm more than other forest biomes (*e.g.* Beck *et al.*, 2011), resulting in changes that are predicted to include an increased risk of fires, infestations, and the northward expansion and changes in forest stand structure and composition (Kabrick *et al.*, 2017).

Climate change impacts on forests are likely to have negative impacts on the provision of some ecosystem services (*e.g.* reduced water supply due to less precipitation, warm winters without snow might reduce recreational skiing); however, they may contribute to enhanced ecosystem services in other respects (*e.g.* higher temperatures having an impact on tree growth and moving the tree line, thus allowing for increased growth of high-elevation trees). Some areas may be particularly vulnerable because current infrastructure and resource production are based on past assumptions of a stable climate and of steady-state natural resource conditions. Any change in forest ecosystems that affects water resources will typically result in a significant loss of ecosystem services. An independent assessment of future climate change impacts on ecosystem services was performed using an integrated modelling platform developed in the CLIMSAVE project (CLimate Change Integrated Assessment Methodology for Cross-Sectoral Adaptation and Vulnerability in Europe) for the same regions as in the IPCC review (Dunford *et al.*, 2015). According to this study, the provision of ecosystem services in southern Europe is projected to decline across all service categories in response to climate change. Other European regions are projected to experience both losses and gains in the provision of ecosystem services. Northern parts of the UNECE region will see increases in provisioning services arising from climate change and, with the exception of southern parts of the same region, the gains and losses are balanced with respect to the effects of climate change on regulating services. The general pattern shows that positive impacts will prevail in cooler regions in northern Europe (including Alpine Europe), and that mostly negative impacts are projected to occur in warmer regions of southern Europe; a balance of positive and negative effects is expected in temperate regions in continental and Atlantic Europe, but scientists are not in agreement regarding the impact in the latter regions.

Some adverse effects linked to climate change, such as more frequent and stronger droughts, forest fires, storms and insect infestations have already destroyed millions of hectares of forests in the UNECE region (Williamson *et al.*, 2009; Mitchell *et al.*, 2014; Landmann *et al.*, 2015). During the past decade, the UNECE region has repeatedly been affected by droughts and increased risks of forest fires. The severity and frequency of meteorological and hydrological droughts have increased in parts of Europe, in particular in south-western and central Europe. With the exception of northern regions, current studies project large increases in the frequency, duration and severity of droughts in the UNECE region.

Such large-scale disturbances, such as fire, bark beetle outbreaks and defoliating insects, will reduce water uptake by trees, reduce infiltration by the soils, causing an increase in runoff, increases and potentially severe erosion and chemical loading. Another impact would be to further release significant quantities of CO_2. How plants will respond to rising concentrations of atmospheric CO_2 will depend on their ability to use water and nutrient resources efficiently under a changing climate. Elevated CO_2 may reduce tree growth and increase the water use efficiency of some tree species, and result in reduced ET, but the effect on hydrologic dynamics will likely be modest (Keenan *et al.*, 2013; Lindner *et al.*, 2014). Warmer temperature may also modify tree phenology, although the effects on ET are uncertain. If fast growing species and genotypes are planted in large numbers in the future, their demand for water resources could reduce streamflow in some locations. Warmer temperature may also accelerate the rate of nutrient cycling in some systems, promoting increased forest growth and elevated nitrogen levels in streams (Burton *et al.*, 2010; EEA, 2017).

However, many studies conducted in the UNECE region (*e.g.* Williamson *et al.*, 2009; Spinoni *et al.*, 2013; Creed *et al.*, 2014; Bugmann *et al.*, 2015) demonstrate that environmental factors (*e.g.* summer precipitation, summer length, and water residence time) and ecological factors (forest type and age) contribute to variability in the water yield responses to climate warming. Climate warming is projected to affect forest water yields but the effects are expected to vary. A study by Creed *et al.* (2014) indicated that mountainous forests are expected to show the greatest sensitivity to climate warming leading to increased water yields, whereas mixed forests are likely to experience the highest elasticity and stable water yields. The same study also highlights that the forest type appeared to influence the resilience of catchment water yields to climate warming, with conifer and deciduous catchments more susceptible to climate warming than more diverse mixed forest catchments.

Climate change is expected to affect site suitability, productivity, species composition and biodiversity. In some locations, *e.g.* in northern Europe, tree growth is observed to increase due to longer growing seasons, warmer temperature and increased levels of CO_2. Range shifts in forest tree species due to climate change have been observed towards higher altitudes and latitudes (Lenoir *et al.*, 2010; Allen *et al.*, 2010). Species ranges will expand or retract, the geographical location of ecological zones will shift, and forest ecosystem productivity will change (Hanewinkel *et al.*, 2013; Keenan, 2015). This will considerably affect the forest structure and the functioning of forest ecosystems and their services. The most vulnerable forest ecosystems are likely to be boreal, mountain, Mediterranean forests (Gauthier *et al.*, 2015), while temperate forests subject to drier climate may be even more at risk (Zang *et al.*, 2014; Millar and Stephenson, 2015).

Land management initiatives and policies must consider the effects of forests on water under projected climate scenarios at local, regional and continental scales. Forest management provides important opportunities for adaptation and mitigation to climate change. As the impact of climate change will vary locally, forest management needs to be adaptive and flexible to match the capacity of local conditions and management options, as well as respond to the growing need for forest products and ecosystem services. Building on practices that are compatible with climate change adaptation may provide early successes and experience for managers wishing to start the adaptation process, but who have neither sufficient financial resources, time, nor the human resources needed to initiate a major effort. It is very likely that adaptation to climate change will become a standard component of sustainable forest management. Managing forests to increase carbon mitigation may have co-benefits, *e.g.* afforestation may store carbon as well as contribute to erosion control and improve water quality (McKinley *et al.*, 2011).

Forests can be managed to mitigate the negative effects of climate change on water resources and ecosystems, as well as ensure a safe and clean water supply and reduced risk of floods and droughts. This could involve adopting management practices to support species migrations, create porous landscapes, and increase diversity in genetic and species planting. Adaptive management may be imperative, and the best way for managers and planners is to remain informed and use knowledge to shape effective local solutions (Millar *et al.*, 2007).

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Chapter

3 THE ENABLING ENVIRONMENT FOR FORESTS AND WATER

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3. The enabling environment for forests and water

The volume of literature on water-related forest ecosystem services has grown substantially over the past two decades. Some of this literature addresses the increasing use of market-based approaches for supporting the provision of such services, including PES in particular (see Chapter 4 for details on PES and other market-based approaches). These voluntary approaches integrate a robust regulatory framework that has been developed over time in those countries in Europe and North America where water and management of water resources are traditionally regulated by law. International, regional and national levels of regulatory frameworks need to be taken into account when considering the relevant regulatory framework for forest-water interactions – including the foundation for the development of PES mechanisms or market-based initiatives. Although defining a precise and exhaustive regulatory framework for forest-water relationships is challenging, this chapter aims to summarize some of the most significant initiatives that have been developed and adopted in the UNECE region.

The institutional framework for a PES scheme generally involves a combination of organizations, social structures and mechanisms that fosters order and cooperation amongst parties (Smith *et al.*, 2006). The consideration of the multiple social-ecological systems, including the existing institutional settings, represents one of the main challenges linked to the development of PES (Matdzorf *et al.*, 2013; Vatn, 2010). The variety of PES definitions (Wunder, 2005) indicates different approaches and mechanisms building on a broad variety of several institutional set-ups (Matdzorf *et al.*, 2013; Muradian *et al.*, 2010); however, institutional economists normally distinguish among three main types of institutions (Vatn, 2010): (a) hierarchy institutions (*i.e.* command-and-control systems); (b) market institutions (*i.e.* market-based rules for voluntary exchange); and (c) community institutions (informal rules and cooperation-based systems). In practice, PES schemes are hybrid constructs, and depend on a mix of market and non-market policy instruments and the involvement of state as well as non-state actors (Higgins *et al.*, 2014; Muradian and Rival, 2012; Wynne-Jones, 2013).

3.1 International context

A major milestone for forests and water relationships, and the recognition of its global importance, was reached in September 2015 with the adoption of the 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals

(SDGs).[4] The SDGs related to water (SDG 6) and land (SDG 15) explicitly acknowledge the linkages between forests and water. SDG target 6.1 reads: *"By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes"*. Similarly, target 15.1 states: *"By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements."* Forests and water, and payments for ecosystem services also indirectly related to the SDGs on cities (SDG 11), consumption/production (SDG 12), climate change (SDG 13) and the oceans (SDG 14).

However, the acknowledgement of the interrelationship between forests and water in the SDGs is not translated in their practical application, mainly the measuring of the indicators. The proposed indicators for targets 6.6 and 15.1 adopted as part of the global indicator framework by the General Assembly on 6 July 2017 do not adequately address forest-water linkages. Both indicators consider either the extent and/or changes in the extent of ecosystems as total area, but do not account for the distribution of ecosystems within the landscape, ecosystem health, nor the quantity or quality of water regulated by the ecosystems.

In case of the SDG indicator 6.6.1, which considers the change in the extent of water-related ecosystems over time, only forests that are temporarily or permanently inundated with water, such as swamp forest and mangroves are included within the measurable ecosystems. Developed by the United Nations Environment Programme (UNEP) under the UN-Water umbrella, with the support of (among others) the Convention on Biological Diversity (CBD), Ramsar Convention, International Union for Conservation of Nature (IUCN) and the International Water Management Institute (IWMI), the indicator includes wetlands, inland open water

4 For more information please see: www.un.org/sustainabledevelopment/sustainable-development-goals.

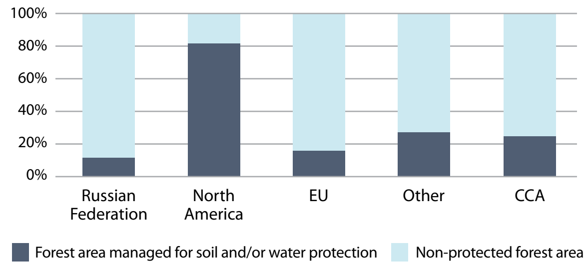
and groundwater aquifers. Although the methodology accounts for a stepwise increase in monitoring the coverage, which can include changes in the spatial extent of water-related ecosystems, the change in the quantity of water contained within these ecosystems and changes in the state of ecosystem health, the timeframe for scaling up from the six pilot test countries has not been defined.[5] Despite a wide recognition of all forests influencing water, especially cloud and mountain, riparian and dryland forests, there is no supporting evidence that forests, more broadly, will be included in 6.6.1; in fact, it is stated that the assumption is that non-wetland ecosystems will be covered by other targets and indicators (UN-Water, 2017).

The Food and Agriculture Organization (FAO) of the United Nations, as custodian of indicator 15.1.1 (Forest area as a proportion of total land area), has proposed using the methodology of the Global Forest Resources Assessment (FRA) to provide a measure of the relative extent of forest per country. The rationale for the indicator presented by the FAO was that the changes in the forest area reflect the demand for other land uses and may identify unsustainable practices in the forestry and agricultural sectors. The indicator does not include disaggregated information on the state of forest health, or the ecosystem services provided. The 2015 edition of the FAO FRA reported that 25 per cent of forests globally were protected for soil and/or water conservation. For the UNECE region, 38.7 per cent of forests have a management objective for soil and/or water conservation (see Figure 3.1). This is primarily due to North American countries where over 80 per cent of forests are managed to protect soils and/or water. In Europe, where most forests are under private ownership, only 12 per cent of forests are reported to be managed for soil and/or water protection, and in the Russian Federation only 10.6 per cent. Although the use of this indicator in the context of the SDGs has some limitations, its application for measuring the target 15.1, or creating of synergies between indicators 6.6.1 and 15.1.1 is a step in the right direction.

Forests figure prominently in Article 5 of the **United Nations Paris Agreement**[6] (2015), particularly with respect to their role as sinks and reservoirs of greenhouse gases; however, the document refers also to the need to incentivize both non-carbon and carbon benefits. While water-related issues are not explicitly mentioned, it can be assumed that adapting forest management to climate change is closely linked to water management, including its capacity to: (a) facilitate water filtration and increase water availability for multiple uses; (b) provide regulation services with regard to extreme

FIGURE 3.1

Percentage of forest area managed for soil and/or water protection



Source (Forest Resources Assessment, 2015).

events; and (c) address any as other risks associated with changing precipitation patterns and rainfall distribution (*e.g.* flood risks). The idea that water is among the most impacted natural resources, but paradoxically also one which can provide solutions to challenges deriving from climate change was given prominence during the Action Day for Water at the 22nd Conference of Parties to the UN Framework Convention on Climate Change (Marrakech, November 2016).

Within an international context, several other initiatives have been defined to address forest-water issues. Although not specifically dealing with the interactions of forests and water, the **Ramsar Convention** (1971) remains a key milestone, in particular with regard to the introduction of wetland management plans. Article 2 of the Convention suggests that hydrology is among the criteria that should be taken into account for the identification/designation of Ramsar Sites (*i.e.* Wetlands of International Importance), thus pointing to the linkages between wetlands and surrounding forests. Article 3 invites Parties to implement their planning to promote the wise use of wetlands in their territory, suggesting that the proper use and conservation of wetlands must also include forest areas in the same watershed/area, considering the impacts that management of one area may have on the other. Connections and integration of wetlands, water, and forests are more evident in many of Ramsar's Wise Use Handbooks. For example, Handbook 2 recognizes the importance of wetlands as well as agriculture and forestry systems, and advocates for policy and management coordination to minimize the adverse effects on water resources due to inappropriate land management. Similar concepts are also confirmed in Handbook 3; Handbook 7 calls for the integration of policies, regulations and guidelines on land uses on river systems and associated wetlands. Three different types of forest are located within Ramsar sites: Intertidal forested wetlands (*e.g.* mangrove swamps); freshwater, tree-dominated wetlands; and forested peatlands. At present, about 30 per cent of all Ramsar sites are predominantly one of these three types of forested wetlands – 1,045 sites covering 124.8 million ha,

5 The six pilot countries are Bangladesh, Jordan, the Netherlands, Peru, Senegal, and Uganda.

6 For more information please see: http://unfccc.int/paris_agreement/items/9485.php.

i.e. 40 per cent of the total area covered by Ramsar sites worldwide. In addition, many other Ramsar sites include different (*i.e.* non-wetland) forest areas.[7]

In a similar way, the **Convention on Biological Diversity** (CBD) implicitly recognizes that forests play a pivotal role in the hydrological cycle, and includes many policy linkages between forests and water in CBD decisions VI/22 and IX/5 on forest biological diversity; decisions IV/4 and IX/19 on inland water ecosystems; and decision V/6 on the ecosystem approach (Blumenfeld *et al.*, 2009).

Additional inputs have been provided by the UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes **(UNECE Water Convention)** (1992) that is intended to strengthen national measures for the protection and ecologically sound management of transboundary surface water and groundwater. In the same year, the Dublin Statement on Water and Sustainable Development was approved at the International Conference on Water and the Environment. In addition, the Fourth UNECE Water Convention meeting (Bonn, 2006) adopted a document on "Recommendations on payments for Ecosystem Services in Integrated Water Resources Management". The document includes a set of strategic, rather than technical, recommendations for the various steps involved in the establishment and operation of various schemes for water-related PES.

Over the past 15 years, policymakers have begun to pay more attention to forest-water linkages at the global level. Two policy declarations highlight the growing concern over the role of forests in water cycle regulation. The first, the **Shiga Declaration on Forests and Water**, was approved at the International Expert Meeting on Forests and Water in 2002, which was held in preparation of the Third World Water Forum in Kyoto (Box 3.1) and has a global scope; the second declaration, the **Warsaw Resolution 2 on Forests and Water** of the Ministerial Conference on the Protection of Forests in Europe (2007), is aimed at the regional level (Box 3.2).

The Forests and Water Agenda made a relevant contribution to the international focus on forest-water interactions and the importance of forest resources for the

Box 3.1

Shiga Declaration on Forests and Water

The Shiga Declaration on Forests and Water[8] was approved at the International Expert Meeting on Forests and Water held in Shiga (Japan) in 2002. The Declaration was intended as a contribution to the discussion and outcomes of the 3rd World Water Forum (2003). It identified five key issues: (a) promoting the development and the wider adoption of holistic approaches to forest and water management that integrate the needs of people and the environment; (b) improving understanding of the bio-physical interaction between forests and water; (c) improving understanding of the cultural and socio-economic impacts of different forest and water policies and management practices; (d) developing better mechanisms for managing upstream/downstream linkages and interactions; and (e) enhancing knowledge and information sharing.

Box 3.2

Warsaw Resolution 2 on Forests and Water of the Ministerial Conference on the Protection of Forests in Europe

Adopted in 2007 by the Ministerial Conference on the Protection of Forests in Europe, Warsaw Resolution 2 on Forests and Water[9] recognizes the close interrelation between forests, forest management and water. Under this resolution, signatory countries and the European Commission committed themselves to: (a) promote sustainable forest management practices in relation to water (*e.g.* maintenance and enhancement of the protective functions of forests, afforestation/reforestation and restoration of degraded forests); (b) coordinate policies on forests and water (*e.g.* improving institutional arrangements, management of forests and water at the transboundary watershed level, education, training, research and extension services to promote knowledge and understanding of forest and water interactions, and increase awareness of the relationship between forests and water); (c) adopt appropriate policies and strategies to mitigate the potential climate change consequences on forest and water interactions; and (d) assess the economic value of forest services related to water, and incorporate this value into policies and set-up tools/mechanisms for internalizing such services, thus making a financial contribution to sustaining forest management.

7 For more information please refer to the Ramsar Sites Information Service, https://rsis.ramsar.org.

8 For more information please see: www.rinya.maff.go.jp/faw2002/shiga.html.

9 For more information please see: www.foresteurope.org/docs/MC/MC_warsaw_declaration.pdf.

regulation and supply of high quality water. Since 2002, the Agenda has committed to a better understanding of forests and water links and their incorporation in practice and policy. It now includes over 30 partners representing international organizations, academia, civil society, non-government organizations and the private sector. Under the leadership of FAO, the Agenda has developed the document **Forests and Water: A five-year action plan**[10], launched during the International Forests and Water Dialogue at the 14th World Forestry Congress in Durban (South Africa), held in 2015.

3.2 Risk management in a changing climate

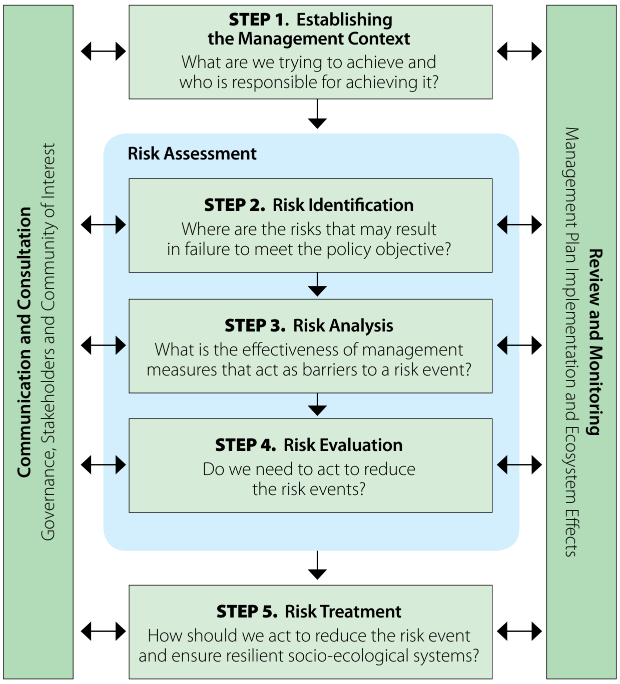
In order to protect ecosystems and ensure the delivery of their services, forest management would benefit from the adoption of an internationally recognized and credible standard that focuses on the reduction of risks to ecosystem health. The ISO 31000 Risk Management Standard (ISO, 2009) has been used across diverse sectors to analyse policy effectiveness by establishing the risk associated with the "residuals" (*i.e.* what is not managed) of the system of management measures that have been put into place to ensure the policy objective is met (Figure 3.2). The system of management measures includes the amount of human activity that is permitted by governments, and the management measures put into place to prevent or mitigate risks associated with human activities. In ISO 31000, the risk is failing to meet the policy objective. The risk of failure is analysed in relation to ecosystem constraints (*i.e.* the available science), and the performance of the system management measures designed to ensure that we continue to operate within ecological constraints (*i.e.* the management). To be effective as an ecosystem approach, the science and management must be explicitly linked in this manner (Creed *et al.*, 2016a).

Creed *et al.* (2016b) showed how the ISO 31000 Risk Management Standard (Figure 3.2) and its Bowtie Risk Analysis Tool (IEC/ISO 31010, 2009) (Figure 3.3) could be used to manage risks to forest water resources through the following steps.

In the "bowtie" risk analysis tool represented in Figure 3.3, the science-related terms are defined as follows: drivers are social, cultural, economic, and political influences that drive human activities; pressures are physical, chemical, or biological agents that are introduced into the ecosystem as the result of human activities that trigger an undesirable effect; effect is the risk event that results because of the residual pressures after implementing existing management measures; impacts are potentially harmful impacts that occur as a result of the undesirable effect; and consequences are the societal outcomes of the impact. Similarly, the management terms are as defined as follows: prevention controls act to reduce the effect; mitigation controls act to decrease the severity of the impacts as a result of the effect, and escalation factors are

FIGURE 3.2

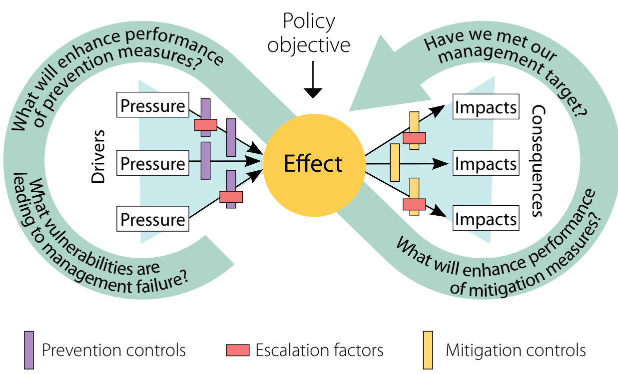
The ISO 31000 Risk Management Standard for the management of risks to forest ecosystem



Source: Figure adapted from Cormier *et al.* (2013).

FIGURE 3.3

The ISO 31010 Bowtie Risk Analysis Tool for evaluating the performance of the management system



Source: Creed *et al.* (2016b).

10 For more information please see: www.fao.org/3/a-be803e.pdf.

outside influences (*e.g.*, climate change) that undermine the performance of prevention or mitigation controls (Creed *et al.* 2016a).

STEP 1. Establish the management context: "What is the management target, what is the risk, and who is responsible for managing the risk"? Here, we need clear policy objectives for forest-water ecosystem services (ES), and we need to define realistic boundaries for the forest-water ES management context (*e.g.* including spatial and temporal lags) (Fremier *et al.*, 2013).

STEP 2. Risk identification: "Where are the vulnerabilities in the ecosystem that may result in an intolerable risk of failing to meet the policy objective"? Here, to identify the risk, we need a predictive understanding of the causal links among pressures (*i.e.* forest management activities), effects (failure to achieve management target), and impacts (consequences of failure to achieve management targets). To achieve this predictive understanding, models will need to be developed that reveal the pathways and their interactions and feedbacks among the pressures-effects-impacts continuum, and that incorporate complex behaviour, including thresholds, tipping points, and regime shifts into forest ecosystem monitoring and assessment programmes (Kimmins, 2002; Hodgson *et al.*, 2015; Yeung and Richardson, 2016).

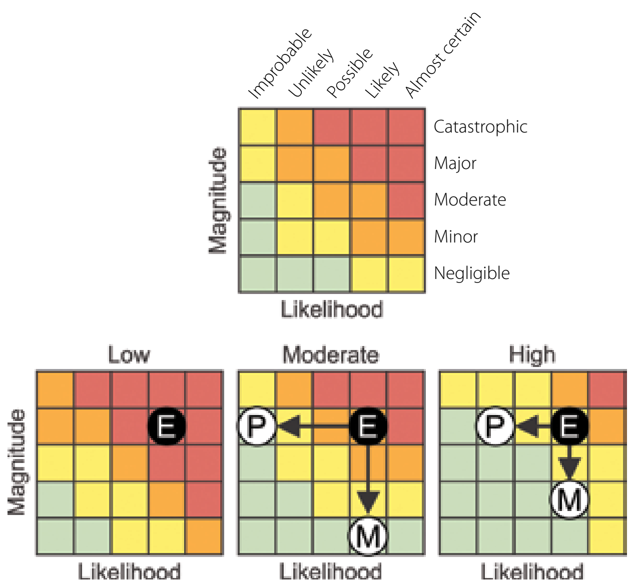
STEP 3. Risk analysis: "What is the effectiveness and compliance/adoption of management measures that act as barriers to the risk event"? Here, we need to analyse the system of management measures that collectively act to reduce the risk to a tolerable level. This formal integration of science (Step 2) and management (Step 3) allows forest managers to identify potential weaknesses in the management system. To conduct this analysis, we need to build inventories of regulatory and voluntary management measures, collect data on their compliance and adoption, and assess their effectiveness. Furthermore, we need to examine the interactive effects of the science and management on the entire suite of ecosystem functions; this includes potential synergies where prevention and mitigation of effects on one ecosystem function lead to improvements in other ecosystem functions, and conversely trade-offs where prevention and mitigation of effects on one ecosystem function lead to the deterioration of other ecosystem function and associated service(s) is protected at the cost of another.

STEP 4. Risk evaluation: "Do we need to change the management system?" Here, we need to evaluate society's tolerance to risk. Risk criteria are used to reach a common understanding that is based not only on ecological outcomes but also social and economic consequences of preventing or mitigating the damage. In Figure 3.4, a risk-tolerance matrix shows the likelihood of the risk on one axis and the magnitude of risk on the other axis, with the risk criteria defining when society deems no management measures are required (green); existing management measures are adequate (yellow); existing management measures need enhancement (orange); or additional management measures are needed, or the human activities must stop (red). This is where the management focus switches from vulnerabilities of the ecosystem *functions* to vulnerabilities of the ecosystem *services* that benefit society. Based on the placement of the effect within the risk-tolerance matrix, the degree of management intervention needed to reduce the risk becomes apparent (Creed *et al.*, 2016a). There is uncertainty both in the science measurements needed to estimate the cumulative pressures and in the management measurements needed to assess the performance of the system of management measures used to reduce the cumulative effects. It is important to incorporate these uncertainties in risk management by setting relatively low thresholds of risk tolerance (ICES 2015).

STEP 5. Risk treatment: "How do we change the management system to reduce the risk to a level consistent with societal values"? This is where the decision makers act, by stopping forest management activities or by changing the system of management measures to enhance prevention or mitigation of effects. Governments need to develop strategies to incentivize people to prevent effects and mitigate impacts of forest management activities.

FIGURE 3.4

Risk-tolerance matrices depicting the likelihood and magnitude of the effects of a risk event



Source: Creed *et al.* (2016a), adapted from ICES (2014).

Note: Coloration within the matrices indicates the level of change required of existing management measures, from red (not tolerable, management measure needs to be changed) and orange (new management measure needed) to yellow (existing management measure adequate) and green (no management measure needed). An example showing an effect (E) that is located within the risk matrix in which new prevention measures (P) are needed to reduce the likelihood of the effect or new mitigation measures (M) are needed to reduce the magnitude of the impact.

The ISO 31000 risk management standard adopts a philosophy of "continuous improvement", where an iterative review of the performance of the management system is undertaken and, if necessary, steps are taken to improve the performance of the management measures to reach the management target (and achieve the policy objective). Global efforts and collaborations are needed to bring together a community of experts to help customize tools to implement an ISO 31000 risk management standard approach to integrate forest water-related ecosystem services into forest management strategies.

3.3 Regional context - European region

With regard to the European context, efforts to broaden recognition of the role of forests in water provision and regulation, as well as soil erosion control, began as early as 1950 when FAO's European Forestry Commission (EFC) examined issues related to soil rehabilitation and conservation through the rational use of water resources in basins. This resulted in the establishment of the Working Party on Torrent Control, Protection from Avalanches and Watershed Management. The working party was renamed the Working Party on the Management of Mountain Watersheds (WPMMW) in 1970, and placed its main focus on the role of forests and trees in the management of mountain watersheds, including their contribution to soil conservation, water management, disaster risk reduction/management, and restoration of degraded lands in upland watersheds.[11] The WPMMW has been tasked to engage EFC member countries to exchange information on forest and water policies, and watershed and risk management practices, as well as to highlight gaps in research, policy and practice (Hofer and Ceci, 2012). The WPMMW has managed to stay active for over 60 years by continuously adapting to relevant issues of global importance. It currently works to promote sustainable development in mountain watersheds in order to enhance resilience to climate change and natural disasters, and to ensure the long-term provision of environmental services by watersheds in both upstream and downstream areas.

As the Alps are widely thought to be the "water tower" of Europe, water figures prominently among the 12 themes included in Article 2 of the **Alpine Convention** signed in 1991 by the eight states of the Alpine arc and the European Community. Signatory Parties are supposed to take measures and coordinate their policies in this field but no specific protocol has yet been developed. With reference to water, the Alpine Convention aims to conserve or re-establish healthy water systems by preserving water bodies from

11 For more information, please refer to the EFC-WPMMW website: http://www.fao.org/forestry/37705/en.

pollution, adopting natural hydraulic engineering techniques and using water power in a manner that combines the needs of both local communities and environmental resources (Permanent Secretariat of the Alpine Convention, 2009). A dedicated platform on water issues was created at the 10th Alpine Conference (2009) to implement recommendations and objectives identified in the second report on the State of the Alps on "Water and Water Management Issues". Article 8 of the Mountain Forest Protocol, *i.e.* the Protocol on the implementation of the Alpine Convention relating to mountain forests, states that the provision and regulation of water resources as among the most important elements in the social and ecological character of mountain forests. The Protocol also calls for the adoption of appropriate management measures to ensure forest effectiveness for water resources.

Additional subregional conventions on water-resource management in Europe include specific initiatives for the management of transboundary water bodies. Two major examples include the **Danube Protection Convention** (1994) that has been signed by eleven countries (plus the European Community) and operates under the supervision of the International Commission for the Protection of the Danube River (ICPDR), and the **Convention on the Protection of the Rhine** (2003) that has been signed by five countries (plus the European Community) and operates under the supervision of the International Commission for the Protection of the Rhine (ICPR). Both initiatives have defined specific measures for river basin management and cooperation for monitoring operations by employing integrated transboundary assessment techniques.

Many of these conventions contribute to the implementation of the **European Directive 2000/60/EC (EU Water Framework Directive, WFD)**. Water legislation in the **European Union (EU)** was first introduced in the 1970s and includes many Directives[12] regulating the use and protection of water resources. In 2000, the EU WFD established the framework for action on water policy, and attempted to set an integrated approach to the protection, improvement and sustainable use of Europe's rivers, lakes, estuaries, coastal waters, and groundwater. EU member countries are requested to adapt domestic laws on water issues to conform to this Directive. In particular, the EU WFD defines that planning and implementation of measures to ensure the protection and sustainable use of water are undertaken within the framework of the river basin.[13] Notwithstanding this, decisions shall be made at a scale that is as close as possible to the locations where water is affected or used.

Article 5 of the EU WFD also requires each member country to undertake a study of river basin districts[14] within its territory in order to assess its characteristics and the impact of human activities on surface and groundwater resources within the basin, and conduct an economic analysis of water uses. The study is to be updated every six years. Member countries shall also establish a register of all areas lying within each river basin requiring special protection under EU legislation on the protection of water or the conservation of habitats and species dependent on water (Salman and Bradlow, 2006).

Water policy in the EU is not a stand-alone policy and shall be integrated with EU policy in other areas, including energy, climate change, transportation, agriculture, regional policy, fisheries and tourism.[15] Additional EU Directives relevant for forest-water connections include Directives on Habitats (Directive 92/43/EEC) and Birds (Directive 2009/147/EC). These Directives focus on conservation measures and the management of endangered species and habitats, including those related to wetlands and forests. An additional Directive, the Floods Directive (2007/60/EC) was designed to help member countries prevent and limit floods and their damaging effects on human health, the environment, infrastructure and property. The latter Directive also takes into account potential effects due to climate change and the adoption of sustainable land-use practices, including forest management measures. Other relevant EU Directives include the Groundwater Directive (Directive 2006/118/EC) and the Environmental Quality Standards Directive (Directive 2008/105/EC), as amended by Directive 2013/39/EU to redefine the list of priority substances causing water pollution.

In many countries, forest and water policies and regulations have long been shaping forest programmes. This has been the case in countries such as France, Italy and Switzerland, since the 18th century, especially for protection purposes in mountainous areas (Zingari and Achouri, 2007). Only in the past few decades, however, has the focus on pure hydrological protection been replaced by a more inclusive approach embracing environmental issues, land use and watersheds (Zingari and Achouri, 2007). The following sections will provide examples of other regional and national enabling frameworks and experiences related to forest-water management. The list is not intended to be exhaustive, or to present exemplary cases but rather aims to provide an overview of different initiatives in different contexts, covering different geographical and ecological conditions (*i.e.* Mediterranean, Temperate and Boreal) within the UNECE region.

3.4 Regional context - Eastern Europe, Caucasus, Central Asia and Western Balkans

As in the rest of the world, the general trend is a move to what is now referred to as integrated water resources management. This implies, for example, that rivers and lakes should be managed as part of a whole basin, including its land area. An overview of the latest water policy developments in Eastern Europe, Caucasus and Central Asia can be found in UNECE (2016). This overview shows that although some progress has been made, integrated water resources management remains a distant objective. In fact, there is a general lack of integrated policy-making in countries of the former Soviet Union. This report will not go into any details on this issue but in most of these countries there is a separation between policy-making for forestry and water management. Water and forest management apply command and control policy instruments that are mainly grounded in a sectoral perspective. In the Russian Federation, 100 per cent of forests are publicly owned, as is the case in the other independent republics of the former Soviet Union. The Baltic States were an exception as forests were to a certain degree privatised after the dissolution of the Soviet Union. In the western Balkans, the share of private forests varies between 10 per cent (Former Yugoslav Republic of Macedonia) and 47 per cent (Serbia).

On a more positive note, several countries have moved towards basin management and are engaged in a cross-sectoral dialogue on policy-making in this area. However, much more needs to be done. In analyses of conditions

12 These include, among others, the: Council Directive 75/440/EEC, Surface Water Directive; Council Directive 76/464/EEC, Dangerous Substances Directive; Council Directive 80/778/EEC, Quality of Water Intended for Human Consumption; Council Directive 91/271/EEC, Urban Wastewater Treatment Directive; Council Directive 91/676/EEC, Nitrates Directive; Council Directive 98/83/EC, Nitrates Directive.

13 EC Water Framework Directive Preamble defines a river basin as: "the area of land from which all surface run-off flows through a sequence of streams, rivers, and possibly lakes into the sea at a single river mouth, estuary or delta" i.e. (art. 2) an area of land that forms a natural basin.

14 According to the EC Water Framework Directive (art. 2), "River basin district" refers to the administrative unit that may comprise more than one river basin.

15 EC Water Framework Directive Preamble, recital 16.

for the establishment of PES mechanisms in the Russian Federation and Ukraine (Bobylev and Zakharov 2009, Rubel 2012), the conclusion arrived at was that the framework legislation in these two countries was not adapted to PES. Rubel (2012) analysed in detail the legal and institutional conditions needed for the introduction of PES in Ukraine, and concluded that, in theory, it is possible to make a direct link between payment for the use of water and financing of water protection measures in Ukraine's water code. However, the legal basis to develop this link needs strengthening. Different fees charged for water use and pollution are partly used for environmental protection linked to water management but the link needs to be strengthened so that more taxes and fees can be used for water protection. The result is that funding for water management measures is expected mainly from the state budget. Rubel (2012) made recommendations on what is needed to create an enabling environment for the development of PES. These include the introduction of the category of PES, and the development of a corresponding opportunity for transfer of funds in the environment, financial and tax legislation of Ukraine.

Bobylev and Zakharov (2009) came to similar conclusions in the case of the Russian Federation. In 2017, Russian President Vladimir Putin approved a list of actions proposed by the State Ecological Council in December 2016 that includes references to establishing national approaches to estimate environmental services of forests and increased use of "green" economic instruments, as well as giving form to Russia´s international activities in the area of PES (Sergey Bobylev, personal communication).

In the three South Caucasus countries of Armenia, Azerbaijan and Georgia, a number of legal, institutional and other bottlenecks for sustainable forest policy, including the estimation and funding of ecosystem services, were identified by Adeishvili (2015). A key conclusion was that capacity building and basic investigations were needed to develop an economy that takes into account the value of ecosystems and biodiversity. Even if the Armenian government approved a law on innovative economic instruments in the environmental sector in 2013 (Burbridge *et al*, 2015), the three countries are quite distant from applying PES in the forest/water sectors.

Western Balkan countries are likely to have a better legal background for the application of PES schemes following their closer alignment with EU legislation (*e.g.* Sekulic 2012 and Ministry of Sustainable Development and Tourism 2014). However, the development of payment for ecosystem services is still very limited.[16]

The main approach for the protection of water bodies in Eastern Europe, Caucasus and Central Asia is the protection of river banks and lakes through the establishment of water protection zones and strips (the equivalent Russian terms are "vodookhrannaya zona" and "vodookhrannaya polosa"). For example, the Ministry of Agriculture of Kazakhstan issued an order № 19-1/446 (2015), referring to the 2003 Water Code, which establishes water protection zones of 300-1000 m around rivers and lakes with specific management rules and water protection strips where economic activities are prohibited with a minimum of 35 m bordering the water bodies. The ministerial order sets up the procedure for establishing management rules of water protection zones.

However, even in cases where legislation is in place, the system of water protection zones and strips has been shown ineffective in many instances; examples of this can be found in Rubel (2012).

In terms of capacity building, significant efforts have been made by mainly international projects to build regional capacity on PES. Examples include:

- Between January 2012 and June 2013, the Regional Environmental Centre for Central Asia (CAREC) carried out a project entitled "Capacity development and networking on PES in Central Asia and Azerbaijan". The project covered water-related ecosystem services, including water quality and quantity, and aimed to promote PES in policy-making in Tajikistan, Uzbekistan and Azerbaijan (Burbridge *et al*, 2015).
- The Regional Environmental Centre for South Caucasus implemented a project entitled "Mainstreaming of biodiversity values into decision-making at various levels of governance in South Caucasus".[17]
- The GEF-WWF project "Fostering payments for environmental services in the Danube basin"

Other projects and initiatives address the economic valuation and application of PES in protecting biodiversity. An extensive account can be found in Burbridge *et al* (2015). However, in spite of these efforts PES schemes remain very rare in the region.

3.5 National context - Italy

According to Act 36/1994, surface and underground water in Italy is State-owned, while private water ownership may occur only if rain is collected on private land. Public ownership of water stems from the strong connection established between water services and forested mountain areas: almost two-

16 An example of this can be seen in the case of the Former Yugoslav Republic of Macedonia, available at: http://biodiverzitet-chm.mk/?page_id=2256&lang=en).

17 More details on this project can be found at: http://www.rec-caucasus.org/n.php?id=1455148013&lang=en.

thirds of the national land surface consists of mountain areas, and more than 66 per cent of national forests are located in areas at altitudes above 500 m, 45 per cent of which with slopes steeper than 40 per cent (INFC, 2005a). The national government has historically defined a set of regulations to prevent deforestation and forest degradation processes, thus limiting hydrogeological risks and maintaining a viable mountain environment (Pettenella *et al.*, 2012).

One of the first among these regulations, the "Forest Act" (Decree 3267/1923), defined restrictions on forest land use and conversion, imposing hydrogeological constraints to prevent soil erosion and regulate the water cycle. Such restrictions still apply (via subnational forest regulations) in 87 per cent of Italy's total forest area, with some regions in the North (Trentino Alto Adige and Veneto) and Centre (Umbria and Tuscany) totalling more than 95 per cent. Constraints also refer to other wooded lands, but with a lower incidence (49 per cent) (INFC, 2005b). In principle, the Act also established a compensation fund, but in practice the lack of public financial resources has limited its use (Pettenella *et al.*, 2012). Ten years later, in 1933, a Water and Hydropower Act (Decree 1775/1933) established that hydropower companies have to pay a compulsory fee per kilowatt installed in their power plants (about 7.0 €/kWh). Money collected is then transferred both to the municipalities included in the catchment basin and those downstream, where water is reintroduced in the riverbed, and invested in local public services. In many mountainous areas, these funds constitute an important source for local administrations and, in some cases, have been used to enhance forest management operations (thinning, forest road maintenance, conversion into high forests, *etc.*).

After a number of minor amendments and regulations, the national regulatory framework was further enriched by the approval of the Water Quality Act (Law 183/1989) and Law 36/1994 (also known as Galli's Act, taken from the name of the main proposer of the law). The latter introduced the concept of catchment area compensation, even though it focused only on public or collective lands following an environment protection principle already incorporated by Law 183/1989. The Law 36/1994 has been fully implemented at a local scale by only three regional administrations in northern Italy (Piedmont, Emilia Romagna and Veneto), and has therefore been very limited. Mechanisms in place define that a certain percentage of water tariffs, collected by the Public Water Authorities, is transferred back to a consortia of municipalities in mountainous regions of the country. The funds shall be used for maintenance and conservation of the mountain areas that contribute to water provision, including (in principle) forest areas (Gatto *et al.*, 2009).

Italy has adopted the EU WFD through Legislative Decree 152/2006; the latter confirms the three driving principles of the Directive itself, namely the "full-cost-recovery principle"; the "polluter-pay-principle"; and the "access-right-guarantee principle" (Kissling-Naf and Kuks, 2004). In particular, the "full-recovery-cost" key concept has been an important step in recognizing the role and costs of ecosystem services on water supply quality (Pettenella *et al.*, 2012). This may be further reinforced by the approval of environmental norms linked to the 2015 National Budget Law, which calls for the development of environmental accounting and PES mechanisms, also with regard to water resources.

3.6 National context - Sweden

Although water is not considered a scarce resource in Sweden, issues related to water and water quality have received increased attention in the course of the past decade (Sandström *et al.*, 2011). According to Ring *et al.* (quoted in Lestander *et al.*, 2015) more than 50,000 lakes and 290,000 km of streams are located within productive forests and involve a wide array of different actors, both as users and owners/managers of water resources. Potential impacts of forest operations and management choices (*e.g.* harvesting, fertilization, road building, *etc.*) on hydrological issues and biological and chemical features of water resources are reported by a number of studies (Kreutzweiser *et al.*, 2008).

Forest management in Sweden, including forest policy and legislation, has traditionally been driven by timber production, economic aspects and profitability, and management models. Forest management has aimed to supply the forest industry with raw materials and has largely been based on clear cutting and conifer monocultures (Brukas and Weber, 2009). The Forestry Act, which stipulates the legal requirements for the practical management of forests, was first passed into law in 1903 and has since been updated several times. The Act is a comprehensive piece of legislation and balances relevant economic, ecological and social interests (Royal Swedish Academy of Agriculture and Forestry, 2009). In 1993, a major review of the Forestry Act took place, putting in place the so-called Swedish Forestry Model, *i.e.* production objectives were complemented with environmental and conservation concerns that should be regarded as equally important (Appelstrand, 2012). Within this shift towards (some) deregulation and multi-purpose forest management (Nylund, 2009), the Act builds on the principle of "Freedom with responsibility", *i.e.* normative requirements have been made less strict, and the responsibility for balancing production, environmental, and social values has been shifted towards private actors (Beland Lindahl *et al.*, 2015).

Although the Swedish Forest Act does not specifically refer to water, the Swedish Forest Agency's prescription to Section 30 of the Forestry Act aims to avoid/limit damages on valuable ecosystems and resources due to any type of forestry operation (Keskitalo and Pettersson, 2012). This includes, among others, the conservation of buffer zones, prevention of nutrient runoff and sediment loads into water bodies and maintenance or improvement of water quality (Royal Swedish Academy of Agriculture and Forestry, 2009). In addition to the Forestry Act, the Swedish Forest Agency is also responsible for enforcing the Environmental Code; this includes requirements for operators to take into account any activities that might have an impact on environmental resources, including water resources (Swedish Ministry of the Environment and Energy, 2000).

Moreover, in 1999 the Swedish parliament adopted 16 Environmental Quality Objectives to be met by 2020. Sustainable forest management is one of them, and several other objectives are to varying degrees linked to forests and water. For example, Objective 3 on Natural Acidification could be addressed by managing the intensity of forest operations and, in particular, adopting proper measures to reduce acidification and nutrient depletion risks connected to increasing demand for bioenergy and the implementation of wholetree harvesting; Objective 9 on Good-Quality Groundwater could be achieved (among other measures) through proper use of pesticides and fertilizers in farming and forestry; Objective 11 on Thriving Wetlands could be reached also through halting the building of forest roads across valuable wetlands, *etc*. (Swedish Environmental Protection Agency, 2013). Progress towards these objectives is monitored by eight government agencies which are responsible for following up and working with organizations and companies to reach the objectives under the coordination of the Swedish Environmental Protection Agency.[18]

As regards the implementation of the WFD in Sweden, five competent authorities (*Vattenmyndigheterna*) – corresponding to the five national river basin districts – have been created and a Water Quality Management Ordinance (SFS 2004:660) has been published (European Commission, 2017). In order to include forest management issues within the implementation of the WFD at a national scale, the Swedish Forest Agency was given the mandate of analysing whether existing laws and other measures needed to be revised. The outcomes of this analysis highlighted the role of forests and forestry in contributing to water management and quality, and indicated the need to adopt additional measures, including for example the widening of buffer zones beyond normative requirements to limit the depletion of nutrients deriving from clear cutting. The same report also stressed the need to develop a specific forest water programme within the Rural Development Programme, as well as to consider the inclusion of water protection as a concern within forest management planning and monitoring (Swedish Forest Agency, quoted in Keskitalo and Pettersson, 2012). The World Wide Fund for Nature (WWF), Sweden and the Swedish forestry sector developed two silviculture water management tools – BIS+ and Blue targeting – to incorporate water management in forestry planning processes (Lestander *et al.*, 2015). Futter *et al.* (2011) studied the implications of the WFD for forests and forestry in Sweden and c noted concerns, such as the lack of a specific reference to forests within the WFD, gaps in the methodologies for assessing water ecological status, a perceived lack of clarity in the national legal framework, as well as other issues. Keskitalo and Pettersson (2012) analysed the implementation of the WFD in Sweden and concluded that it only resulted in relatively small changes in the substantial law, mostly with regard to the implementation/conservation of buffer zones. They also argue about the large role of private and overlapping authorities and jurisdictions in Swedish forest-water governance. Sandström *et al.* (2011) investigated potential trade-offs between different ecosystem services delivered by Swedish forests and how these trade-offs are governed. They foresee increasing conflict between timber production and water quality in the future as a result of the requirements to enhance water quality in the WFD. They concluded that governance solutions introduced for implementing the WFD are too recent to assess their effectiveness in solving conflicts between multiple functions of forests and water.

3.7 National context - United Kingdom

While the multiple use of forests was already a goal of Anglo-Norman landowners in the 12th Century (Wilson, 2004), the concept of multifunctional forestry, encompassing a wide range of ecosystem services, was first introduced in the "Forestry Practice" manual published by the Forestry Commission since 1933. It was only in the tenth edition (1991) that reference was explicitly made to the conservation of ecosystems, landscape design and consideration of water and soil (Hibberd, 1991).

After decades of national policies supporting afforestation and encouraging timber production, mostly with non-native coniferous species, a shift in forest policy took place in the 1980s following criticism on the adverse effects on biodiversity, landscape and the water environment (SEPA, 2007). Attention to forest multifunctionality, including water issues, has mostly been driven by a commitment to sustainable forest management practices in the early 1990s, through the implementation of the United Kingdom Forestry Standard (UKFS), and the transposition of EU directives and regulations into the UK regulatory system. As for the latter, several primary and secondary pieces of legislation transpose the EU WFD into law in the UK, thus contributing to the protection of the water environment and associated resources. These include water environment regulations for England and Wales, Scotland and Northern Ireland, as well

18 See: www.miljomal.se.

as additional regulations at the national and subnational (*i.e.* basin district) level (Forestry Commission, 2011). The EU Floods Directive has been transposed into the UK law by means of several Acts adopted between 2009 and 2010 (*e.g.* Flood Risk Management (Scotland) Act, and Flood and Water Management Act). Legislation also addresses potential flooding from reservoirs through the Reservoirs Act (1975); however, post-EU Floods Directive regulations introduced a risk-based approach to reservoir safety for 'large raised reservoirs' (*i.e.* holding 10,000 m^3 or more), with a system of regular inspections, monitoring and supervision activities.

Protecting and enhancing the water environment and water resources is one of the objectives of the Corporate Plan of the Forestry Commission England and also forms part of the Welsh Assembly Government's Woodlands for Wales Strategy and the Scottish Forestry Strategy (Nisbet *et al.*, 2011).

The Forestry Commission (2011) has also developed specific Forests and Water guidelines for the implementation of the UKFS. This document represents the main regulatory instrument driving good forest practice for the protection of freshwaters. Although the Guidelines have no formal legal status, compliance is required for approval of forest operations on public lands and grant support on private lands (Nisbet *et al.*, 2011). The UKFS also constitutes the basis of forestry practice for the independent UK Woodland Assurance Standard (UKWAS), which is used for voluntary independent forest certification. First published in 1988, the Guidelines include two levels of compliance, namely legality and good forest practices, and are intended to help forest managers meet UKFS requirements in relation to forest-water connections and may be influenced through forest management operations (*e.g.* water yields, waste management, use of chemicals and pesticides, *etc.*). The Guidelines acknowledge the benefits of protection forests and sustainable forest management for water quality; however, they also state that forestry can have a range of detrimental effects on water, both within forests and downstream. Land management activities, including badly implemented and/or large-scale forestry operations, can lead to soil erosion, affect water flows and degrade the quality and ecology of waters. While this has implications for the economic, environmental and social benefits that water provides, it can be addressed through planning and implementation of appropriate land use and forestry and management solutions.

Following the findings of the Millennium Ecosystem Assessment, the UK government decided in 2007 to conduct an assessment for the UK to enable the identification and development of effective policy responses to ecosystem service degradation. The UK National Ecosystem Assessment (UK NEA) was the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity (UK NEA, 2011) and remains an important reference.

3.8 National context - United States of America

The United States Forestry Service (USFS) boasts that it manages the largest single source of water in the country. According to the USFS, over 180 million people rely on forests for their drinking water (USFS 2017). Nevertheless, many laws and institutions operating at different scales oversee and regulate the management of forests and water in the United States of America. A detailed overview of institutional governance and regulations of forests and water at the national scale has been developed by the Committee on Hydrologic Impacts of Forest Management of the National Research Council of the National Academies (2008). The authors of this review underline that "*fragmentation of administrative responsibility for the effects of forest management on the hydrologic processes in watersheds and landscapes occurs both vertically and horizontally* (p. 33)". In particular, as it is the case for other countries, including the UK and Italy, responsibilities are split vertically among federal, state, regional and local government bodies/levels and often horizontally as well, among agencies separately in charge of specific resources/activities (*e.g.* forest-land management, water resource management and regulation/assessment of forest management impacts on water resources). Furthermore, states, municipalities and counties own and manage forestlands for various goals, and at different scales, and broad discretion is given to agencies/organizations in charge of managing these resources. Finally, the increasing number of forest investments by timberland investment management organizations (TIMOs), or real estate investment trusts (REITs) since the 1990s has led to an acceleration in the shift within private ownership categories, *i.e.* from forestry and timber companies, to financial investors. This shift favoured forest management operations and other operations, including land sales for development, mostly to maximize investors' financial return.

The recent boom in bioenergy has further emphasized this trend, especially in the country's south-eastern states. Many US cities and towns depend on such fragmentation, together with multiple uses of forested watersheds (*e.g.* drinking water supply and timber production), for their water supply. Integrated management of forests and water at the watershed scale has become difficult (Arnold and Fohrer, 2005), and has often led to controversy and conflicts. Notwithstanding these problematic issues, many relevant initiatives have taken place; these include the pioneering Tennessee Valley Authority – the first watershed authority formally established worldwide (Box 3.3) – to more recent ones. In recent years, however, most of problems have not been related to trade-offs between productive forestry and the provision of water-related services, but rather to 'keeping forests as forests' through proactive forest management, avoiding forest losses and land use changes deriving from development and encroachment, as well as water impairment due to agricultural or suburban runoff (U.S. EPA quoted in USDA, 2017a).

Box 3.3

The Tennessee Valley Authority: A pioneering approach to watershed management

The watershed approach and the idea of working on land use and management practices (including forest management practices) to improve water-related services were developed and adopted at the beginning of the 20th century. With the launch of the New Deal Plan by President Roosevelt during the Great Depression of the 1930s, a number of new projects and agencies were established to help the hardest hit areas of the United States. Among them was the Tennessee Valley Authority (TVA) (1933) – the world's first and most successful watershed management authority. The Tennessee River valley was continually affected by malaria, low income conditions, floods, deforestation and soil erosion, and the TVA aimed to help reduce these problems by introducing and extending better farming methods, reforestation and fire control measures, and building dams for hydropower energy production. It thus contributed to job creation and, ultimately, to improving the quality of life in Tennessee and parts of seven other different south-eastern states.

Public concern about the effects of forest management on hydrology has focused primarily on water quality. The Clean Water Act (CWA, 33 USCA, Section 1151 et seq., 1972) sets the basic structure for regulating discharge of pollutants into US waters and, more broadly, sets a national goal to attain water quality. The Environmental Protection Agency (EPA) has overall responsibility for implementing the Act, and individual States that may decide to adopt stricter regulations. In order to ensure appropriate water quality conditions, as defined by State water quality standards for all water bodies, the CWA requires point sources of pollution to obtain discharge permits, which are not needed by non-point sources. Most forestry activities, like site preparation, reforestation, thinning, prescribed burning, pest and fire control, harvesting operations, *etc.*, belong to the second category. Specific State programmes are required to control non-point sources of pollution, including impacts from silvicultural activities. The EPA has introduced a set of best management practices (BMPs) to be adopted within management plans and to be implemented before, during and after forest management activities as a tool to address forest management impacts on water quality. BMPs include many issues addressed by existing forestry acts, *e.g.* clear-cut size limits, riparian harvest buffers, road-building, regulation of the application of chemicals (fertilizers, pesticides), wetlands protections, reforestation, *etc.*

Many other Federal Laws stipulate how the effects of forest management on watersheds must be addressed in management plans and actions. For example, the 1960 Multiple Use and Sustained Yield Act (16 USC 525-531) addresses the establishment and administration of national forests to provide for multiple use and sustained yield of products and services, including timber, recreation, watershed protection, and wildlife and fish conservation. Among other issues, the Act recognized that national forests are important watersheds, therefore water diversions and associated infrastructures require the issuing of special permits. The 1976 National Forest Management Act (16 USC 1604(g)(3)(E)) addresses, among other issues, potential criticisms linked to clearcutting and defines rules for avoiding/minimizing adverse impacts from forest operations. The US Forest Service ensures that harvesting is not detrimental to watershed conditions, and that timber harvest plans take into account the protection of water bodies, including stream systems and banks, wetlands, lakes, *etc.* The US Forest Service is also in charge of protecting instream flows for fish habitat and outdoor recreation (Wilkinson and Anderson, 1985).

In authorizing the EPA to set maximum contaminant levels in public drinking water, the 1974 Safe Drinking Water Act (SDWA) also addresses water quality and the potential effects on forest management issues. In the 1980s, the focus of SDWA-related measures was on treatment and filtration methods; however, more emphasis has recently been placed on the protection of drinking water at the source, *i.e.* at the watershed level. Watershed protection derive from this idea and rely also on forest management measures, and include: Hetch Hetchy watershed (in Yosemite National Park) providing water to San Francisco; the Cedar River and South Fork Tolt watersheds providing water to Seattle; and the Catskill-Delaware watershed providing water to New York. (Dudley and Stulton, 2003). All states are required to develop a source water assessment to identify risks to all the water resources that are being used, or that will be used, as drinking water supplies. The EPA lists many forest management activities, *e.g.* harvesting, use of chemicals, residue and waste management, *etc.*, as potential sources of water contamination.

Some national forests in the United States are specifically or mainly intended for safeguarding water resources. An example is provided by the Angeles National Forest, created in 1892 and currently administered by the US Forest Service: like many of California's national forests it has been established and managed to safeguard and preserve water supplies, in particular to the city of Los Angeles (USDA, 2017b).

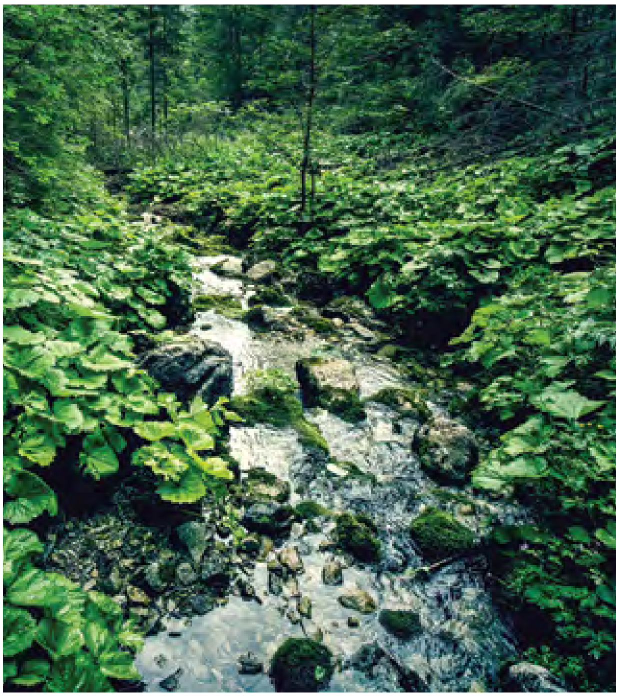
Many other federal and state laws might apply to forest management and have connections with water issues. These include, among others, the Endangered Species Act (ESA) (16 U.S.C. §§ 1531-1544), which reflects the increasingly recognized importance of aquatic and riparian habitats, as well as laws aiming to protect scenery along water bodies, in many cases limiting forest harvesting to buffer zones (*e.g.* the

Federal Wild and Scenic Rivers Act). Other laws or regulations also exist and limit the use of chemicals aimed at disease and weed control during reforestation activities (*e.g.* the Federal Insecticide, Fungicide and Rodenticide Act).

3.9 Conclusion on enabling environment

It is widely and increasingly recognized that forests play an important role in producing and regulating the world's temperatures and fresh water flows, and that forested watersheds are essential for sustaining freshwater supply. The interactions between forests and water provide a huge range of products and services that are of vital importance to the functioning of the biosphere, to society and to our well-being.

The challenge that we are now confronted with is how to find a way to better integrate water-related ecosystem services supply into forest management objectives, while concurrently maintaining changing societal needs and expectations on the use of forest resources. Different forestry practices will be needed to support the future quality of our water supply. As a result, there is a continued need for an enhanced knowledge base on forest and water interactions at multiple scales, including interactions at both small and large watershed scales, and even beyond watersheds. Looking forward, we will need to promote and enable institutional and regulatory environments in order to create synergies between the management of forest and water resources, and the multiple institutions and sectors engaged in their use and management.



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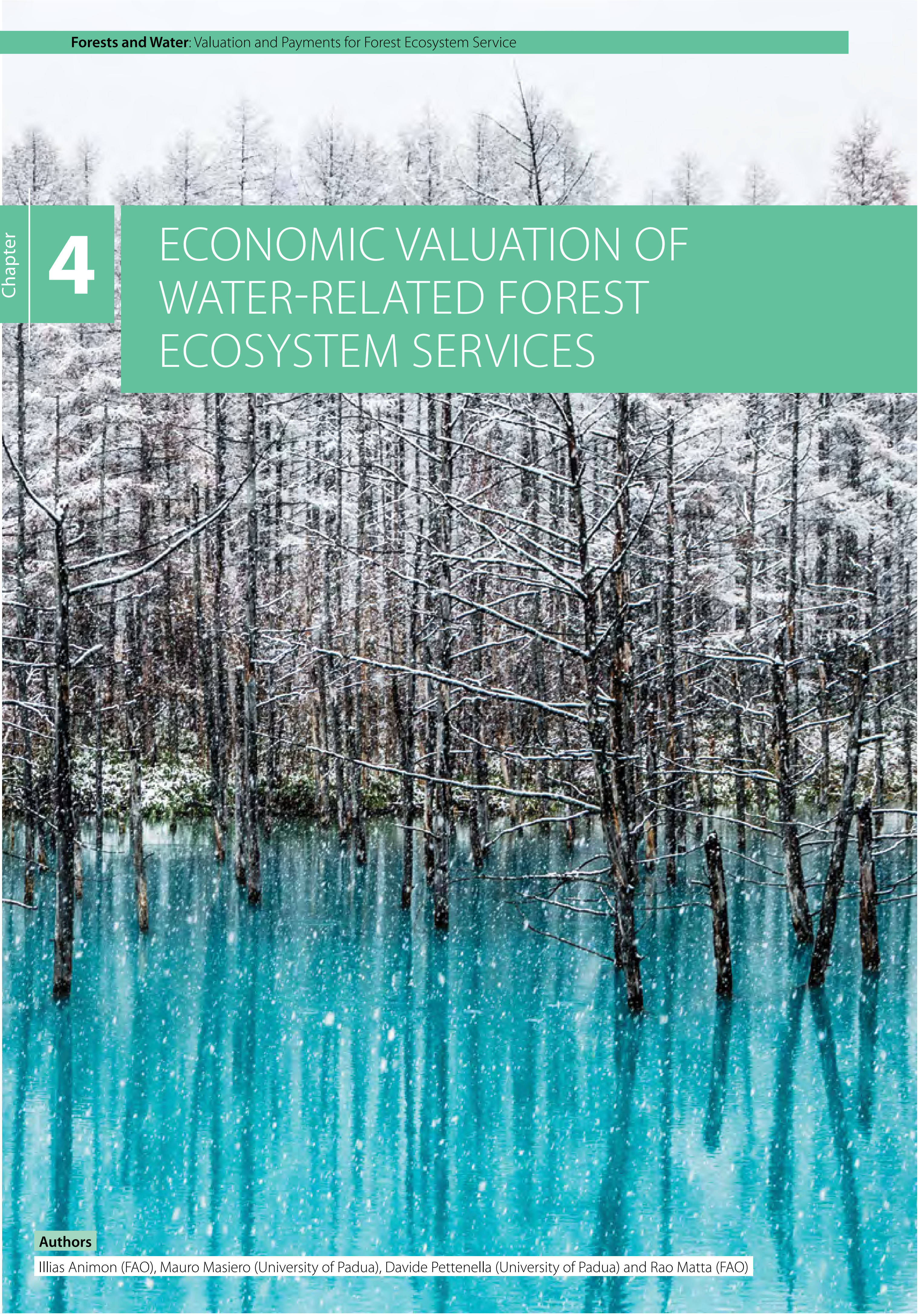
Chapter 4

ECONOMIC VALUATION OF WATER-RELATED FOREST ECOSYSTEM SERVICES



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4. Economic valuation of water-related forest ecosystem services

Assessment of water-related ecosystem services is an important step in enabling sustainable management of forests. A service is assessed for different purposes, and can variously be used to: (a) conduct a scoping or a situation analysis; (b) enhance environmental awareness or advocate for or against a policy option; (c) compare alternative policies, programmes and projects; (d) identify livelihoods, development and investment opportunities; (e) design environmental policy instruments and incentives; and (f) tackle environmental conflicts (Berghöfer *et al.*, 2016). It could also be used for assessing the impacts of policy changes.

Quantitative analysis of ecosystem services and estimating economic values, including those related to water from forests, has recently gained increased attention in the context of several initiatives, including the Millennium Ecosystem Assessment[19], Common International Classification of Ecosystem Services (CICES)[20], the Economics of Ecosystems and Biodiversity (TEEB)[21], New Ways to Value and Market Forest Externalities (NEWFOREX)[22], Mapping and Assessment of Ecosystems and their Services (MAES)[23], and Wealth Accounting and the Valuation of Ecosystem Services[24]. Valuation of ecosystem services could help in better understanding the relevance of the services for human well-being, enabling better decision-making and promoting more investments to enhance and maintain the services.

Water supply and water cycle regulation (including timing and magnitude of runoff and floods), and water purification are key services that forest ecosystems provide. These represent the life-support functions of forests. Quality and quantity of water from forests are valued for different purposes. The impact on social welfare determines the economic value of water, which is given by the aggregate impact on the utility of individuals in society. The utility depends on preferences. Water has high conveyance costs and, consequently its value may differ according to where it is found. Value also varies with form (*e.g.* raw water from a river or treated before delivery). Also, demand for water can vary over time (*e.g.* seasonal differences) (FAO, 2004; Young, 1996). Many valuation methods exist and to capture the values correctly the choice of valuation method should match the kind of service in play. Water-related externalities also make different approaches to valuation relevant (Thorson, 2014).

19 http://www.millenniumassessment.org/en/index.html.

20 http://cices.eu.

21 http://www.teebweb.org.

22 http://www.newforex.org.

23 http://biodiversity.europa.eu/maes.

24 https://www.wavespartnership.org.

This chapter presents some key issues in economic valuation of water-related forest ecosystem services.

Valuation techniques

Some valuation techniques rely on economic tools, some draw on non-economic measures (*e.g.* in social and cultural dimensions), and some integrate both. In all cases, economic valuation builds on the biophysical, non-economic, understanding. It aims at measuring people's preferences for the benefits from ecosystem processes (TEEB, 2008). However, it will be often difficult to value all services in monetary terms. Measurement in monetary terms enables the assessment of trade-offs, demonstrates the importance of some ecosystem services, and yields many other benefits. Measurement approaches vary depending on what is measured (TEEB, 2008). Combined with economic valuation, non-economic valuation could help to inform policy choices.

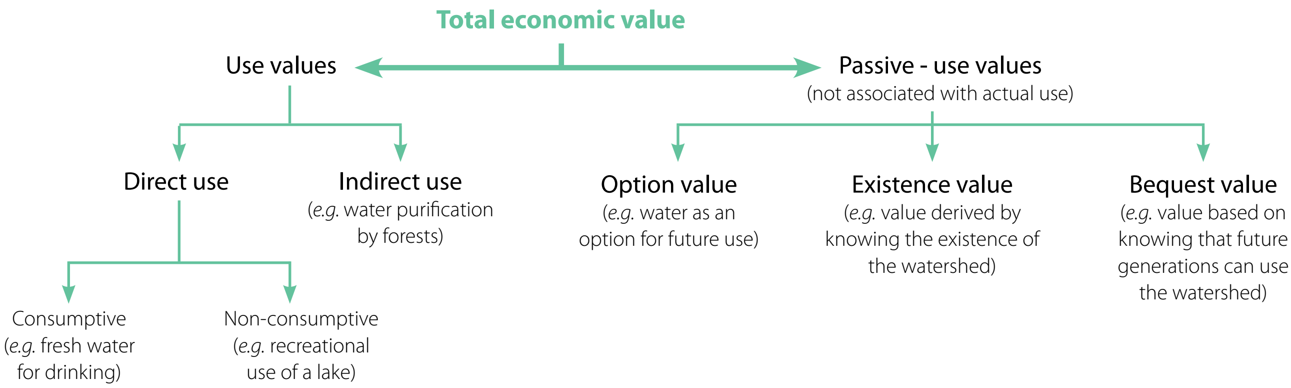
Economic values consist of use values and passive-use values (also referred to as non-use values). Use values include direct and indirect values. Existence and bequest values are examples of passive-use values (Figure 4.1). In general, measuring indirect use values poses greater challenges than measuring direct use values. Because use values imply some kind of action, behaviors are observable and preferences can thus be inferred rather straightforwardly. Assigning a price to passive-use values is more challenging and must generally rely on stated preferences methods. The economic valuation includes methods based on market value analysis and demand. Analyses of market values include the methods where the benefits and costs are considered as proxy. Demand-based methods encompass methods based on revealed preferences (*e.g.* travel cost method, hedonic pricing method, etc.) and stated preferences (*e.g.* contingent valuation, choice experiment, etc.). The value estimated by the above methods in one study site could be transferred to a closely related location through a benefits transfer approach[25].

Valuation results depend on what is considered in the analysis, among a range of benefits such as increased drinking water supply, farm production, electricity generation, recreational benefits and quality of habitats. For example, for any intervention in forests that reduces quality of drinking water supplied to a nearby village, the required additional water-related treatments and costs could provide one measure of

25 See www.ecosystemvaluation.org, www.aboutvalues.net, www.efi.int/files/attachments/e45/publications/1cost_e45_guidelines.pdf, https://www.unece.org/fileadmin/DAM/timber/publications/SP-34Xsmall.pdf, https://www.gov.uk/guidance/ecosystems-services, http://earthmind.net/rivers/docs/ukdefra-eftec-valuing-our-natural-environment.pdf, http://www.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-5-The-economics-of-valuing-ecosystem-services-and-biodiversity.pdf, https://www.nap.edu/read/11139/chapter/4 , http://www.marbef.org/wiki/Economic_Value, Forest Europe (2014), DEFRA (2007) and Price (2014) for more details of these valuation methods.

FIGURE 4.1

Some key constituents of total economic value



value. Others such as costs in dealing with sediment load downstream, the effects of reduced flow and storage of water could be considered. Factoring in negative externalities may reduce the total economic value (TEV). For example, in Greece erosion in poorly managed forests was reported to reduce the TEV of forests by up to 51 per cent (Croitoru, 2007). The values related to recreation or fishing linked with water from forests could be other components of valuation. If livelihoods are also in focus, other effects (*e.g.* the sustained or increased provision of food due to the interventions) need to be considered in the valuation exercise. Tools such as InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs)[26] are useful in modelling economic values. Another useful tool is ARIES (Artificial Intelligence for Ecosystem Services), which is helpful in spatial economic valuation of ecosystem services[27]. Techniques such as multi-criteria analysis could help in integrating and comparing multiple values of ecosystem services[28].

Once values are measured, understanding the sharing of benefits between downstream and upstream stakeholders could be important. Clearly defining who can deliver the service sustainably, and who realizes the benefits and their interactions is relevant in decision-making, for example in the design of PES mechanism.

4.1 A few examples of values/valuation

Table 4.1 shows different methods used for some water-related services reported by de Groot *et al.* (2012). The authors screened over 320 publications covering over 300 case study locations. Out of about 1,350 consequent value estimates, 665 value estimates were selected for the analysis of: (a) the number of value estimates per valuation method for different ecosystem services; and (b) the value of ecosystem services in monetary units in selected biomes. Overall, provisioning services are more often valued through direct market pricing methods, while regulating services are mainly assessed using avoided cost and replacement cost, in addition to direct market pricing (Table 4.1). Table 4.2 shows the difference of some service values (values presented as 'averages') in different forest biomes (de Groot *et al.*, 2012).

Table 4.3 gives some examples of studies following different methods in the UNECE region. See Krieger (2001) for the values, including water quantity and quality service values, for different regions in the United States of America, and Ojea *et al.* (2012) for values in a few other countries.

26 See http://www.naturalcapitalproject.org/invest.

27 See http://aries.integratedmodelling.org.

28 See https://www.unece.org/fileadmin/DAM/timber/publications/SP-34Xsmall.pdf.

TABLE 4.1

Value estimates per valuation method and selected provisioning and regulating ecosystem services

Type of services	Number of estimates	DMP	FI	AC	MC	RC	HP	TC	CV	GV	Others
Total	665	297	51	60	13	56	3	24	93	13	51
Provisioning services	287	219	23	8	2	14	0	0	1	8	12
1. Water provision	38	5	10	7	1	9				3	3
Regulating services	152	20	7	51	9	40	0	0	7	0	18
1. Water flow regulation	5		2	1		1					1
2. Waste treatment	31	1	1	5	2	19				1	2
3. Erosion prevention	17	4		7	1	1				1	3

Source: de Groot *et al.* (2012).

Note on abbreviations: DMP—Direct Market Pricing; FI—Factor Income/Production Function; AC—Avoided Cost; MC—Mitigation and Restoration Cost; RC—Replacement cost; HP—Hedonic Pricing, TC—Travel Cost; CV—Contingent Valuation, and GV—Group Valuation.

TABLE 4.2

Monetary value (in International $/ha/year[29], 2007 price level) of some provisioning and regulating ecosystem services in selected biomes

Service	Tropical forests	Temperate forests	Woodlands	Grasslands
Water provision	27	191	-	60
Regulation of water flows	342	-	-	-
Waste treatment	6	7	-	75
Erosion prevention	15	5	13	44

Source: de Groot *et al.* (2012).

Note: The data represent the average of the values found for a particular service and biome. Calculations are based on 665 values out of about 1,350 value estimates obtained from screening 320 publications.

TABLE 4.3

Selected studies with values and methods

Service	Country	Valuation Method/ approach	Value	Unit	Source
Annual ground water recharge	Denmark	Choice experiment	6-8.8	WTP in Euros /m^3 of additional ground water	Thorson (2014) based on Campbell *et al.* (2013)
Groundwater protection of surface water & drinking water quality	Denmark	Contingent valuation	711	WTP in Danish Krone /year	Hasler *et al.* (2005)
Groundwater protection of surface water & and drinking water quality	Denmark	Choice experiment	3104	WTP in Danish Krone /year	Hasler *et al.* (2005)
Erosion prevention	15	5	13	44	

29 The international dollar, or the Geary–Khamis dollar, is a hypothetical unit of currency. It is used for standardizing monetary values across countries by correcting to the same purchasing power that the U.S. dollar had in the United States at a given point in time (de Groot *et al.*, 2012).

Table 4.3 *(Continued)*

Service	Country	Valuation Method/ approach	Value	Unit	Source
Water purification	Denmark	Choice experiment	912	WTP in Danish Krone /year	Hasler *et al.* (2005)
Water purification	Denmark	Contingent valuation	529	WTP in Danish Krone /year	Hasler *et al.* (2005)
Agriculture soil protection Water supply protection	Greece	Production function Damage cost avoided	45.2	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Protection against erosion	Albania	Defensive expenditures	2.9	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Water supply protection	Croatia	Damage cost avoided	10	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Protection from erosion, floods, landslides	Italy	Damage cost avoided	154	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Protection from fires, avalanches, floods and landslides	France	Defensive expenditures	7.8	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Agriculture soil protection Water supply protection	Portugal	Production function Damage cost avoided	23.3	Value in Euros/ha of total forests	Cited in Croitoru and Merlo (2005)
Fresh water	Italy	Market price	75	Economic value in Euros/ha/year	Häyhä *et al.* (2015)
Hydrogeological protection	Italy	Replacement cost	328	Economic value in Euros/ha/yeaR	Häyhä *et al.* (2015)

Different values estimated in British Columbia are shown in Box 4.1. Box 4.2 illustrates the water purification values leading to investments in New York City.

Groundwater quality and water regulation aspects have so far not received much attention among valuation researchers compared to other aspects such as recreation and biodiversity (Elsasser *et al.* 2009*;* Elsasser *et al.*, 2016). Yet, watershed protection benefits are reported as high in many countries, both in absolute and relative terms; for example in some countries in the Mediterranean region they constitute the single most valuable forest benefit. In Greece and Italy, they account nearly half of the total economic value of forest-related services (Croitoru, 2007).

Existing regulations concerning water quality and forest conservation imply a significant effect on additionality principle and on provision costs. The economic evaluation of water-related ecosystem services has been shown to be a tough task, both from a methodological point of view and for its high

Box 4.1

Value of ecosystem services in the aquatic ecosystems in the Lower Mainland of British Columbia[30]

A study in British Columbia, Canada showed that 30 per cent of the known ecosystem services in the Lower Mainland's aquatic ecosystems provide between 30 and 60 billion Canadian dollars (CAD) in benefits annually. The most important ecosystem service values were aesthetic and recreation services (between CAD 23 billion and CAD 44 billion annually), water supply (between CAD 2.3 billion and CAD 7 billion annually) and disturbance regulation (protection from storms and flooding, drought recovery etc. between CAD 2 and CAD 5 billion annually).

Box 4.2

Savings in water purification leading to investments for improving watersheds[31]

About 90 per cent of water used daily in New York City comes from reservoirs in the adjacent Catskill and Delaware watersheds; the US EPA concluded that water from these watersheds need not be filtered until at least 2017. This saved approximately USD 10 billion to build a filtration plant and operating costs of hundreds of millions of dollars. Until 2017, the City agreed to set aside USD 300 million to acquire land to restrain development that causes runoff and pollution. It committed itself to encouraging measures to allow sediment to settle before water enters the final sections of the drinking water system.

30 Source: Molnar *et al.* (2012) cited in https://www.cbd.int/financial/values/g-ecowaterwetlands-teeb.pdf.

31 Source: De Palma (2007); Elliman and Berry (2007)cited in https://www.cbd.int/doc/case-studies/inc/cs-inc-teeb.Chapter%209-en.pdf.

costs, and often scheme managers and/or local stakeholders will often find them unaffordable. However, economic evaluation has proven to be useful for gaining attention from policymakers, and to negotiate the cost of provision for several ecosystem services. Example of economic valuation of water-related services in Italy is shown in Box 4.3 and some valuation efforts in Eastern Europe and Central Asia are in Box 4.4.

Box 4.3

LIFE+ GESTIRE Project: Economic valuation of water services provided by Natura 2000 sites within Lombardy Region of Italy[32]

Natura 2000 is an EU-wide network of nature protection areas designated under the 1979 EU Birds and the 1992 EU Habitats Directives to ensure the conservation of valuable and threatened species/habitats. The network covers about 18 per cent of the total EU area. Lombardy (Northern Italy) hosts 242 Natura 2000 sites, covering a total area of about 372,000 ha (i.e. 16 per cent of regional area) 30 per cent of which consist of forests. Within the framework of LIFE+ GESTIRE Project,[33] an economic assessment was carried out of selected marketed and non-marketed ecosystem services delivered by Natura 2000 network in Lombardy. The study included an economic assessment of the drinking water provision service offered by the network, based on GIS-based identification of officially recognized water sources and derivations located within Natura 2000 sites, and the creation of a dedicated database. The potential volume of water supply per year for each source was determined based on official data from concession documents, and multiplied by the unit water tariffs (considering a mix of 70 per cent household and 30 per cent non-household tariffs), net of concession fees paid by the concessionaire, to compute the total value of the service. Two different hypotheses were taken into consideration: (a) the hypothesis that all (i.e. 100 per cent) of water harvested from sources is delivered to consumers; and (b) the (more realistic) hypothesis that only 70 per cent is actually delivered, while 30 per cent is wasted due to physical losses along the water pipeline network.

A total of 670 water sources located within the regional Natura 2000 network have been identified and mapped in 59 different protection sites. The estimated value of water provided by these sources, net of concession fees, ranges between 100 and 143 million Euros per year, i.e. about 14 times the value of the wood and firewood officially provided by the whole regional Natura 2000 network on an annual basis.

4.2 Improving and transferring values to the policy process

In Europe, the knowledge on methods and values of forest-related ecosystem services is unevenly distributed (Forest Europe, 2014). Various obstacles hamper broader consideration of approaches and results of monetary

Box 4.4

Valuation in Eastern Europe and Central Asia

Regionally, a considerable amount of work has been carried out to analyse and estimate the value of ecosystem services, in particular in the Russian Federation (Bobylev *et al.*, 2013;Tikhonova, 2016), but also in Belarus (Ministry of Forestry of the Republic of Belarus, 2015), and Kyrgyzstan (Suparaeva *et al.*, 2017).

In 2013, Belarus decided to develop a methodology to estimate the value of ecosystem services for use in the national strategy for the protection and sustainable use of biodiversity for the period 2011-2020 (Ministry of Forestry of the Republic of Belarus, 2015).

Efforts have been made in the Russian Federation to develop a national report on ecosystem services to highlight the significance of the services it provides at the global level (Bobylev *et al.*, 2013; Tikhonova, 2016).

valuation of services in policy decisions. They include: (a) cultural barriers (*e.g.* reservations existing in several European countries for using these); (b) methodological barriers (*e.g.* lack of generally accepted procedural rules amidst methodological complexities of valuation); and (c) political barriers (*e.g.* difficulty in implementing and communicating political decisions on intangible values based on consumers' surplus) (Forest Europe, 2014). A few general measures to improve valuation include:

Enhancing access to existing valuations: several meta-databases of valuation results are outdated and lack focus on forests and methodological details. Improving databases and making them publicly accessible in all countries (*e.g.* the Environmental Valuation Resource Inventory34) might promote better dissemination and applicability of results (Forest Europe, 2014).

Filling knowledge/data gaps: original and up-to-date valuations can be costly; adequate resources therefore need to be allocated for addressing data gaps (Forest Europe, 2014).

Better use of existing data and capacity building: transferring valuation results from one location to other suitable sites by developing appropriate transfer protocols, and solving scaling or aggregation problems could help in better use of existing data. Also, transferring knowledge on methods and building capacity to implement them may be necessary, especially in countries that have little experience in the application of valuation (Forest Europe, 2014).

32 Source: Pettenella *et al.*, (2015).

33 See www.naturachevale.it/em.

34 See https://www.evri.ca/Global/Splash.aspx.

Carrying out more scientifically rigorous and empirical efforts to establish clearer links between forestry and water services: identifying specific types of settings where valuation is particularly useful and establishing common and better practices for analysis, communication and use in decision-making.

When designing valuation studies and interpreting their results, clarity is needed on: (a) the purpose of the valuation; (b) the characteristics of the services in question and which elements need to be considered (*e.g.* existence value); (c) the role of the economic valuation in the decision-making process; and (d) alternatives to economic valuation in the decision-making process (Forest Europe, 2014) and their pros and cons. The services also need to be valued in a specific physical and social context (Price, 2014).

The TEEB stepwise approach, for enabling assessment and integration of ecosystem services in local and regional management, consists of six key steps: (a) specify and agree on the problem with stakeholders; (b) identify which ecosystem services are most relevant; (c) identify information needs and select appropriate valuation methods; (d) assess value and expected changes in availability and distribution of services; (e) identify and appraise policy options; (f) and assess social and environmental impacts of policy (information sources and examples on these are available in Russi *et al.*, 2013). Among the key principles to develop scientific policy advice are credibility (*e.g.* assessment results are precise and trustworthy), relevance (*e.g.* results address the right questions at the right moment in the right way), and legitimacy (*e.g.* assessment is widely acceptable) (Berghöfer *et al.*, 2016). Also, as Thorson and Wunder (2014) argue, that to make valuation studies more policy-relevant, the focus needs to shift away from TEV to value distribution. Further recognizing, demonstrating and internalizing, or capturing values connected to the impacts on different social categories, can greatly improve the decision-making process (TEEB, 2010).

4.3 Challenges related to valuation

Our ability to assess the benefits is limited by their prevailing non-market values, and by the lack of information; clearly identifying and measuring the quantity and quality of all water-related services and estimating their true values could be difficult. Also, unintended double counting like a service valued at two different stages of the same process could potentially creep in sometimes, *e.g.* a forest providing water flow (as a regulating service) and potable water supply (as a provisioning service) (Fu *et al.*, 2011), could cause valuation challenges because water flow regulation and water treatment by soil help to provide the same final product of potable water. Also, because of the limitation of available economic tools, not all services can reliably be valued in monetary terms (TEEB, 2008).

Monetary valuation may be unnecessary or even counterproductive in some instances, especially if it is seen as contrary to cultural norms, or if it fails to reflect the plurality of values (TEEB, 2010). No single all-encompassing method exists and values could vary depending on the method. Some approaches, such as stated preference have shortcomings, for example estimating unbiased values (*e.g.* the phrasing of the questions depends on who sponsors the research and information bias), and difficulty in accurately separating the WTP to different services could pose challenges (Price, 2014). Prices do not reflect the correct value if there are negative externalities or imperfect competition. Hence, market-based methods could also be biased. Thus, determining the 'actual value' of the service could be challenging, especially in some socio-cultural contexts and in the backdrop of concerns stemming from ethics and bias (see Kill [2014] for an account of the debates on the "financialization" of environmental services).

Indirect use values of many water-related ecosystem services often go unnoticed until they get diminished or lost. While people value and generally appreciate the services, assigning proper values appears difficult because they are quite often unpriced owing to policy and market failures (*e.g.* markets failing to reflect the full social costs or benefits). In such a situation, it is difficult to determine price and quantity relations and make decisions. The time preferences of stakeholders could vary, impacting relative prices. Also, issues exist in studies on the scope (number of service) and geographic and temporal scale (Nelson *et al.*, 2009), as well as challenges posed by their complexity which hampers a general understanding and public discussion. Amidst these challenges, practical decisions may often need to be informed by economic values and available evidence. Other general valuation challenges and considerations include the following:

1. ***Accounting the interdependence within an ecosystem and between others***: A policy affecting water-related services in an ecosystem may have complex and indirect consequences on other ecosystems, for example flood control policy affecting wetland protection policy. The value of a service may depend on its relationship with other ecosystem services (DEFRA, 2007).

2. ***Issues related to spatial scale***: The spatial area chosen in valuation will impact the conclusions of the analysis. Water quality may depend more on the condition of the upstream areas of the catchment basin than on where water users live. Care is therefore needed in defining the appropriate spatial scales during the analysis (DEFRA, 2007). The impact measures of using water in the local and regional economy could be estimated, for example in terms of revenue, income and employment, increased agricultural production, better human health, *etc.*

3. ***Factoring in time-related issues***: Impacts on ecosystems could extend beyond a specified time period during an evaluation. Enough information needs to be collected to comprehend how these changes will develop over time and impact the economic assessment. Normally, using an appropriate discount rate could be useful for converting all estimates to present values (DEFRA, 2007).

4. ***Considering thresholds and limits***: When ecosystems deteriorate beyond a certain threshold, an irreversible change is likely to take place, leading to a permanent loss of services. Such irreversible changes are often not easy to consider in economic appraisals. The degradation of quality and quantity of a service or stock will reflect in increased marginal values to take account of this scarcity. An economic valuation study is unlikely to capture this well. A proper understanding is needed on how ecosystem functions may change temporally and spatially, and how this will affect the quantity and quality of the water. The uncertain future losses associated with potential change could be assessed by a sensitivity analysis that will help to identify how the assessment of outcomes is likely to change based on the values or assumptions used in valuation. Transparency of the assumptions and sensitivity and scenario analysis could inform further the analysis. Also, valuation should focus on the final services to avoid double counting (DEFRA, 2007).

5. ***Cumulative effects***: individual decisions to develop a part of the whole area will lead to loss of some natural resources. Making such decisions repeatedly and independently of each other in an uncoordinated manner will affect the total value owing to the cumulative effect of these decisions; this will, in turn, affect the sustainability of the service because of, among others, the loss of connectivity between different parts of the resource. Therefore, analysing the effect of individual decisions on the total resource is helpful to consider the cumulative effects. The marginal cost of using the resource changes based on the cumulative impact of the use of the resource. Considering the cumulative impacts at a programme level may sometimes result in

a different cost-benefit relationship than considering each project on its own. See the detailed explanation of the above and other challenges and a few examples in DEFRA (2007).

Sound science is essential to provide strong evidence. Care also needs to be taken while attributing a value to natural capital when other inputs (*e.g.* labour) are involved. This also pertains to the issue of resource rent.

Detailed discussions on the problems and challenges are also available in Price (2014) and de Groot *et al.* (2010). As an important tool for policy-making, economic valuation should be viewed as just one input for decision-making (DEFRA, 2007). In certain cases, the values could be decisive (*e.g.* avoided cost for water treatment when water quality is a constraint).

4.4 Conclusions on valuation

Understanding the wide range of values on water-related forest services explained in this chapter is essential to promote responsible decision-making. More scientific evidence is, however, needed to enable this. Values expressed in monetary units are often better understood by decision-makers, and may help to better recognize the importance of services, as well as minimize uncontrolled exploitation. A comprehensive economic framework should ideally consider all the values systematically. However, valuation could be tailored to specific policy settings. The limited application of valuation in such cases (instead of the total value approach) may possibly avoid some above-mentioned challenges. Currently available economic valuation methods are useful, but many remain controversial because of the limitations of economic tools to accurately capture all the values and associated challenges. Great potential exists, however, to further improve and apply these valuation methods and better use the values generated, particularly in designing policies and investment measures related to water-related forest ecosystem services.

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Chapter 5

PAYMENTS FOR FOREST-RELATED WATERSHED ECOSYSTEM SERVICES

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5. Payments for forest-related watershed ecosystem services

One of the main challenges in the forestry sector is the adequate accounting and benefit-sharing of positive externalities deriving from sustainable forest management and reforestation activities. Positive externalities in this context refer to all the services and products that result from well-functioning forest ecosystems. Unstable economic conditions in the UNECE region resulting from the financial crisis in 2008 have contributed to undermining investments in public goods provision, such as forest conservation and other environmental policies (Geels, 2013). With continuing problems of budget austerity, PES and other voluntary, market-based mechanisms are seen as an alternative source to public funding, and as an alternative source of income for private land owners for, among others, the provision of hydrological services. These mechanisms can be gradually integrated into traditional top-down command-and-control regulatory approaches.

It is therefore important to understand the structural and context-specific elements that shape the design of these market-based tools. Among the voluntary tools, PES offer a promising mechanism to increase the supply and compensating the cost of provision of hydrological services, especially in the absence of an enabling legislative framework or functioning local governance (Schomers and Matzdorf, 2013). PES schemes involve a range of actors, institutions, and financial options, and operate in a locally and regionally specific context. The following chapter will elaborate on structural elements, such as governance and legal frameworks, the interplay of actors and institutions, as well as the material, social and institutional capacities available to decision-makers. It will thereby create a typology of PES designs, touching on governance, costs of provision, and financial instruments available to PES scheme managers and practitioners to successfully create PES schemes that can deliver meaningful outcomes.

5.1 Governance and design of water-related forest ecosystem services

In the literature, PES schemes are generally understood in accordance with the definition given by Wunder *et al.* (2016).[35] Nevertheless, there has been increasing use of a less strict definition "*PES are a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources*" (Muradian *et al.*, 2010). While Wunder stresses the point of transaction mechanisms, Muradian focuses on the type of actors and outcomes of PES mechanisms, giving a broader and more comprehensive definition that better fits existing examples. When considering PES schemes in general, and PES schemes in the water sector (also known as payments for watershed services (PWS)), most schemes in the United States of America and Europe are best described as "PES-like" implemented by public entities, often acting in a rather complex institutional framework (Leonardi, 2015; Bennett *et al.*, 2014; Vatn, 2010). In the UNECE region, forests are often publicly owned and strict traditional water-related regulations decrease the level of voluntariness of sustainable land management practices.

5.1.1 Key external aspects shaping the development of PES schemes

Within the scientific literature, several criteria and analytical frameworks have been used to classify and describe different governance and design models of PES worldwide (Ezzine-De-Blas *et al.*, 2016; Derissen and Latacz-Lohmann, 2013; Muradian *et al.*, 2010; Muradian and Rival, 2012;). Nevertheless, forest-related PWS do not develop in an environmental and institutional vacuum; therefore, analysis and design should be carried out according to local and regional **structural elements**, such as:

- **Ecosystem structure, process and services**: PWS design is highly influenced by the characteristics of targeted ecosystem structures (forests and agricultural lands are subject to different use restrictions), processes and hydrological services (especially in regards to their rivalry and excludability) (Kemkes *et al.*, 2010). Depending on the targeted hydrological services, we have different internal interactions among actors and a specific institutional interplay (*e.g.* hydropower generation usually has a different normative background from tap water provision). Besides, service attributes, such as quantity, quality, timing and the spatial characteristics of the flow between service provision and consumption, also shape the scheme and influence the type and location of interacting organizations (Brauman *et al.*, 2007). Hydrological services are often mismatched with respect to timing (i.e. the timing of hydrological services is not necessarily instantaneous and can result in lag effects and change over time, for example with forest age) and on spatial scale, where the service providers are often located upstream and service users are situated downstream (Serna-Chavez *et al.*, 2014). This spatial mismatching increases the local horizontal interplay and forms the basis of PWS scheme governance systems.

35 Described as: "(a) a voluntary transaction, where (b) a well-defined environmental service (ES), or a land-use likely to secure that service (c) is being 'bought' by a (minimum one) service buyer (d) from a (minimum one) service provider (e) if, and only if, the service provider secures service provision (conditionality)" (Wunder *et al.*, 2008).

- **Type of actors**: The type of actors influences the design and implementation of PWS schemes. Following the institutional analysis and development framework (IAD) (Ostrom, 2011), a comprehensive analysis of resource users has to take into account different aspects, including: (a) preference and resource roles, rights and responsibilities; (b) preferences, interests, expectations and values; (c) actions and interactions, use and management of resources; (d) information sharing; (e) lobbying; and (f) deliberation. These aspects are all useful to better understand the decision-making processes relating to resource strategy and management. The interactions of actors create networks and shared rules on resource management and conservation. Therefore, PWS are essentially networks of organizations that set specific economic rules for the sake of a specific ecosystem service provision, leading to social and natural capital improvement (England, 2000; Hejnowicz *et al.*, 2014). As a result, the main PES classifications are based on the type of actors (such as public, private, private non-commercial) and the power/economic relations among them.
- **Institutional interplay**: A third analytical dimension that externally influences the whole PWS supply chain, on both the supply and demand sides, is that of institutional interplay (Mitchell, 2003; Young, 2000). Institutional interplay is concerned with how the scheme interacts with other institutions at different levels. Institutions can interact both horizontally and vertically depending on the level of social organization with which they interact (Young, 2000). An example of vertical interplay can be related to the synergies between WFD (an EC top-down policy instrument), and its implementation at the national level and its impact on the acceptability and adoption of PWS schemes at the local level. An example of horizontal interplay can be found within the integration of different local property and use rights regimes and the design of the PWS scheme. The commons often interact and influence the design of PWS schemes (Ostrom, 1999). The interactions can also be dual in nature, i.e. functional or political. The former is more connected with the local biophysical and the socio-economic context (for example, the type of ecosystems and their services), while the latter is more related to the intentional and deliberate act of linking institutions to achieve a collective goal and improving institutional effectiveness (such as, for example, the EU with the WFD). PWS schemes at the UNECE level operate in a very complex, vertical and horizontal institutional context. Water uses, such as tap water consumption, hydroelectric power production, irrigation and flood control, are all highly regulated and generally, there is stratification of institutions at all levels. Hydrological services are highly conditioned by other institutional sectors, such as agriculture and forestry, urban development, climate and health regulations (Tzoulas *et al.*, 2007). PWS schemes can interact as a catalyst of these stratified institutions, creating synergies and harmonization of collective goals. However, if the design does not take into account all the different aspects of institutional interplay, PWS schemes may overlap with existing regulations and create conflict, especially when dealing with local existing property and user rights (Turner *et al.*, 2003).
- **Capacity and scale**: are two cross-cutting dimensions that influence all the above-mentioned factors, and thus determine the final performance and outcomes of a scheme. Corbera *et al.* (2009) defines the term "capacity" as the "***availability of social, institutional and material capital to design and implement PES programmes to achieve their stated objectives***". Usually, forest PWS are the result of an interaction of several organizations or groups with different capacity levels. Therefore, in order to ensure the scheme's success, it is important to assess each actor involved, and assess them in terms of their technical, financial, legal and political capacity. PWS are quite complex systems that have to respond and adapt to different geographical, administrative and institutional scales. As such, they are not usually formed by newly developed organizations; instead, special attention is paid to existence of cross-scale institutions (local partnerships) that are able to cope with multiple scales of intervention (Heikkila *et al.*, 2011). Cross-scale institutions, such as local action groups, or other local and regional partnerships, are important in addressing both the multifunctional role of forests and other ecosystems and the demands of different water uses, *e.g.* drinking water, and irrigation (Leonardi, 2015). On the other hand, the concept of scale entails the spatial, temporal and quantitative dimensions for the measurement of a certain object or process. A proper geographical scale for the implementation of PWS is important as it contributes to improved outcomes within the hydrological process (Wendland *et al.* 2010); in addition, a landscape approach is more likely to work than an on-farm approach. Finally, we should distinguish the administrative scale from the implementation scale, as a scheme can be managed from a national administration but implemented locally, *e.g.* at the catchment level. In the analysis of capacity and scale, practitioners have to pay attention to how the design of the scheme responds to the needs of targeting different governance and ecosystem scales, as this affects the final performance and outcome of the scheme.

5.1.2 Key design aspects to be considered for PES development and analysis

If the aforementioned external factors shape the emergence of PWS, project developers can create the schemes, and at the same time take into account **different design and governance aspects** – the choice will ultimately lead to the success or failure of the scheme:

- **Degree of voluntariness**: the voluntariness is the degree to which the contracting parties, the service provider(s) and the beneficiary(ies), enter into an agreement and participates through a free and informed process of negotiation (Wunder, 2005). The voluntariness principle is, therefore, a characteristic that differentiates PES from more "government-based" command and control measures. However, voluntariness is not as "black or white" a principle as it first may seem (i.e. voluntary vs. not voluntary). In fact, development of PES schemes are negotiation processes where two or more involved parties participate with different degrees of power and participation (de Groot and Hermans, 2009). Therefore, we can distinguish different degrees of voluntariness according to the actual degree of participation and level of information between the contracting parties (Fung, 2006). Moreover, the role of governments and regulations may influence the voluntariness only from the supply side (for example, through imposing sustainable forest management practices or restrictions on clear cuts), or on the demand side (for example, through higher water quality standards imposed on bottle water brands), or a mix of both supply and demand side. The degree of voluntariness also relates to the concept of "additionality". The provision of ecosystem services is "additional" to the business-as-usual scenario (Kroeger, 2013). The assessment of additionality, therefore, depends on what is already required by law and the additional effect of the payment, regarding the ecosystem service provision.
- **Degree of directness**: By directness of the transfer, we refer to the extent to which individual providers receive direct payments from the ultimate beneficiaries of the environmental service (Muradian *et al.*, 2010). The less direct case is when governments play an intermediary role in the transaction between the final user and service providers. This is the case, for example, of agri-environmental payments schemes, such as the English Woodland Grant Scheme where the government pays landowners to plant new forests (Nisbet *et al.*, 2011). The more direct case is related to instances where PWS contracts are signed directly between beneficiaries and service providers, i.e. 'bilateral agreements'. As intermediate examples of directness there are "scope taxes", as is the case for the Lower Saxony water levy (Bluemling & Horstkoetter 2007), or "beneficiary pay

funds" that are organized under third-party funds or trusts that collect beneficiary payments and redistribute them to the service providers, as in the case of Upstream Thinking (OFWAT, 2011).
- **Degree of commoditization**: By degree of commoditization, we refer to the extent and clarity with which compensation received by environmental service providers has been determined by transactions involving a tradeable commodity (Muradian *et al.*, 2010). We may find five main degrees of commoditization, starting from: (a) "no monetary benefits" (in kind payments); (b) rewards (social acknowledgement for resource managers who have historically played an important role in the provision of ecosystem services); (c) subsidies/incentives (incentives that do not fully cover the opportunity costs of more environmentally-friendly practices); (d) payments (payments are expected to cover fully the opportunity cost of more environmentally friendly practices); and (e) markets (markets are consolidated payment flows among services, beneficiaries and providers. These are the cases where we observe a fairly high degree of commoditization, often paired with some kind of marketplace exchange arrangement).
- **Degree of additionality:** the additionality principles describe "What would happen without the payment"? To be additional, the increased provision of hydrological services must be made in direct response to the payment. Therefore, the service provision must be additional to the initial baseline. Several design factors influence the additionality of schemes, including: (a) the spatial targeting of the contracts (whether or not payments are addressed to those areas for higher hydrological service provision); (b) differentiated payments (Table 5.1), which lead to a higher cost efficiency (payments diversified according to the types of adopted management practices, the opportunity

costs, etc.); and (c) conditionality[36] as the capacity to tie the payment to the provision of the hydrological service (Ezzine-De-Blas *et al.*, 2016).

TABLE 5.1

Payments characteristics and structure

Characteristics	Specifications
Funding mechanism	[Single source funding, multiple source funding, utility/public budget allocation, consumer water levy/ fees, CAP payments, national/EU funding, private budget allocation, water rights]
Payment source	[Public, private, mixed, citizens]
Payment mode	[Input - based, output - based]
Payment type	[Cash, in-kind, both]
Payment frequency	[One off, periodical, both]
Payment time	[Upfront, after adoption of management practices, after ES delivery]
Payment eligibility	[Horizontal, targeted]
Payment amount in relation to costs of ES provision	[Spill over, partial cover of costs, full cover of costs, above the costs]
Payment aim	[Avoided negative externalities, compensate negative impacts, compensate opportunity costs, provide positive externalities]
Payment amount	[€/Ha min, €/Ha max, total transaction last year available, historical transactions]

Source: Elaborated from Leonardi (2015).

5.1.3 Main PES governance models

As we have seen in previous paragraphs, voluntariness, directness, commoditization and additionality are important factors to consider in the design of PWS schemes, particularly as all of them will ultimately influence the performances of the schemes. All these factors are, at the same time, influenced by the presence, or absence, of government intervention within the PWS scheme.

The public sector can intervene both as buyer and/or as legal actor, providing a legal framework and/or obligations for the creation of PWS. Figure 5.1 classifies the four following main types of PWS governance models depending on the role of state: (a) user-and non-government financed payments; (b) government-financed payments; (c) compliant payments; and (d) compensation payments (Matzdorf *et al.*, 2013). The user-financed PWS, represent the classical Coasean type, market-based instruments, where the contracts are negotiated by two private parties, without any intervention from the government, neither as a buyer nor as a legal actor (Engel *et al.*, 2008). The categories where the government intervenes in the scheme as a buyer correspond to the "Pigouvean approach". The state can be seen as a "third party acting on behalf of service buyers" (Engel *et al.*, 2008). This is the case of agri-environmental schemes, as well as in those schemes where municipalities are paying forest owners on behalf of citizens to increase water-quality within the water abstraction areas.

FIGURE 5.1

PES governance models

STATE INVOLVED AS A BUYER	STATE INVOLVED AS A REGULATOR: No	STATE INVOLVED AS A REGULATOR: Yes
No	User-financed (Coasean approach) and non-government financed payments, *e.g.* Vittel case study	Compliant payments, *e.g.* mitigation and wetland banking in the U.S.
Yes	Government-financed payments (Pigouvian approach), *e.g.* agri-environmental schemes in the EU	Compensation payments for legal restrictions, *e.g.* groundwater protection areas payments

Source: Matzdorf *et al.* (2013).

Compared to other more private user-financed schemes, agri-environmental schemes are often associated with a lack of additionality, as the self-interest of citizens is often not well reflected in the public body acting on their behalf. An interesting example of a mixed model user-government financed payments can be found in those schemes where final users are charged with a water levy, as is the case in Lower Saxony (Bluemling and Horstkoetter, 2007). In this case, the state acts as a legal driver and influences the demand side by creating a "duty to pay" for environmental externalities (positive or negative), thereby providing a financial source for PES development.

36 Conditionality of the payment: Conditionality is the degree to which the service provision is conditional to the payment. This principle is often very hard to prove because of several complexities. First, many schemes lack of knowledge about the "baseline" scenario, so as to understand and measure how the payment have influenced the service provision, compared to a "no intervention" scenario (Kroeger, 2013). Secondly, payments are often targeted to management practices that are already in place, so these can be characterized as payments for "spillover" effects. Sometimes payments are used to enforce regulations that should anyway respected by law (Pirard, 2012). Therefore, there is a lack of real additionality of the payment respect to the business as usual scenario.

The last category, compensation payments for legal restrictions, is related to those cases where the government regulates the supply of ecosystem services (*e.g.* by restricting clear cuts within a forest catchment area).

Often, these last four broad categories generate mixed models between market and public intervention and a third institutional dimension, the community intervention (Muradian *et al.*, 2010; Vatn, 2010). Community institutions are particularly relevant where the social interest is very high and associated with the institutional goals of many civil society organizations (CSOs), as in the case of forests. Therefore, in practice, PWS often result from the cooperation achieved among different stakeholders, state regulations state, civil society lobbying and fundraising, and business sector self-interest.

5.1.4 Types of governance models for PES

A more detailed classification is presented in Table 5.2 below to give a more complete picture of the several governance models specific for water-related services. Table 5.2 shows the main programme typologies and sub-types of governance models. The same classification is used to assess the identified PWS in the UNECE region, as listed in Annex 1.

The table was developed on the basis of criteria, such as: voluntariness (demand and supply); directness (between the beneficiary and the supplier); aims and drivers (compensate, avoiding impacts, providing additional ecosystem services); and financing mechanisms (Leonardi, 2015).

TABLE 5.2

Typologies of PWS in the UNECE region

Programme typologies	Sub-type	Major drivers	Main financing sources	Examples (See, Annex 1)
Public – non-voluntary	Compensation for legal restrictions	Increase acceptance of legal restrictions through compensation of opportunity costs	Public budget allocation or scope taxes	Danish groundwater abstraction
Public regulated	Agri-environmental schemes	Public goods provision and partial cover of adoption of management practices	Common Agricultural Policy	Greening within Common Agricultural Policy
	Public bilateral agreements	Local public goods provision	Budget allocation	Forest infiltration areas
	Water charge - public bilateral agreements	Investing on water quality. Charging customers for water related services via water charges	Scope taxes	Saxony Cooperation Act and the water bill
	Regulated trading initiatives	Regulatory compensation	Compensatory trading schemes	Wetland and Nutrient Banking, Woodland carbon code.
Compensatory private initiatives	Trading initiatives	Standardized water footprint voluntary compensation	Compensatory trading schemes	Peatland code, UK. Private trading initiatives in USA
	CSR offsetting	CSR water footprint voluntary compensation	Private sponsor	Coca Cola water stewardship programme
Private voluntary payments	Avoided impacts bilateral agreements	Avoid use of chemical inputs through paying for opportunity cost incurred (no associated benefits)	Private budget allocation	Wessex Waters Methaldeyde programme in UK
	Multiple benefits partnerships	Improve hydrological service provision through natural capital maintenance and improvement. Based on partnership model	Multiple sources and instruments	Danone catchment partnerships, France. Upstream Thinking, UK
	User funded schemes	Charging final beneficiaries to invest on targeted hydrological services	Beneficiary pays fund	Tourist payback schemes, UK
	Environmental benefits – bilateral agreements	Improve hydrological service provision through natural capital maintenance and improvement. Based on bilateral agreement	Private budget allocation	SCAMP, UK

Source: Leonardi (2015).

Well-known categories are already well represented in the literature; therefore, we will limit our discussion on the main categories, and only give a detailed explanation on new emerging models, as well as the more frequent ones that have been recorded in the UNECE region.

Multiple benefits partnerships

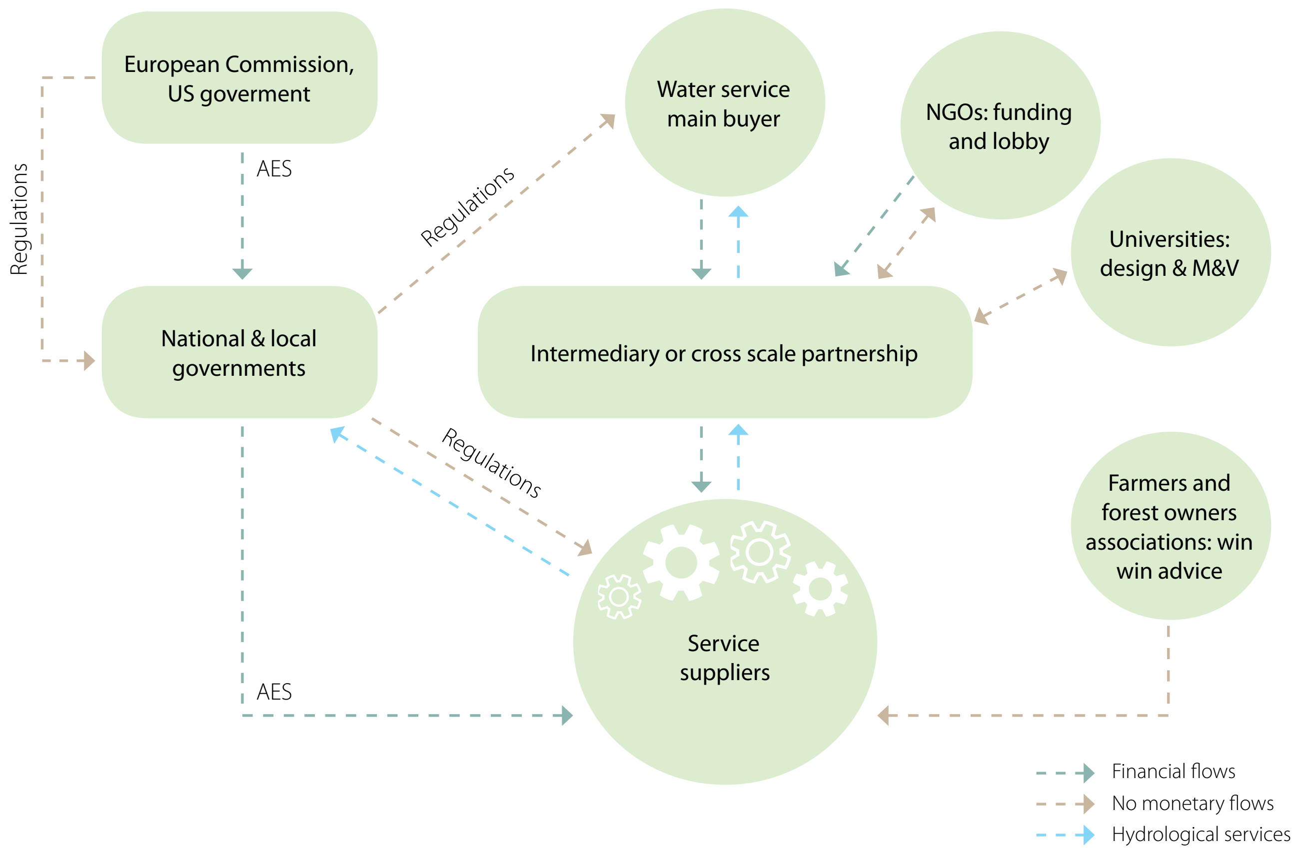
As explained in the introduction to this chapter, while the literature focuses more on theoretical "market-based" approaches to PES, in reality most of long-lasting water-related schemes base their success on the "community" and "integrated financing" approaches (Leonardi, 2015). According to the inventory provided in Annex 1, in the UNECE region, multiple benefits partnerships are an emerging and promising category that includes all those projects that have:

- **Participatory and collaborative local-national governance**: These include private companies, public regulators, charities organizations and local authorities. These actors are often organized under an umbrella organization, a partnership or a cross-cutting institution.
- **Multiple sources of funding**: These are used through the different development phases and match funding ensures higher stability and complementarity among different sources.
- **Multilateral agreements**: These contracts are signed by more than one organization.
- **Higher co-benefits**: These focus on water-related issues; however, they also target biodiversity, carbon and social-economic benefits. Increasing co-benefits is the main element incorporated to increase scheme acceptability and actor participation.

In fact, networks and collaborative approaches at the local level seem to be characteristics of existing successful case studies, where regulators, private companies, local authorities, technical and civil society organizations share their expertise and, through match funding, deliver high-level watershed schemes around the region. For example, in England, Upstream Thinking is an "umbrella" programme initiated by South-West Water, which includes several subprogrammes (Exmoor Mires, Dartmoor Mires Project, WRT, Working Wetlands, Wild Penwith, Otter Valley, Fowey River, *etc.*). This "umbrella" project

FIGURE 5.2

Schematization of the PWS partnership model



Source: Leonardi (2015).

targets different catchments and water issues with a panel of different intermediaries, local authorities and suppliers (see Chapter 6, for a detailed description of the case study). In some European countries, partnerships have also emerged in response to the requirements of Article 14 of the EU WFD on public information and consultation. This is the case of river contracts in Italy where many stakeholders interacting with the river system develop political and economic agreements on the long-term planning of river basins. The unique Italian case study of forest infiltration areas for groundwater recharge (see Annex 1) is part of a broader "Aquifer contract", where public, private and CSOs are committed to the sustainable management of a specific aquifer.

In England, catchment partnerships are funded by a special government fund and aim to meet the requirements of Article 14. These locally based partnerships are a promising fertile ground for the emergence of new PWS around the EU. In the United States, government-initiated partnerships are already a consolidated phenomenon. Figure 5.2 represents a schematic model of multiple benefit partnership.

Bilateral agreements

Bilateral agreements are direct contracts between service suppliers and buyers. In this category, all those schemes where transactions and agreements are mainly between two main actors have been grouped together, and bilateral agreements have been broken down into the following subgroups:

- **Public bilateral agreements**: These are enforced by public bodies, on behalf of taxpayers, where suppliers (private or public) participate in the agreement on a voluntary basis. They are mainly managed by municipalities or public utilities. The funding mechanism is through a direct budget location.
- **Water charge bilateral agreements**: as above, but the funding mechanism is based on the adoption of water charges, which increase the directness between suppliers and beneficiaries. For example, in the Lower Saxony cooperative agreements, funds are collected by utilities through a levy on water customers' bills; the funds are then transferred to the Lower Saxony government, which then signs an individual "grant contract" with utilities on the basis of planned cooperative agreements to be signed with farmers. Eventually, utilities sign a bilateral contract with individual farmers and forest owners.
- **Avoided impacts bilateral agreements**: often led by a private organization (often a private utility or a bottled water brand), where the main aim of the programme is to avoid a specific hydrological issue, such as nitrates or agri-chemicals. A water company, for example, may focus on water-related issues that can threaten its business, without special attention to other important co-benefits. The focus is not necessarily on providing an improved ecosystem service but avoiding a human impact on the service. Cooperation with other actors is often missing in this model. The PWS managers usually work directly with suppliers, without collaborating with intermediaries or support organizations.
- **Environmental benefits – bilateral agreements**: These focus on improving hydrological services and increasing the provision of other co-benefits, and are often managed by private entities. These PWS adopt an ecosystem approach to catchment management. Cooperation with other actors is often missing in this model. The PWS managers work directly with suppliers.

Other schemes

The following schemes are less frequently encountered:

- **Compensation for legal restrictions** are schemes used by state or regional authorities to compensate the opportunity cost of land owners and their ability to meet certain agricultural practices restrictions within drinking water protected areas. They are quite specific to the European context and often used to improve the acceptance of regulations or address equity concerns. An example comes from the "mutual agricultural claims water extraction" scheme in the Netherlands, where the public water utility (Water Bedrijf Groningen) compensates income loss for restrictions on the use of pesticides imposed by law to groundwater recharge catchments in the Drentsche Aa National Park.
- **Water targeted agri-environmental schemes**: as the EC itself understood, there was a lack of integration between the CAP payments and water quality goals (especially in the previous programming period, therefore most agri-environmental schemes lacked direct links with the water quality goals set by the EU WFD. An example of a national scheme is the Catchment Sensitive Farming Capital Grant scheme in the UK, which funds capital improvements that have a direct impact on water quality, with specific focus on nitrates and sediments. This scheme provides match funding for many PWS in the UK.
- **Offsetting based on philanthropic motivations** by private organizations still count for very little in the UNECE region. Some of the identified programmes are still in a pilot phase, and some are connected to voluntary offsetting of water footprints, but with a very small link between actual impact and compensative intervention. They lack a proper methodology for compensation and are usually connected to a "spot" intervention. They all involve private beverage companies, such as Danone, Coca Cola, Bionade, etc.

- **Trading initiatives**, such as the Peatland Code, which is a DEFRA pilot project. The Code is a voluntary standard for peatlands restoration projects in the UK, which tries to create a trading system for multiple benefits provided by peatlands. The only regulated trading initiative in the EU was located in Spain, within the Special Plan for the Upper Guadiana, where the basin authority has established a trading system for water abstraction rights. The system generated resources for reforestation projects around the valley. However, according to WWF Spain, the system has failed due to corruption and over-allocation of water rights that led to groundwater depletion (WWF, 2012). Trading initiatives are much more developed in the United States; however, these initiatives are more closely linked to wetlands, nutrients banking, river payback schemes, and not to forest ecosystems (McKenney and Kiesecker, 2010).
- **User-funded schemes** are usually private schemes managed by an intermediary that, on one hand, collects money from beneficiaries (anglers, tourists, etc.), and on the other hand, pays the service providers directly or directly implements restoration projects. Under this category, we can find the "tourist payback schemes" or angling passports in the UK.

Regardless of the design of the scheme, an important factor that influences the emergence of forest-related PWS is connected with the cost of provision (CoP) of the hydrological service, *i.e.* the cost that the service supplier (*e.g.* farmers and forest owners) have to bear in order to provide a certain ecosystem service. The next section will analyse the topic focusing on the different component of CoP, and at what level schemes are partially or fully covering it.

5.2 Cost of provision

In a market economy, the costs incurred to manufacture a product, or a service, represents a fundamental determinant of their supply decisions for producers. Similarly, producers of water-related ES subordinate their choices about the level of service provision to the need of covering their relative costs. Therefore, when developing a policy/market incentives, it is really important to look at costs of provision (CoP) to examine the problem from the perspective of the provider of an ES. At the same time, the buyer will also be interested in the CoP as this normally affects affordability of the services.

The CoP concept is often used in economic theory, as CoP are considered as a proxy for value within certain decision-making processes, irrespective of the policy or market-based instrument that supports the supply of a water-related ecosystem service (see Chapter 4 on valuation of water-related forest ecosystem services). For example, the costs met (or the avoided costs saved) to restore a resource damaged by a flood and return it to its original condition, *i.e.* the replacement cost (Barbier, 2007), are considered to be a measure of the economic magnitude of the environmental damage itself (Zafonte and Hampton, 2007) as well as a proxy of the value of the service provided by some land protection investment.

Box 5.1

Type of actors and market situations

Participating actors

Although PES theory mainly refers to two actors (a service provider and a service beneficiary), other actors can influence the design and implementation of the contractual agreement. We can therefore summarize the main groups that are typically involved in a PES scheme:

Buyers or beneficiaries: those who are willing to pay for an improved, safeguarded or restored ecosystem service. These include citizens, water utilities, municipalities, beverage companies, etc.;

Sellers or service providers: a change in management practice among land and/or forest managers can potentially secure or improve supply of the ecosystem service;

Intermediaries: that can serve as agents linking buyers and sellers and can help with scheme design and implementation. They often are NGOs, public authorities, river trusts, forest owners' associations, etc.;

Knowledge providers: these include resource management experts, valuation specialists, land use planners, universities, participation experts, business and legal advisors who can provide knowledge essential to scheme development;

Regulators: that can impose command and control measures that influence PES or can regulate and/or facilitate the start-up and the effectiveness of PES mechanisms;

Funding agencies or sponsors: public or private entities that fund the start-up or feasibility studies for a PES scheme;

Moreover, there might be different buyer(s)/supplier(s) combinations. The literature distinguishes between four types of **market situations** (Lockie, 2013):

- *One to one* – represents a bilateral monopoly or oligopoly with only one/few ES sellers and one/few ES buyers;
- *One to many* – represents a monopsony or oligopsony with many ES sellers but only one or few ES buyers;
- *Many to one* – represents a monopoly or oligopoly situation with only one/few ES sellers but many ES buyers;
- *Many to many* – represents a PES situation with many ES sellers and many ES buyers.

The combination of different actors and market types originates several PES governance models that are broadly characterized in the next section.

Source: Sattler *et al.*, 2013.

Detractors of this approach claim that production or reproduction costs are not an appropriate proxy for valuing environmental services (Bateman *et al.*, 2011). One reason for this is the argument of 'strong sustainability', whereby natural capital and manufactured capital are not substitutable because of the complexity of ecosystems (Dietz and Neumayer, 2007). Another reason is that cost is not a measure of consumer surplus or willingness to pay. In fact, in the presence of downward sloping demand and upward sloping supply, total value will always exceed total CoP. For these reasons, when CoP are used as a proxy of the ES value, a risk of underestimation of the TEV is always present, with the associated problem of supporting a lower-than-optimal level of ES provision when CoP are used to define compensation measures. These critiques reflect a relevant issue in the debate on the use of CoP as a proxy of environmental values: indeed, defining how far to go in the consideration of the costs based on the provision of ES is still a partially open question from a theoretical point of view. From a practical point, the use of CoP can be appropriate for decision-making in certain settings, particularly if alternative approaches are being considered to achieve the same outcome (*e.g.* clean water provision). It must be underlined that many of the existing financial schemes, *e.g.* the EU's CAP, continues to rely massively on the CoP method. The application of agri-environmental measures, in particular, has contributed to the publication of a large amount of literature on the role of CoP to incentivize farmers to enter protection programmes. The literature covers agricultural issues in depth, but forestry is scarcely covered, as the CAP provisions traditionally less target it.

There are many advantages to covering the costs incurred by paying providers of water-related services. One such advantage is certainly the higher acceptability by actors operating on the supply side; another would be the fact that compensation can be supported by evidence based on hard data (*i.e.* the real costs incurred), rather than on questionable and controversial estimates of externalities. Water-related services supported by the adoption of a CoP approach can be regulated through the ease with which expenditure can be traced and accounted, *i.e.* through filed invoices, or the standardization of the costs of some operations; this makes the implementation of incentive policies and the monitoring and auditing activities much simpler and more transparent.

From this perspective, a shared belief amongst policy theorists and decision makers is that the reference to CoP can represent an operational solution to achieve satisfactory levels – in terms of effectiveness as well as efficiency and equity – of the supply of water-related service. For this to occur, however, some important conditions must be met.

The first one, as already mentioned, is the definition of the CoP components: The approach must be especially comprehensive and include not only direct, but indirect (income foregone) and, importantly, transaction costs.[37] Indeed, this distinction sometimes makes the implementation of the CoP approach a controversial issue; for example, in the case of a new investment to protect a water catchment area, the CoP are connected to the new added direct land management costs plus income losses, as well as the transaction costs needed to negotiate, organize and implement the investment. If a compensation for the CoP is provided by society (but the same approach is valid for any type of beneficiary, even a single private actor), the CoP should be less than the extra benefits (also in terms of positive externalities related to the protection of aquatic ecosystems), and the extra costs (if any) due to the investment; this includes those transaction costs needed to negotiate and monitor the investment (see Figure 5.3).

The correct calculation of the three components of the CoP is not easy: From a public goods point of view, costs and benefits should also be based on the internalization of ES and resource costs, and this calls for complex and site-specific analysis. Some cost components, *e.g.* depreciation and capital costs of infrastructure and equipment, depend on accounting practices, the ownership of the land, and the risk attitudes of the actors involved in water investment. Moreover, water systems are frequently managed as multipurpose resources, and it is not easy to allocate specific CoP that are related to common management costs. Three international research projects have developed guidelines dealing with these problems in the CoP evaluation.[38]

The concept of transaction costs in service provision is crucial in achieving policy effectiveness: for the supply of environmental goods, start-up initiatives normally require strongly motivated managers and a temporary extra payment above ordinary CoP to cover the costs of the change, *e.g.* in management systems, or in acquiring new information. One concealed but pivotal determinant affecting ES provision is the different consideration of VAT in national fiscal systems.

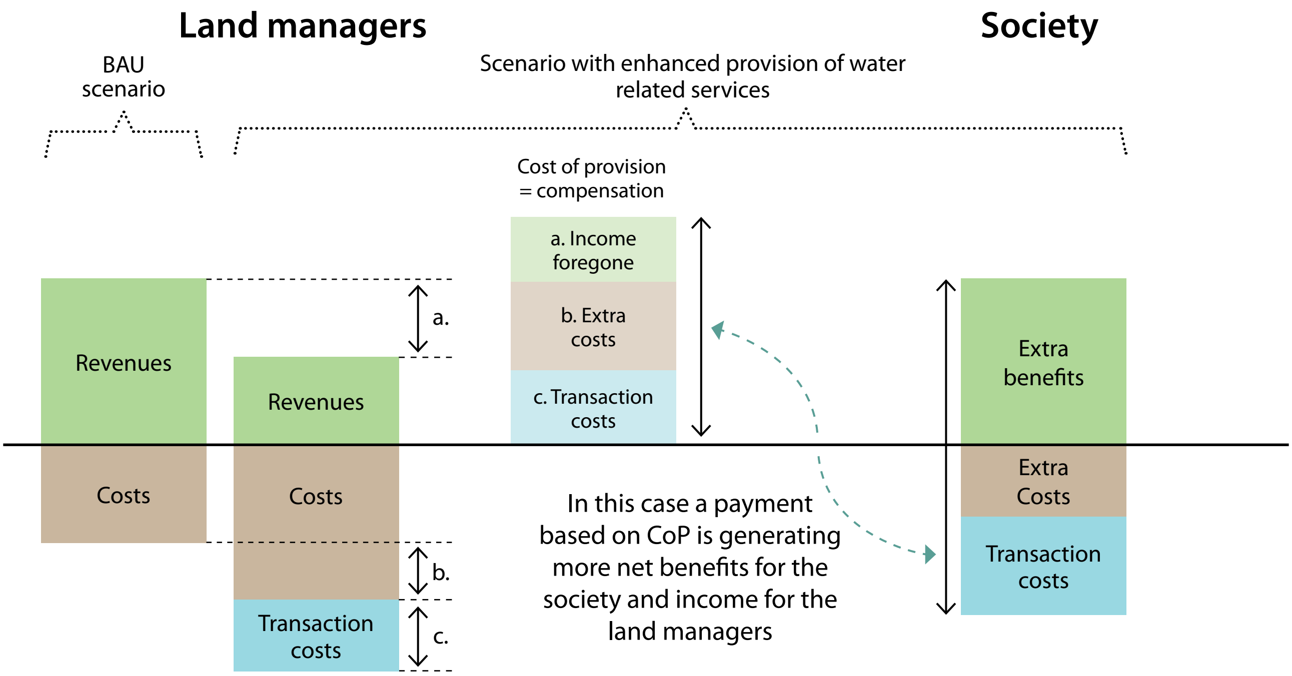
37 In the well-known Vittel case study of implementing a PES for improving the quality of mineral water in a catchment area in the Vosges region (France), it took 10 years to negotiate a compensation programme between the company and local land managers.

38 These three publications provide useful guidance and can be consulted for matters relating to the economic valuation of forests and water resources:

- "Development and Testing of Practical Guidelines for the Assessment of Environmental and Resource Costs and Benefits" – AQUAMONEY (www.wise-rtd.info/en/inSfo/development-and-testing-practical-guidelines-assessment-environmental-and-resource-costs-and-9).
- "A new environmental accounting framework using externality data and input-output tools for policy analysis" – EXIOPOL (www.feem-project.net/exiopol).
- "New Ways to Value and Market Forest Externalities" - NEWFOREX (www.newforex.org).

FIGURE 5.3

Costs of provision components and how these can be justified for organizing compensation by society



Source: Pagiola and Platais, 2007.

Unfortunately, this aspect is very often neglected in the design of market-based instruments, and can lead to some perverse effects. Moreover, an 'opportunity cost' perspective should be adopted when considering CoP: locally changing environmental or external conditions can positively or negatively affect a providers' sets of alternative opportunities; this in turn, can shape their attitude towards the provision of water-related services. Therefore, a narrow approach to CoP may fail to induce a quantitative change, or an upgrade in the desired service. However, it should be kept in mind that CoP can often represent the minimum threshold for triggering an ES offer.

A further challenge with the use of CoP is associated with the non-homogeneity of the same category of water services, and hence heterogeneity of CoP across agents: the same ES, in the same context, can be associated to a different CoP. Therefore, the second important prerequisite in any approach operating through CoP is that flat untargeted compensation is not the only element to take into consideration. This aspect is essential in order to both achieve effectiveness through an adequate financial support and ensure efficiency in public spending.

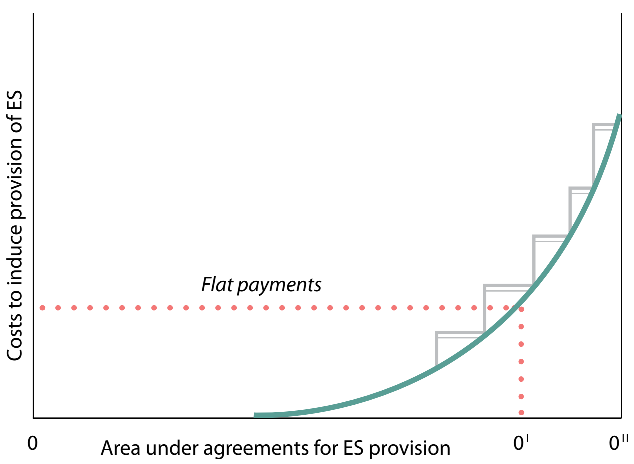
In general, indeed, one basic and strong motivation for the use of CoP is its alleged accomplishment of a better efficiency in public spending. CoP calculation can be the basis for tariff definition and for ranking projects related to water development, and for selecting those that have, for example, the lowest costs of provision of tap water per m^3 or per inhabitant. A tariff for a water service, *i.e.* the price of water, has an impact on the final demand by consumers, and consequently on the efficiency of water resources use. If a tariff is set below the CoP, it may lead to the risk of wasting water; it may also not support the full implementation of maintenance costs for water delivery infrastructure, and may not provide adequate rewards to land managers in the catchment area. This is why CoP calculations are considered the basis for implementing the full-cost recovery principle, as defined in Article 9 of the EU Water Framework Directive on water pricing (EEA, 2013)the European Environment Agency (EEA. The implementation of the principle of full-cost recovery in pricing of basic infrastructure, such as tap water provision, primary education and health care services, is a political question needing a balanced compromise between, on the one hand, the need to ensure access to a basic service and, on the other hand, for covering the CoP, *e.g.* protecting aquatic resources, and improving the efficiency of the service.

Whitby and Saunders (1996) already explored and clarified the field of compensation under financial instruments, showing that instruments based on flat levels of compensation easily run the risk of under- or over-compensating the ES provider. Figure 5.4 depicts one possible supply curve of ES and shows how carefully differentiated and calibrated payments (either according to land zoning, or even better, negotiated with individuals to cover each precise amount of CoP needed by each provider to accept the change), could induce better provision in areas covered by an agreement for ES provision. The negotiation process should, theoretically at least, approximate the remuneration of water-related services to the marginal cost incurred by land managers, plus the profit necessary to stimulate the agreement. A more efficient solution to the flat payment is given by differentiated payments according to land zoning, which can take into account site-specificities, at least at a meso-scale. From this perspective, a CoP approach can also be seen as an instrument to select the most efficient potential suppliers based on, for example, auctions for water-related service compensation mechanisms.

One final remark connected with the idea of using CoP as a compensation instrument is the inherent risk of paying for something that, in any case, would be achieved with lower payments or none at all. As a matter of fact, some cases of uncompensated ES provision can be a normal practice by land owners, based on traditional cultural habits and the introduction of payment systems can undermine ethical commitment to stewardship and conservation (Colman, 1994).

FIGURE 5.4

A supply curve of ES as a function of CoP and related payments



Flat payments
Differentiated payments according to land zoning
Differentiated payments on an individual CoP basis

Source: Whitby and Saunders, 1996.

5.3 General approaches to financing payments for water ecosystem services from forests

5.3.1 An overview of existing schemes in the UNECE region

Investments in forest-related watershed services in the UNECE region are increasingly gaining importance as a tool to meet water policy targets and habitat conservation. However, as previously shown, design and governance, aspects are quite diverse, and come with several challenges depending on the regional context, local regulations, and institutions involved in the development process. Moreover, forests are not usually the main land use targeted within payment schemes because of already existing high environmental standards set by law on forested habitats, especially in the United States of America and Europe. Nevertheless, improved forest management (for example, fire control, conversion from pine to broadleaf forests, water-friendly forest technologies and management) and reforestation are also frequently used as “proxy” management practices to provide hydrological services. The importance of including forests and trees within PWS is even bigger if we include other type of forest management, for example forest-hydrology management practices (such as slope and riparian vegetation restoration, *etc.*) (Leonardi, 2015).

The identification of existing schemes and global and regional trends is not without difficulties. In fact, information is not always available online and, if available, it is often described in local languages, and the complexity of each case study requires specific attention and analysis.

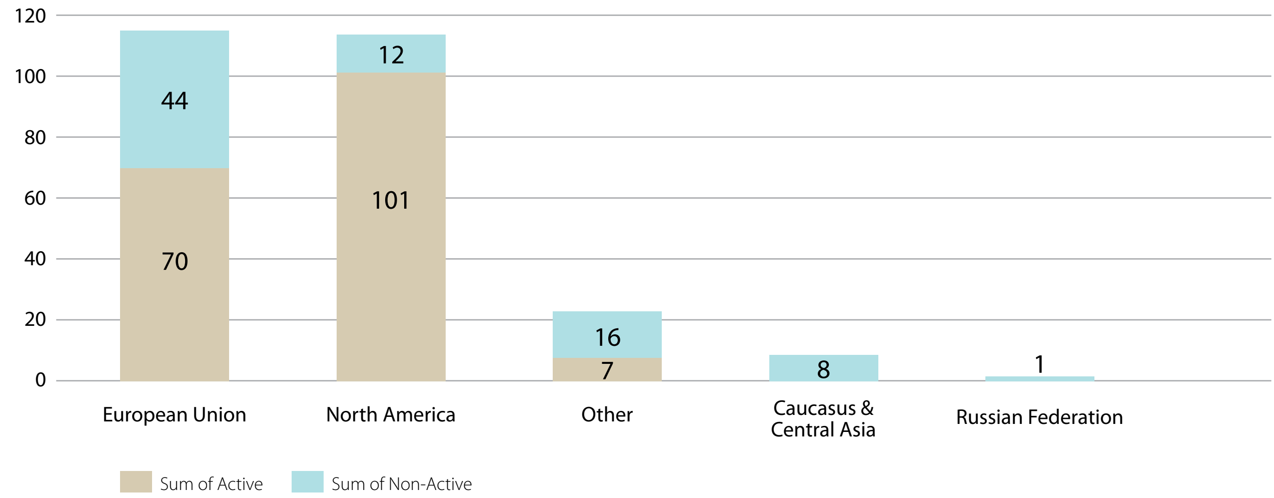
With the attempt to provide an overview of trends of water-related forest ecosystem services financing s chemes for the UNECE region, the present report has merged and updated existing global and regional inventories (Bennett, 2016; Leonardi, 2015), and provided further new schemes. A targeted research was also conducted with a specific focus on CIS countries that were not reporting any case study in the existing literature. Annex 1 presents a non-exhaustive, nevertheless a very comprehensive, list of forest-related PWS, classified by region, country, type of governance models, financing sources, and with links to available online literature.

Overall, we identified 259 schemes for the UNECE area that have been reported in the existing literature or inventories.[39] However, only 178 schemes had enough information to verify their status or past effectiveness (see Annex 1). Figure 5.5 represents the number of PWS schemes per UNECE region

39 According to the 2016 Ecosystem Marketplace report, a total of 419 programmes in 62 countries invested in the natural ability of forests, wetlands, grasslands, and other ecosystems to ensure clean, reliable water supplies for cities and communities, and to combat the threats posed by rapid urban expansion and agricultural pollution.

FIGURE 5.5

Number of active and non-active (design, pilots, unknown) PWS schemes by UNECE regions



Source: Leonardi, 2015.

divided by active and non-active (unknown, design, pilot phase). While North America has the highest number of existing schemes, followed by Europe where the number of new schemes is growing; other regions have almost none or non-active payments. No references could be found on payments for water-related ecosystem services from forests in 30 out of 56 UNECE countries.[40]

Historically, North America has a more market-based approach to environmental conservation and since 2008 the U.S. Department of Agriculture, through the Office of Environmental Markets (OEM), has leveraged standards and market infrastructures that facilitate market-based approaches to agriculture, forest, and rangeland conservation. This type of service is not present in the EU or any other country and has a unique function in stimulating the creation of PES schemes.

The reasons why there are few schemes in countries outside of North America and Europe are summarized below in order of importance:

- Most countries without PES have natural assets, lower population density and pollution drivers with fewer needs in term of water quality (for example in the Russian Federation, where there is high availability of clean water and low-density population).

Box 5.2

Payments for Ecosystem Services in the Russian Federation

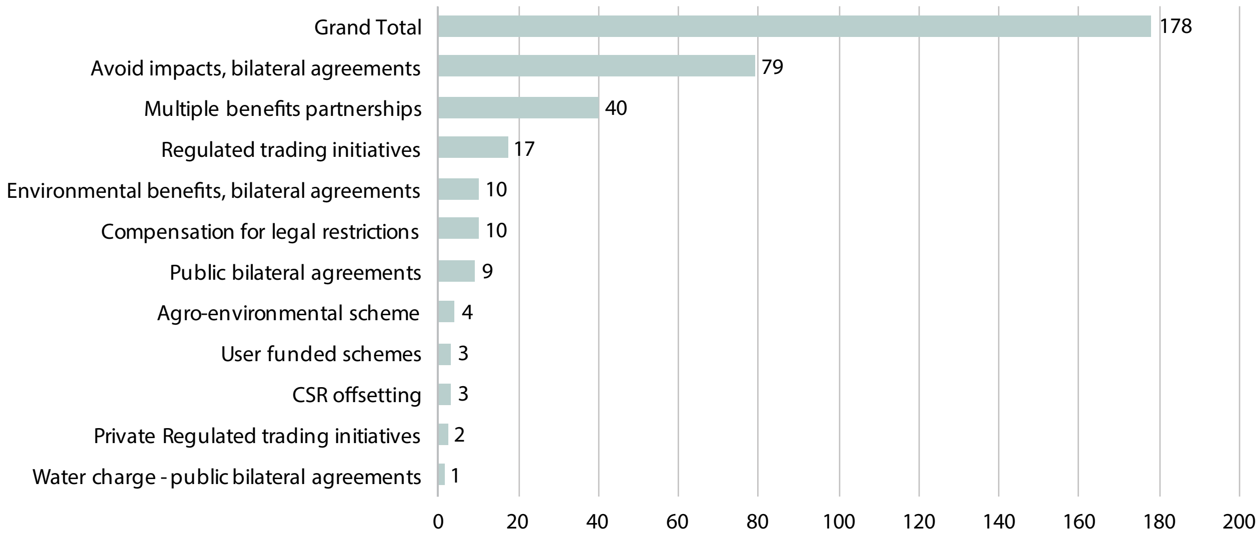
While the scientific underpinnings of PES have a strong foundation in the Russian Federation, with the estimation of the scope and value of ecosystem services (for example Bobylev *et al.*, 2013; Kasimov and Kasimov, 2015), no practical examples of PWS can be identified in this country. The Federal Law on Environmental Protection (including after the changes made in 2014) focuses on norms and standards, and does not include PES as an instrument for protection of the environment. Therefore, the governance, design and funding sources of identified schemes also follow the level of involvement and public funding provided by the public sector, through water-specific policies (*e.g.* water bills frameworks, compensatory or trading schemes), grants, agri-environmental schemes, etc.

- Most of the literature related to PES has only been published in English, and is therefore not easily accessible to practitioners in non-Anglophone countries.
- Many countries in the Caucasus and Central Asia still maintain top-down and regulative approaches to the provision of ecosystem services. Therefore, without incentives for bottom-up and community-based initiatives.
- Civil society organizations (*e.g.* knowledge transfer services, NGOs, forest owners' associations) are not as active as they are in North America and Europe, and do not actively lobby and try to shape the governance and design of payments for ecosystem services schemes.

40 Albania, Andorra, Belarus, Bosnia, Bulgaria, Cyprus, Czech Republic, Estonia, Greece, Iceland, Ireland, Kazakhstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Macedonia, Malta, Monaco, Montenegro, Norway, Romania, Russia, San Marino, Slovakia, Tajikistan, Turkey, Turkmenistan, Uzbekistan and Vatican City.

FIGURE 5.6

Number of schemes by governance typology



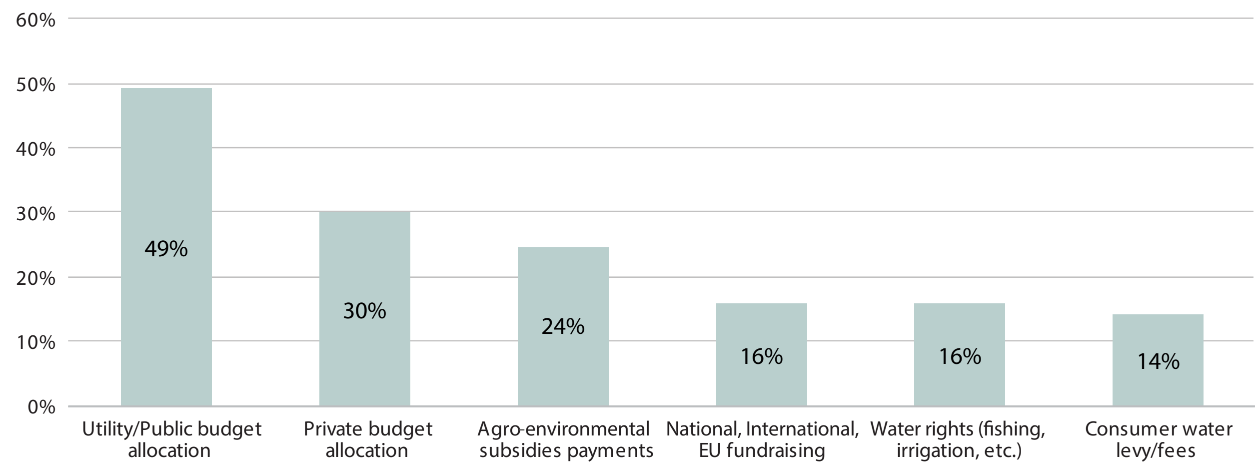
Source: Elaborated from Leonardi, 2015.

We have identified several design features of existing schemes, but programmes are often a combination of two or more design options. Besides, some programmes diversify and adapt their governance structure depending on the type of catchment, actors involved and existing regulations. According to our survey, schemes that use a combination of design features and policy tools have proved to be successful in terms of outcomes and amount of transactions. However, following the theoretical classification framework presented in the previous paragraphs, we assessed all inventoried PWS to better understand the frequency and the characterization of the main PWS typologies.

Figure 5.6 shows the frequency of the main typologies of governance models identified among the schemes listed in Annex 1. The most frequent models avoid impacts on bilateral agreements (schemes that focus on decreasing agriculture pollution through reforestation or tree hedges); have multiple benefits partnerships (often public-private-community partnership adopting a match funding approach); and have regulated training initiatives (this mostly concerns the United States).

FIGURE 5.7

Frequency of funding sources for PWS schemes[41]



Source: Elaborated from Leonardi, 2015.

41 A total of 258 PWS schemes across the UNECE region were assessed according to their funding sources.

TABLE 5.3

Main type of resource transfer mechanisms

Type resource transfer mechanism	Description	Examples
Public procurement	PWS where the public entities (municipalities, water utilities, etc.) buy the environmental services on behalf of the general public/beneficiaries. This is the case of all budget located by the European Commission for the agri-environmental schemes, or when any city pays farmers on behalf of citizens.	The English Woodland Grant Scheme, Catchment Sensitive Farming, etc. New York City, etc.
Scope tax (Water charge)	PWS where the public entities buy the environmental services on behalf of the general public/beneficiaries through a specific scope tax. This instrument is often used by water companies that set levy water abstraction charges on bill payers.	Lower Saxony, Germany.
Tradable rights	PWS where through a banking system service providers and beneficiaries are connected through a brokering/credit developer.	Wetland mitigation, nutrients banks in USA.
Beneficiary pay funds	This is used by schemes that are organized under third party funds or trusts that collect the beneficiaries' payments and redistribute them to the service providers.	Angling passport Scheme (UK), where fishermen pays a River Trust (NGO) who directly pays the farmers.
Bilateral agreements	The economic instrument is based on a contract signed directly between final beneficiaries and service providers. Resources are transferred between two bank accounts, with no need for a third-party entity or fund.	Vittel in France.

5.3.2 Governance and design

Generally, we identified several financial and economic instruments to allow the transfer of resources from beneficiaries to the suppliers (see Table 5.3). However, the main instruments can be summarized in five broad categories, with different degrees of directness between the actors: public procurement (less direct), scope taxes, tradable rights and/or credits, beneficiary pay funds and bilateral agreements (more direct).

However, regardless of the financial instrument used for transferring the payments, most schemes use multiple sources of funding, while very few rely on one main financial source (Figure 5.7). With the emergence of partnership schemes and match funding, systems schemes have generally declared a main investor per project; however, many schemes have reported the use of funds from EU projects, agri-environmental payments and other local spot-donors, which are more difficult to track. This analysis shows how the integrated financing models are a reality among existing schemes. While public budget allocation remains an important financing source, other sources such as water user levies and trading credits are also used, sometimes complementarily.

TABLE 5.4

Overall investments amount for the UNECE Region

Region	Number of programmes tracked	Value in 2015 (Billions)
North America	95	3.8
Russian Federation	n/a	n/a
Caucasus and Central Asia	n/a	n/a
European Union	71	6.37
Other	n/a	n/a
Total UNECE	166	10.17

Source: Forest Trends, 2016.

5.3.3 Scale of investments on watersheds [42]

Ecosystem Marketplace (a Forest Trends initiative) tracks watershed investments transactions at a global level; this is done through an online survey and network of regional contacts that gather data on yearly investments in

42 These data were taken from "State of watershed Investments (Forest Trends, 2016)".

watersheds.[43] However, the diversity and often local scale of such watershed investments sometimes make it very difficult to analyse and compare the amounts involved and related impacts. It is likewise impossible to obtain market data that distinguish those watershed investments that are "forest-related" to those that are not.

While there is no unified market for transactions for watershed protection (in contrast, for example, to a compliance carbon market), the value of these transactions is an order of magnitude larger, reaching nearly USD 25 billion in 2015. Globally, programme transactions grew by a yearly average of 11.8 per cent between 2013 and 2015. Most of this spending (USD 23.7 billion) came in the form of direct subsidy payments from supranational, national and state/provincial-level governments to landholders to protect critical watersheds. The biggest water-related agri-environmental scheme measures, *i.e.* those in the North America, EU and China, account for the largest share of the pie. Regarding the UNECE region, payments account in total for about USD 10.17 billion (Table 5.4).

5.3.4 Matching financing sources

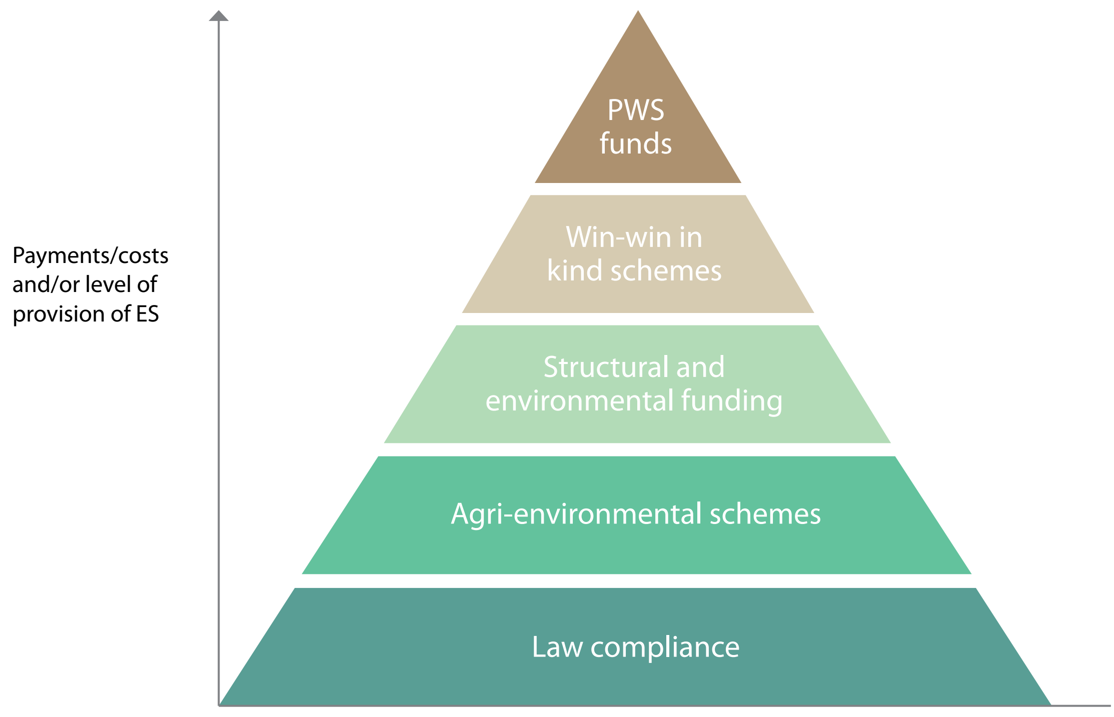
While match funding is a global trend for watershed payments, this is particularly true for the UNECE region, which is hosting the main agri-environmental schemes in the European Union and the United States. Figure 5.8 represents the stratification and complementarities of policies, funding sources and payments tools that PWS uses, particularly in the case of multiple benefit partnership models. The first stratum represents the baseline in the provision of hydrological services, *i.e.* the compliance with water-related environmental regulations. For instance, in the EU PWS are not stand-alone policy tools; they are set within a rather complex regulation framework of compulsory legal requirements on diffuse pollution and flood risks under the principle of "polluter pay" (the WFD is also called an umbrella Directive, covering floods, nitrates, and other water issues).

Secondly, most of schemes that develop on agricultural and forestlands rely on match funding coming from the adoption of sustainable agricultural/forest management practices with "cross compliance" tied to the CAP subsidies from the EU or other programmes in the United States. In most of

43 Ecosystem Marketplace defines a watershed investment as "any transaction between a buyer and a seller where financial value is exchanged for activities or outcomes associated with the maintenance, restoration, or enhancement of watershed services or natural areas considered important for watershed services".

FIGURE 5.8

Mixed funding source model



Source: Elaborated from Leonardi, 2015.

the cases these subsidies cover from 50-80 per cent of the cost of implementing a certain management practice or infrastructure improvements. Private sources, coupled with win-win farm/forest managers' advice and capacity building services, are then meant to supply additional funding to cover the co-funding of subsidies and the additional cost of providing targeted environmental services, such as higher water quality for drinking purposes. The mix-model situation represented in Figure 5.8 has proved to be successful in the main catchment schemes in England, such as SCaMP and Upstream Thinking. About 64 per cent of PWS in the EU directly or indirectly use CAP payments or other sources as match funding. Moreover, the start-up of the scheme is paid by environmental support funds, such as the LIFE programme in the EU (Leonardi, 2015). It is not uncommon, that scheme managers help farmers and forest managers to obtain co-funding from agri-environmental public funds. As explained in previous paragraphs, almost 50 per cent of PWS couple payments with in-kind support, through training and free-advice that is likely to maximize the results.

5.4 Conclusions on payments for water-related forest ecosystem services

The number of forest-related PWS are increasing as mechanisms to improve the provision of hydrological services and biodiversity conservation. In the UNECE region, North America has the largest number of active schemes (101), followed by the European Union with 70, with other countries accounting for only seven active schemes. One of the reasons explaining the large and more stable number of active schemes in the United States is that long-term policy support enjoyed by market-based instruments. In the European Union, the European Commission has only recently started to support these schemes, for example through the LIFE funding. Nevertheless, practical policy support has mostly been provided by individual member States such as Italy, Germany and the UK. In other UNECE member States, the concept of PWS is still relatively new. The policy agenda of these countries is based on hierarchical and traditional management of forest areas (*i.e.* top-down and regulation-based); hence, the scientific and stakeholder communities have found that the implementation of PWS has been challenging, on both a conceptual and skills level. These difficulties have mostly been due to a lack of information and the absence of guidance documents and examples available in local languages. Another reason may be unwillingness by governments in the region to institute separate financial flows that may encourage corrupt practices. This is part of the reason why ecological funds, a system that in some cases has similarities to PES but lacks its specificity, have mostly been closed down.

A general trend over recent years has been to centralize various payments for the use of resources to the consolidated state budget rather than channel them, for example, into ecological funds. For instance, in the Russian Federation, the federal environmental fund was closed in 2001.[44] Public ownership of forests is another factor that may limit the application of PES. Private owners of forests, who are important stakeholders with an economic interest, would be the first to benefit from proposed management options, as exemplified by existing PES schemes in Western Europe.

Our analysis has generally found that PWS schemes based on a partnership model are more successful in accessing multiple sources of funding, increasing organizational resilience to changing political support, and obtaining a long-term commitment of forest owners and managers.

Box 5.3

Bundling ecosystem services in the European Union

The Habitats and Bird Directives that cover almost 18 per cent of the EU's terrestrial territory and 21 per cent of its marine areas represent a favourable link between biodiversity policies and PWS. These sites face both biodiversity and water-related issues and thus benefit from PWS schemes. An example of this is the SCaMP project managed by United Utilities in north-west England, the Upstream Thinking project managed by South-West Water; in both cases, the relation between the habitat directives was crucial for their design and implementation (see Chapter 6). In order to meet the requirements of the Directive, management authorities have to identify the source of funding to manage their protected areas. The European Commission therefore created a dedicated website, guidance and financing tools to raise private-public match funding and encourage member States and regional authorities to undertake innovative financing tools, such as PES, visitor payback schemes and trust funds.

The new Green Infrastructure Strategy (Green Infrastructure - Enhancing Europe's Natural Capital Strategy) approved by the European Commission (EC) in 2013 seeks to integrate green infrastructure within the existing funding mechanisms (including CAP, the Cohesion Fund, the European Regional Development Fund, Horizon 2020, and others). According to the strategy, the EC and the European Investment Bank have established the Natural Capital Financing Facility (NCFF), an ad-hoc EU financing facility to support public and private organizations seeking to develop Green Infrastructure projects. Again, all these public funds will look for possible match funding mechanisms, providing an opportunity for emerging PWS.

Considering that most of Natura 2000 areas are water-related ecosystems, such as rivers, lakes, wetlands, peatlands, etc., many of the identified EU PWS have joined the support of the EU funds dedicated to Natura 2000 areas to cover start up, piloting and monitoring activities. The new trends highlighted above build a solid basis for future development of new PWS at EU level.

44 see https://www.lawmix.ru/comm/5931.

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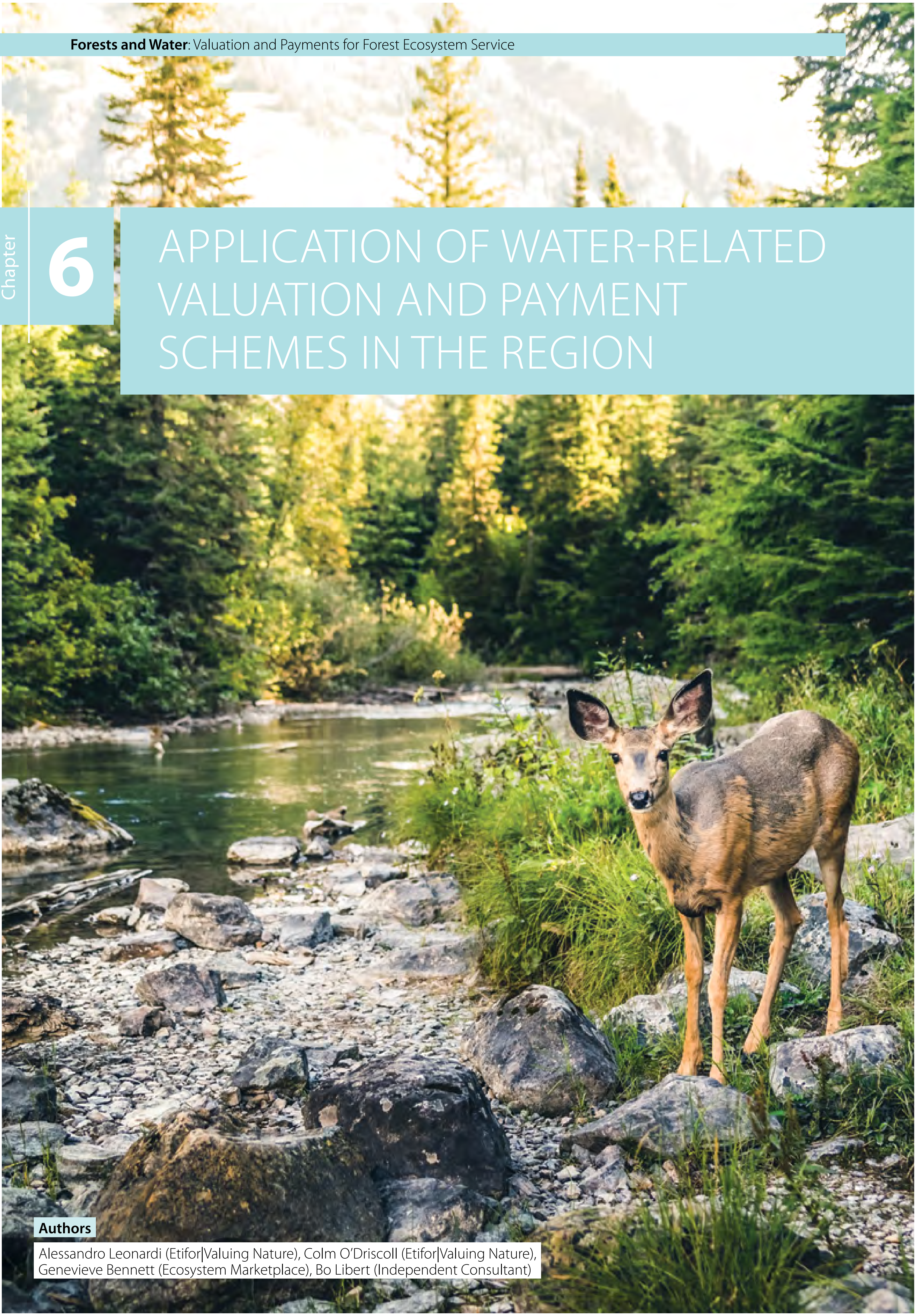

Chapter

6

APPLICATION OF WATER-RELATED VALUATION AND PAYMENT SCHEMES IN THE REGION

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6. Application of water-related valuation and payment schemes in the region

6.1 Examples of forest-related payments for watershed services (PWS)

The following case studies are selected from Annex 1 to highlight practical examples and represent different governance models targeting forests ecosystems around the UNECE region (Table 6.1). These examples were selected because they were deemed successful as they incorporated good practices in terms of economic transactions, impacts, duration, and for their geographical representativeness.

6.1.1 Romagna Acque water fund in Emilia Romagna, Italy[45]

The context

Romagna Acque S.p.A., is a publicly owned company managing all drinkable water resources of the Romagna subregional area. A consortium of municipalities was established in 1966 to reduce the cost of supplying drinking water. Twenty years later, the company was responsible for the distribution of water over the whole Romagna area; in 1994, Romagna Acque S.p.A. was established and became the owner of all water resources in 2004.

45 This case study has been updated and drawn from Pettenella *et al.* (2012).

TABLE 6.1

Selected case studies on forest-related payments for watershed services

Programme	Type of service	Main buyer	Funding source	Governance model	Funding in 2015 (in Euros)
Romagna Water Fund, Italy	Water quality and avoided dam sedimentation	Public-Private water utility (public owned)	Budget, allocation (4 per cent of revenues)	Compensation for legal restrictions & Bilateral agreement	838,308
Land Stewards, Italy	Flood control and water damage mitigation	Public watershed authority	Mixed: Budget allocation, EU funding, CAP	Public bilateral agreement & Multiple benefit partnership	70,000
Protection of the Chon-Aksuu watershed, Kyrgyzstan	Water quality, avoided soil erosion and river sedimentation	Public-private Water User Association and Mushroom Pickers Association	Mixed: Private budget, location, international and EU funding	Multiple benefit partnership	In kind
Upstream Thinking, UK	Water quality	Private water utility	Mixed: Budget allocation, EU funding, CAP	Multiple benefit partnership	1,000,000
SCAMP, UK	Water quality	Private water utility	Mixed: Budget allocation, EU funding, CAP	Environmental benefit bilateral agreement.	2,300,000
Watershed Partnerships for Resilience to Wildfire in Northern Colorado, USA	Water quality	Public water utility	Mixed: Private and public budget allocation	Multiple benefit partnership	400,000
Coca-Cola – USFS – NFF Partnership to Replenish Water and Restore Public Forest Lands in the USA	Water provision	Private company	Private budget allocation, donations	CSR offsetting & Multiple benefit partnership	600,000

Source: Leonardi (2015), Bennett and Leonardi, 2014, 2017.

The company's' most important water source, is a dam-basin in the central Apennines (Ridracoli, municipality of Bagno di Romagna), which covers 50 per cent of the Romagna tap water supply (108 M m^3/year). The dam's profitability was compromised by the high level of sedimentation and water quality maintenance.

In 1993, the company carried out research to better understand how catchment management could minimize soil erosion and improve water quality. The research showed a clear impact of forest operations on soil erosion, such as clear-cut or forest conversion from coppice to high stands; the minimal silvicultural treatments, or natural evolution of stands, to strongly reduce erosion. These last two practices were shown to have a positive influence on nitrogen reduction and pH stability.

The payment

In 1988 Romagna Acque Spa began to allocate 2 per cent of its revenues (increased to 3 per cent in 2008 and 4 per cent in 2012), to the mountain towns of Santa Sofia, Premilcuore and Bagno di Romagna, where treatment plants of water resources are located. In 1993, Romagna Acque Spa decided to invest a portion of its annual revenues (4 per cent) from the water bills to set up an environmental fund to compensate landowners in the catchment areas, to help them cover the costs incurred while introducing changes to management practices (Bagnaresi *et al*., 1999). The utility allocates the funds to the municipalities to sponsor programmes and initiatives to improve environmental conditions of the valleys, as well as promote economic and social development of the municipalities. The three municipalities surrounding the reservoir received Euros 782,370 in 2010; Euros 661,959 in 2011; Euros 531,921 in 2012; and Euros 838, 308 in 2013. The Romagna Acque Spa fund makes a significant contribution to the valley's environmental protection.

The Romagna Acque Spa can be categorized as a public-public bilateral agreement, with a utility budget allocation source of funding system. The level of directness is still very low, falling under the definition of "public procurement". The commoditization is also very low as there is just one main buyer and only three suppliers. The payment is based on the percentage that is applied to the annual revenues, and not on the level of service provision or management practices that are implemented. Moreover, this scheme is one of the few that provides an upfront payment to municipalities, as funds are transferred on a yearly basis to the municipalities to fund environmental restoration projects around the valley.

The voluntariness of the scheme is very low, as the municipalities cannot decide to adopt management practices that may affect reservoir water quality and sedimentation. Indeed, one of the reasons for the creation of the fund was, among others, to compensate municipalities for the economic losses and additional costs related to the dam and the reservoir. Therefore, the Romagna Acque fund is a hybrid scheme, and falls between a bilateral agreement and a compensation scheme for legal restrictions. Moreover, another design characteristic that has allowed the fund to be successful in the long-term is the systematic application of a charge on total revenues. This 4 per cent charge, although not applied directly to customers' bills, provides a long-term assurance on financial resources, increasing trust towards the fund and the general stability of the scheme.

The benefits

The positive impact of the PES scheme resulted in a 25 per cent decrease in soil erosion (from an initial level of 40,000 m^3/year to the ongoing 30,000 m^3/year), and a consistent nitrogen reduction as well as pH stabilization. In terms of performance, both Romagna Acque S.p.A. and the landowners increased their utility: the company reduced its costs for water purification and assured longer dam life, while the landowners increased or maintained their annual forest revenue.

6.1.2 Preserving hydrological functions in the forested Serchio Valley (Tuscany), Italy[46]

The context

The Serchio Valley is a forest area of Tuscany. The river Serchio runs through the valley, and there are about 115,000 ha of uplands and 1,500 km of streams. These territories require continuous hydrological monitoring and investments due to their geographical isolation and morphological conditions. An association of municipalities (Unione dei Comuni Media Valle del Serchio) had in the past been in charge of the management of streams and other forest and land hydrology operations. The high cost of intervention in the extended valley and increasing depopulation of mountain areas has led to an innovative partnership between forest owners/farmers and public authorities.

In 2006, an association of municipalities established a payment agreement with about 40 farmers and forest owners to improve flood risk monitoring and control over a 500 km water course within the mountain basin. After almost ten years, the agreements are still active, and the number of land stewards is growing. The responsibility for water management was passed to the Consorzio Bonifica 1 Toscana Nord (a large water irrigation consortium) following the recent centralization reform of water management authorities in Tuscany (Reg. Law 79/2012). An agreement was made with the association of municipalities of the Serchio Valley to maintain land stewards to benefit from their social capital and local knowledge and the best practices they have introduced. The centralization of decision-making added complexity to the system; nevertheless, the new

46 The case study has been drawn and updated from Leonardi (2015).

authority has lent a more formal structure[47] to the scheme, and is looking at ways to enlarge the model of land stewards to other parts of the region.

The payment

Since 2006, the payment scheme has had two main components directed to land stewards:

- **Fixed amount**: A fixed amount of Euros 6,000 per year would be paid during the initial phase and Euros 4,000 per year in subsequent years for monitoring and evaluating the degree of risk and providing an alert report service to public authorities on forest slope instability or waterway obstruction. However, under the new management scheme, the fixed amount has been reduced to Euros 500 per year following an agreement with landowners.
- **Work-based compensation**: Based on the identified hydrological issues, landowners provide direct forest-hydrology operations, negotiating the terms and economic conditions of the interventions on a case-by-case basis with the public authority. Landowners usually contribute to the removal of trees and other sediments from riverbeds to avoid overflowing, combined with the management of riparian vegetation. Usually, the metrics to estimate the value of the services that land stewards provide is based on the average cost of a public authority staff member per number of days worked. So it is based on the actual cost of provision (in terms of staff days), and not in the real value of the hydrological service or benefit.

The scheme can be categorized as a public bilateral agreement, whereby public authorities directly pay landowners for the provision of forest hydrological services. The scheme can be classified as "public procurement". Several workshops have been held under the scheme to negotiate with service suppliers and to define the design, the type and payment amounts. Thus, the scheme is characterized by free and informed negotiation between the two parties. Land stewards also have high conditionality as the payment is divided into two types: a flat rate for participating in the scheme; and a demand/service-based payment. This division creates an incentive to meet the requirements of the scheme. The small number of landowners makes it possible to check and monitor the performance of each service supplier while, at the same time, as covering a vast remote area that would otherwise be difficult to manage. A main weak institutional aspect of the land stewards' scheme is related to the source of funding as the watershed authority decided to invest in the scheme on a yearly basis; service suppliers, therefore, have very little trust in the long-term commitment of public authorities. The project manager has reported the difficulties of managing the scheme in the context of political instability and recent public austerity measures. Therefore, the sustainability of the scheme is decided on a yearly basis, depending on the financial availability and national and local political decisions. A change on the authority's Board could easily lead to the termination of the scheme.

The benefits

Overall, the programme is investing about Euros 70,000 per year – a small budget compared to the huge economic and environmental benefits provided by land stewards to society. The land stewards scheme has contributed to decreasing flood risk and water damage costs, as well as provided society with an environmental benefit resulting from the training of forest owners, organizational arrangements and networks. According to the project manager, the scheme has also contributed to savings of 80 per cent on the total annual cost of management interventions in the area. The alert and control system of landowners works through an interactive Information and Communication Technologies (ICT) system (IDRAMAP), which land owners can use to report and alert public authorities, and allow them to deliver hydro-geological risk control. The scheme also has a high level of social co-benefits as it provides an alternative source of income for marginalized landowners in remote areas of the Serchio Valley. It also has improved community participation in hydrological landscape management.

A national law regulating PES schemes is currently undergoing approval (following the Environmental Decree 221/2016). However, this PES has made use of another law[48] in relation to innovation in agriculture that makes it possible for public bodies to contract private and public entities to deliver landscape management works. This law was conceived to promote multi-functional agriculture, but the concept of "provision of ecosystem services" has not been achieved adequately, and land steward contracts refer to the

47 All forest owners taking part in the scheme are registered on the online system for public procurement by the authority in line with transparency obligations.

48 Decreto Legislativo 18 maggio 2001, n. 228 "Orientamento e modernizzazione del settore agricolo, a norma dell'articolo 7 della legge 5 marzo 2001, n. 57" and Legge 97/1994 - Art. 17.

"number of hours of labour" needed to carry out planned forest-hydrology works, instead of specifying the quantity and conditions for ecosystem services provision.

6.1.3 Protection of the Chon-Aksuu watershed, Kyrgyzstan

The context

An unconventional case demonstrating payment for ecosystem services is found in the Chon-Aksuu watershed (Issyk-Kul region, Kyrgyzstan). The scheme was developed in a project managed by the Regional Environmental Centre for Central Asia, and was funded by Swiss Re from 2010, with continued work funded by the Norwegian government. The problem addressed by the scheme is overgrazed pasture and degraded forests, which is leading to erosion and increased levels of suspended sediments in rivers, and lower water quality.

The payment

PWS buyers include the Water Users Association (WUA) and the Mushroom Pickers Association; sellers include are the Pasture Committee of Temirovka village and the local forest administration (Issyk-Kul Leskhoz). A general agreement was signed between all parties, as well as three bilateral contracts. The bilateral contracts bind: (a) the forest administration and the WUA; (b) the Pasture Committee and the WUA; and (c) the Forest Administration and the Mushroom Pickers Association.

Buyers were not interested in cash payments, so in-kind contributions were considered instead. The final agreement reached stipulated that payments would be made in the form of work days (the buyers would work to help the sellers improve the land). Under the scheme that was established, the WUA would set aside 10 workdays a year to the Forest Administration to help with tree plantation, fencing, *etc.*, and 20 workdays a year to the Pasture Committee to improve the quality of pastures. For its part, the Mushroom Pickers Association would provide 30 workdays a year to the forestry unit to help with ground preparation, tree plantation, *etc.*

The Forest Administration allocated 10 per cent of fees collected from tourists to plant trees, fence new plantations, fence important places for natural regeneration, and use the labour contribution for activities related to forest ecosystems improvement. The Pasture Committees for their part agreed to: (a) prepare a pasture management plan; (b) follow recommendations on maximum pasture load; (c) repair key infrastructures to enable access to remote pastures; (d) fence temporary some pastures for regeneration; (e) limit and control grazing in the forest areas, and use the labour contribution for activities related to pasture ecosystems improvement; and (f) established a monitoring and evaluation group and a Coordination Committee monitored the mechanism.

The benefits

All stakeholders (public servants, local residents and school pupils) increased their capacity to sustainably use existing natural resources. Other benefits included the reforestation of 14 hectares, representing 37,000 seedlings of spruce and birch trees in mountain areas (more than 70 per cent), and poplar and willow trees in the valley, which amounted to a total contribution of ecosystem services beneficiaries of about USD 9,600. In addition, 500 m of access road to mountain pastures would also be improved to destock overgrazed pastures and limit soil erosion.

6.1.4 Upstream Thinking: A private-public-community multiple benefits partnership, United Kingdom[49]

The context

South-West Water (SWW) is a private company that manages regulated water and waste water network; and serves nearly 600,000 customers in south-west England. In recent years, intensive mixed livestock farming, moorlands and peatlands degradation have decreased water quality in many reservoir, rivers and aquifers around the region. In 2008, SWW understood the potential for a catchment-wide approach and started a pilot project (Exmoor Mires Project) to restore 326 ha of peatlands within a SSSI. Additionally, Westcountry Rivers Trust (a charity organization devoted to river restoration and protection) through the EU-funded WATER project demonstrated the success of payments and advice for farmers for sustainable catchment management. Following the success of these projects, SWW started an "umbrella initiative" called Upstream Thinking. The initiative groups many different PWS under the same brand and aims to improve water quality in river catchments in order to reduce water treatment costs and provide multiple benefits, such as climate change mitigation and biodiversity conservation.

The payment

In 2010, OFWAT approved SWW's Upstream Thinking project with a budget of nearly Euros 12 million for the period 2010 -2015 (equivalent to 65p/year on each customer's bill, considering an investment period of 25 years); this sum would

49 This case study has been updated and elaborated by Leonardi (2015).

be spent on several subprojects to restore moorlands, fencing water courses, improving infrastructure of farms and reducing the use of chemicals in agriculture. This initiative represents a revolutionary approach by the UK water industry as it allows capital investment on third-party land for the first time. Each project shared the same vision and contributed to move from a "water treatment" industry-based approach toward a more integrated and holistic catchment and ecosystem approach.

The initiative is categorized as a multiple benefit partnership, whereby SWW delivers conservation funds in collaboration with a wide range of national and local organizations. Devon Wildlife Trust and the Cornwall Wildlife Trust are the main partners for moorland restoration, while the Westcountry Rivers Trust, with its extensive technical experience, delivers programmes targeting diffuse pollution from agriculture in West Penwith, the River Fowey, the Tamar, Wimbleball and Roadford catchments and the Otter Valley. Natural England, Environment Agency, English Heritage, and the National Farmers Union have all supported the project through match funding with agri-environmental payments schemes, monitoring and policy advice. Universities, such as the Universities of Exeter and East Anglia, were involved in monitoring and designing the payments schemes. SWW has overall responsibility for managing the project and reporting progress against targets to regulators. Each individual project has its own management team and reporting arrangements and formal management agreements were established with each individual delivery partner. Financial governance and reporting is undertaken by SWW finance and regulatory structures. The project has experimented with two different types of payment delivery mechanisms:

- *advisor-led PES mechanisms*, where farmers were identified by advisors, and offered a fixed-price deal in which South-West Water would pay 50 per cent of the costs of capital investments;
- *auction-based PES mechanisms*, where farmers were asked to enter in competitive bids where the best value for money principle allocates the final grant request.

The benefits

A comparison between the two systems has shown that the auction-based system delivered between 20 and 40 per cent better value for money than the fixed-price alternative. However, the advisor-led system turned out to be more appropriate for small-scale projects where site-specific considerations are needed. Auctions were preferred for large-scale catchments, particularly where there is little detailed local knowledge and eco-hydrological conditions are quite homogeneous around subcatchments. Beside the payment mechanisms, SWW has designed a "Conditional Grant Agreement", which sets out the project, period, grant and terms, and a "Deed of Covenant" which ensures the Conditional Grant Agreement is passed on in the event of a sale or change of tenants. These agreements are to guarantee the permanence of the investments on third-party land, maintaining a legal interest in the capital works (paid with the fees paid by SWW customers), and securing that the investment will provide long-term effects on water quality, therefore ensuring the best value for money. South-West Water has indicated that reducing pollution at source rather than investing in engineering solutions to treat polluted water downstream has a benefit-cost ratio of some 65 to 1.

6.1.5 United Utilities SCaMP, United Kingdom[50]

The context

United Utilities is the UK's largest water company and manages the regulated water and wastewater network in North-West England. It owns 56,385 ha of land to protect the quality of water entering the reservoirs, which help to supply nearly 7 million people. Around 30 per cent of its land is designated as a Site of Special Scientific Interest (SSSI), and constitute a nationally significant habitat for biodiversity conservation. However, many of the fragile habitats, such as moorlands and peatlands in the upland catchment areas have been damaged by historical industrial air pollution, agricultural activities and climate change. Agricultural policies have encouraged farmers to drain the land and put more livestock on the fields. This has been at the expense of water quality, the landscape and wildlife. Over the past 30 years, United Utilities has experienced a substantial increase in the levels of colour of raw water in many upland catchments.[51] The removal of colour requires additional processing plant, chemicals, power and waste handling to meet increasingly demanding drinking water quality standards and customer satisfaction. Consequently, annual operational costs of water treatment have increased significantly.

The payment

United Utilities began its innovative Sustainable Catchment Management Programme (SCaMP) to benefit both water and wildlife to address watercolour and turbidity issues.

50 The case study was updated and drawn from Leonardi (2015).

51 The coloration is due to the degradation of peatland into water.

Between 2005 and 2010, the project incorporated working with farm tenants, providing them with Euros 14.1 million in funding for moorland restoration, fencing, woodlands, farm infrastructure and protecting watercourses, across 27,000 ha of water catchment areas managed by United Utilities. However, at the beginning of the programme, the UK public water regulator, OFWAT, which is in charge of approving water utilities' management plans every 5 years, objected because of concerns about subverting the 'polluter pays' principle. At the time SCaMP was the first existing payment scheme for sustainable catchment management of its type in the UK, and the matter was discussed in detail by regulators, who had to ensure that the "best value for money" principle was respected. Based on its cost-benefit analysis and demonstrated multiple benefits[52] (water quality, biodiversity and carbon storage), SCaMP was then approved by OFWAT, opening the door to the catchment approach within the water sector.

SCaMP can be categorized as a multiple benefit partnership. As the PWS is managed on their own land, the utility has adopted a "top-down" approach with tenants that may join the scheme. Entering into the scheme is sometimes a precondition of maintaining the tenancy agreement. Nevertheless, in order to create a collaborative learning process on catchment management, United Utilities made the case for a vast collaboration through the establishment of a National Stakeholder Group (cross-cutting institution). The group includes the UK Department for Environment, Food and Rural Affairs, the Consumer Council for Water, Natural England, Forestry Commission, UK Environment Agency and the Drinking Water Inspector, which eventually supported the project with new regulations, guidance documents and match funding through agri-environmental schemes. Besides, an intermediary organization – the Royal Society for the Protection of Birds (RSPB) – was contracted to develop SCaMP farm plans, and asked to help in explaining the plans to tenants and submitting grant applications. Moreover, RSPB was essential in the first phase of lobbying with existing water authorities.

The benefits

United Utilities also contracted a local consulting firm to provide the baseline for main hydrological indicators (*e.g.* coloured dissolved organic matter (CDOM), turbidity units (NTU), dissolved organic carbon and water table level). Annual monitoring has shown that SCaMP land management treatment does have a positive effect on water quality (United Utilities, 2012). Despite its positive impact on water colour, a detailed and participatory cost-benefit analysis (CBA) of SCaMP has shown how the main benefit is overwhelmingly greenhouse gas regulation due to the small capital and operational expenses savings (CAPEX and OPEX), with biodiversity also generating considerable benefits. The CBA model suggests a range of benefit to cost ratios of between 2.24 to 25.38, mainly because of the error margins for net changes in GHG fluxes, future market values for carbon and potential variation in expected biodiversity benefits. The study considered the very low operational and capital savings because the methodology took into account only those investments and operational costs directly linked with colour removal and waste treatments, and was thus not considering business as usual investments in new machinery (Higginson and Austin, 2014). SCaMP climate and biodiversity co-benefits have therefore strongly contributed to the economic sustainability of the programme. Moreover, one of the co-benefits of the scheme is that it contributed to the socio-political and institutional acceptability of the scheme.

SCaMP during its phase 2 (2010-2015) covered the remaining 30.000 hectares under United Utilities' supervision. In almost ten years of work it has created local and national partnerships and encouraged regulators and other water utilities to promote catchment management schemes to secure raw water quality. In 2014, United Utilities started to extend the SCaMP approach on land that it does not own, and began working with catchment partnerships in north-west England through a newly created funding schemes called 'catchment wise and safeguard zones'. United Utilities demonstrated high replicability of the scheme and SCAMP is now an example of watershed payment at national level.

6.1.6 Watershed Partnerships for Resilience to Wildfire (Northern Colorado), United States of America

The context

The Colorado-Big Thompson Project (CBT) is a federal water diversion project that supplies supplemental water for agricultural, municipal, domestic and industrial purposes to

52 Water utilities in the UK are considered private companies but public bodies under the s28G of Wildlife & Countryside Act. The Natural Environment and Rural Communities Act, which came into force on 1st October 2006, requires all public bodies, including United Utilities, to have regard for biodiversity conservation when carrying out their functions. As a result of the SCaMP programme, the company exceeded government Public Service Agreement targets for SSSIs returning 98.6 per cent of its land into a favorable or recovering condition by 2010. Indeed, the UU SSS duty was one of the main legal reasons that allowed OFWAT, at first, to approve SCaMP investments.

much of northeastern Colorado in the United States. The CBT project includes 12 reservoirs with a total storage capacity of 104 million megaliters, three pumping plants and six hydroelectric power plants. Around 80 per cent of CBT's water comes from snowmelt in high elevations, mainly forested watersheds.

Northern Colorado Water Conservancy District ("Northern Water"), a public agency, operates and maintains CBT in partnership with the US Bureau of Reclamation (USBR). Northern Water delivers CBT water to more than 860,000 residents in 32 cities, towns and rural domestic water districts, including the cities of Fort Collins and Greeley. Between April and October, Northern Water also delivers CBT water to ditch, reservoir and irrigation companies serving thousands of farms.

In the western United States, there has been a general trend of bigger, more frequent wildfires over the past three decades. Wildfire severity has been linked to drought and the steady deterioration of forest health in the Colorado Rocky Mountains due to mountain pine beetle infestation, a history of fire suppression that has increased tree density in the forests, and urbanization at the wildland-urban interface, which has been associated with an increase in man-made fires. Wildfire's after-effects in watersheds often include increased runoff and erosion of sediment, ash, and debris during post-fire rainfall events.

In 2012, Northern Water had a "wake-up call," when the nearby High Park fire left the participating cities of Fort Collins and Greeley with unreliable water quality (to the degree that it was sometimes untreatable) during rainfall and spring runoff events. A year after the fire, a rainstorm resulted in a major irrigation channel becoming so clogged with debris and sediment that service was interrupted for ten days during which irrigators had to depend on in-reservoir water. Uncertainty around supply has also affected the availability of temporary water for rent to irrigators by municipalities, exerting negative pressure on the region's agricultural economy.

Fire behaviour and intensity can be modified with treatments to reduce fuel loads, such as thinning tree stands, removing diseased or dead trees, prescribed burns, and removing or rearranging ladder fuels (*e.g.* dense vegetation near the forest floor that can assist fires in reaching the crowns of trees).

The challenge for water service providers in wildfire-prone areas is that fuel treatments tend to be expensive and labor-intensive, averaging USD 354 per ha. For Northern Water, the problem was compounded by the sheer size of its source water areas and the treatment needs of those areas. A 2014 watershed assessment identified more than 130,000 hectares likely to significantly contribute to sedimentation and debris loads to water sources. The average costs, to treat all of these areas would require more than twenty times Northern Water's annual operating revenues.

Compounding this challenge is the fact that Northern Water and its municipal sub-district owns only 1,335 ha (equal to <1per cent of total land) in of its watershed on the West Slope of the Continental Divide. Roughly, three-quarters half of Northern Water's source water areas fall within neighboring public national and state forests or in the Rocky Mountain National Park.

This mix of landowners in important headwaters areas means that Northern Water needed to work with federal and private land stewards to develop fuel treatment programmes to protect CBT water quality. In 2012, the U.S. Department of Agriculture approached Northern Water about a partnership that would include the USFS, Northern Water, the Colorado State Forest Service (CSFS), and USBR. The National Park Service and Western Power Administration were also identified as key stakeholders.

The Partnership itself is relatively loosely structured. It does itself not directly implement projects. Instead, members meet monthly to prioritize and plan projects, which are then carried out by partners directly, or in coordination with one another. Partnership activities have been mainly funded by cost sharing from partners and several state and federal grants. Recently, Northern Water implemented a rate increase for customers, which will create an annual budget for watershed protection. Private landowners carrying out fuel reduction treatment projects with the CSFS contribute on a 50/50 cost share basis. Partners also contribute significant in-kind support. Altogether, about USD 2 million in funding has been raised through the Partnership.

The payment

The Partnership is focused on minimizing the impacts of fire on water quality, through fuel treatments, forest restoration, and limiting sedimentation of reservoirs post-fire. Projects currently cover about 360 hectares on a mix of private lands, USFS lands, USBR lands, and within the Rocky Mountain National Park. Work is planned on another 425 ha of USFS lands. The Partnership is currently (as of 2015) developing a five-year plan that identifies a portfolio of projects and roadmap for implementation, based on technical analysis. Amongst other activities, the Partnership has also pursued post-fire response planning. This includes mitigation activities, such as sediment basins to minimize post-fire erosion, and coordination to improve emergency communication channels between agencies, identify locations for response supplies (logs, rocks), and planning to prepare for quickly securing permits for mitigation activities post-fire.

Projects are chosen for their potential watershed benefits, rather than their size. Partnership activities have been informed by a series of mapping and other technical studies to help members reach consensus on priority areas for intervention – a challenging task given the size of the watersheds.

The benefits

Participants report that the Partnership has helped to improve communication between agencies and led to more strategic resource management, such as having the flexibility to locate projects in priority areas across multiple land ownership types. Having multiple partners at the table has also sometimes meant additional funding; for example, Northern Water agreed to fund some pre-existing fuel treatment projects on 44 ha which USFS had already planned and completed environmental impact assessments, but had been unable to implement. Data generated on hydrologic outcomes from fuel treatment, and on potential trade-offs between fire hazard reduction and other hydrological services are also helping to inform how agencies manage their lands.

The Partnership's emphasis on planning for post-fire response represents an evolution from previous strategies. It also reflects a hard-nosed appraisal of reality: Northern Water's source area is simply too large to fully treat, especially at the current rate of implementation. Therefore, the Partnership has agreed that preparing for the inevitable next severe wildfire is a critical task. This approach calls to mind the adage that "natural events happen, but natural disasters are man-made", and a useful example for other water service providers and cities seeking to manage their own disaster risks.

6.1.7 Coca-Cola – USFS – NFF Partnership, United States of America

The context

In September 2013, the US Department of Agriculture (USDA) and Coca-Cola North America announced a five-year partnership aiming to return up to 1 billion gallons of water to streams, rivers, and aquifers in the United States through watershed restoration on National Forest System lands.

The Coca-Cola Company has set a goal of fully "replenishing" by 2020 an amount of water equivalent to the volume it uses in its finished beverages. Through its partnership with the USDA Forest Service and the National Forest Foundation (NFF), Coca-Cola funds a range of projects: repairing stream crossings, restoring streams damaged by wildfires, even re-introducing beavers (in the Okanogan-Wenatchee National Forest's Methow River watershed).

To date, work has been carried out in the Angeles National Forest (CA), Carson National Forest (NM), the Midewin National Tallgrass Prairie (IL), the Huron-Manistee National Forest (MI), and the Pike National Forest (CO). Coca-Cola North America is matching the National Forest Foundation contributions two to one. The National Forest Foundation is a congressionally chartered non-profit organization in partnership with the USDA Forest Service.

The payment

Projects are selected based on their potential to replenish water to the landscape, project costs, existing restoration need, and proximity to Coca-Cola operations or its bottling partners. At present, four projects take place in watersheds upstream of Coca-Cola facilities; others don't directly benefit the company but were chosen for their strong replenishment potential and existing restoration needs. The National Forest Foundation works closely with the USDA Forest Service and local partners to implement these restoration projects, one of several IWS initiatives administered by the NFF tracked in this year's report.

Replenishment values are calculated based on an internal methodology developed by Coca-Cola, Limnotech, and the Nature Conservancy (TNC) to better understand the quantifiable benefits of watershed restoration. The private sector firm Deloitte provides independent verification of outcomes. Coca-Cola receives replenishment credit proportional to its funding contributions. Current Coca-Cola and National Forest Foundation projects in US National Forests will deliver an estimated 460 megaliters of water.

The benefits

Worldwide, the Coca-Cola Company has replenished 191.9 billion litres as of the end of 2015 through similar projects in 71 countries. In mid-2016, Coca-Cola announced that it had achieved its replenishment goals. In fact, water returned to nature and communities exceeded the company's water use by 15 per cent. For the USDA, the partnership is mutually beneficial. Sixty million Americans rely on National Forest lands for drinking water, but the Forest Service faces a serious backlog of forest restoration work. An estimated 48 per cent of watersheds on National Forest lands are considered impaired or not functioning properly.

As of the end of 2015, the partnership has delivered nearly USD 2 million to watershed projects. Replenishment projects also generate benefits for wildlife beyond volumetric outcomes. Project managers in the Huron-Manistee National Forest have reported the biggest run of native anadromous fish in decades, following stream crossing repairs in Brayton Creek. A mink – a species rarely seen in the project area – was also recently sighted.

Coca-Cola is eager to see other companies take up the model, and its methodology is publicly available. The National Forest Foundation says the partnership has sparked interest from others in the private sector in funding their own "replenishment" initiatives.

6.2 Conclusions on case studies

Economic drivers and co-benefits enhance the cost effectiveness of PWS schemes

Economic drivers are important in the context of European and US programmes, particularly as many water utilities are concerned by the increasing operational and capital cost of water treatment. The potential business risk associated with non-compliance to drinking water quality standard is reported as priceless. Moreover, regulators and/or investors are increasingly asking for performances monitoring and cost-benefit analysis.

The land-stewards project in Italy has reported operational cost savings of 1 to 4 (with or without a project scenario). In fact, forest owners provide a decentralized monitoring and management of water channels, avoiding all cost of displacement within the large mountain catchment.

The cost-benefit analysis (CBA) carried out by United Utilities demonstrates how the positive cost-benefit ratio is given by the inclusion of multiple benefits, such as carbon and biodiversity. Operational and capital savings were considered to be very low as the methodology only considered investments and operational costs directly linked with colour removal and waste treatments, and did not take into account business-as-usual (BAU) investments in new machineries. Therefore, climate and biodiversity SCaMP co-benefits strongly contributed to the economic sustainability of the programme, providing a range of benefit-to-cost ratios of between 2.24 to 25.38 (considering the different optimistic and pessimistic scenarios in term of GHG, biodiversity and water quality response). Overall, CBA results are established on a case-by-case basis, and within the context of the costs and benefits considered during the study.

PWS do not always represent a better economic option when compared to conventional grey infrastructures; however, if we consider the co-benefit in term of social, biodiversity and climate outcomes, payment schemes are certainly important in addressing water quality and other policy goals.

Civil society organizations drive PWS providing multiple benefits

Increasing attention is being paid to co-benefits of PES schemes, which are always difficult to quantify. Although theoretical approaches focus on "well-defined service" (see definition Wunder (2005)), successful PES schemes re-enforce the multifunctional role of ecosystems (through co-benefits), and highlight the economic and social benefits, which increase the acceptability and effectiveness of the overall scheme. Co-benefits are often demanded by the multiple actors involved in PES schemes management, as in case studies presented in Chapter 6 (Leonardi, 2015).

In many cases, PWS have been shown to have an impact on hydrological services, while also providing other important co-benefits, such as carbon stock, biodiversity conservation, and economic opportunities for landowners. According to the examples provided in Annex 1, PWS directly targeted biodiversity and social co-benefits related with the increasing economic opportunities of landowners, as in the cases of the land stewards, SCAMP and Upstream Thinking; carbon has only been designated as a targeted co-benefit in a few projects.

Environmental organizations are often concerned about biodiversity conservation rather than drinking water quality issues. However, they have understood that collaborating with water utilities or other water authorities, forestry and agricultural sector could maximize their impacts and successfully collaborate for delivering projects with multiple benefits. In some cases, CSOs have advocated for donors to give greater emphasis to PWS, as in the projects being piloted by WWF. In other cases, such as RSPB in the UK SCAMP or WRT in southern England, environmental organizations have lobbied for national and local political support, allowing for the development of emerging schemes and triggering water utilities and policy makers to adopt PWS as catchment approach.

Having a project co-benefit approach leads to increasing local acceptance, participation and match funding for a long-lasting scheme.

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Chapter 7

CHALLENGES AND RECOMMENDATIONS

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7. Challenges and Recommendations

7.1 Defining and measuring ecosystem services

Defining, measuring and valuing water-related ecosystem services from forests at an appropriate scale, and with precision, remains challenging in the context of the implementation of payment mechanisms. Some argue that this is because of the risk that valuation of complex multiple ecosystem service interactions may rely on highly simplified indicators (Civil Society Reflection Group on the 2030 Agenda for Sustainable Development, 2017). While overcoming such a limitation requires appropriate scientific knowledge, technical competencies and skills, it also requires stakeholder consultation and participation. Besides the site-specificity of services, the sharing of knowledge and experiences can help to reduce cost and promote a more efficient approach to the implementation of payment mechanisms. Information can also allow the development of an accounting system focusing not just on ecosystem service flows, but also on the natural capital stock.

7.2 Legal and regulatory framework: The role of governments

Due to their novelty, water-related forest PES schemes in some countries are frequently unregulated by national (or local) legal frameworks. For example, ownership and/or use rights over ecosystem services might not be defined within national legislation or there may be conflicts between legal and consuetudinary rights. A legislative framework might include legislation on PES and ecosystem-related issues (*e.g.* water laws, forest laws, protected areas laws, *etc.*), and indirectly relevant laws (Greiber, 2009). An analysis of the enabling framework at the international, regional and national level has shown that a uniform process of integrating PES-enabling policies is unlikely due to the specificities of local and historical contexts. However, countries can build on international and regional initiatives and local best practices. To ensure that key authorities responsible for policy-making – including finance and tax authorities – are more forcefully engaged in the dialogue on the development of new PES schemes, it is necessary to establish platforms to create a mutual understanding of PES principles and practice.

The amendment and/or integration of existing ecosystem-related legislation might be an alternative solution to the development of brand new PES-specific legislation. For example, the EU WFD introduced the requirement for an economic analysis in river basin management plans; this analysis builds on the concept of full-cost recovery and aims to verify the extent to which financial, environmental and resource costs are recovered, how cost recovery is organized, and the way in which key water users contribute to the cost of water services.

Relevant laws include all laws/regulations that can contribute to favourable conditions for PES schemes, including financial and contractual norms, fiscal regulations, agriculture and forestry laws, property regulations, and customary rights. In some cases, existing laws can provide a useful framework and valuable inputs for the development of PES initiatives, as was the case with the 1933 Water and Hydropower Act in Italy (Decree 1775/1933) which established a compulsory fee for each water user.

The legal framework should provide guidance and support to allow parties to a PES to design and implement agreements that are adapted and appropriate for local conditions (Greiber, 2009). The attempt to over-regulate the governance and the design of PES schemes might limit their capacity to innovate and adapt to local conditions. Private water-related PES schemes are often developed at a local scale and address very specific problems; therefore, they do not strictly need a specific legal framework beyond contract laws. Nonetheless, issues might arise with regard, for example, to fiscal issues (*e.g.* applicable tax regime). A more robust and integrated policy and legal framework might become necessary to scale up the project and extend any results and positive impacts to the regional or national level. Most successful governments initiatives (in the United States of America and the United Kingdom) have focused on the provision of technical advice, harmonization of existing market initiatives, promotion of best practices and seed/start-up funding, rather than creating new regulations.

Increasing the number of forest-related PWS schemes in the UNECE region could help countries to achieve several targets included in overlapping SDGs, *e.g.* those related to water (SDG 6) and land (SDG 15), which explicitly acknowledge the linkages between forests and water. Despite some weak indicators and lacking guidance on the practical application the forests and water linkage within the SDGs, increasing the implementation of PWS schemes can help to make policymakers and the public aware of the importance of this interrelationship, and deliver sustainable outcomes.

7.3 Design and governance

By analysing a number of case studies on the most frequent governance and design typologies to be found in UNECE member States, the following set of general rules can be retained for an optimal design of water-related forest PES schemes.

Scale and ecosystem services: The geographical scale of the scheme should be proportional to the scale to which hydrological services are provided by nature (at least at the watershed level). However, the scheme should consider all type of ecosystems involved within the catchment and provide a differentiated portfolio of management practice. For each desired hydrological service, the scheme should identify the structures (ecosystems), as well as the functions and environmental benefits. Qualitative and quantitative indicators, using hydrological services attributes should be defined to create a baseline and facilitate the final monitoring of outcomes.

Interaction of key actors: The first assessment of partners (*e.g.* buyers, intermediaries and suppliers) has to be based not only on their willingness to participate but also on their capacity (readiness) and the scale of their activities. Technical capacity is fundamental and is enhanced if it is linked with the right geographical and/or territorial scale for hydrological service provision. Project managers should design PWS to allow key actors in the conservation of water-related ecosystems to participate in the design and implementation process. The inclusion of key actors, such as intermediaries, universities, farmers associations, *etc.*, is a prerequisite for the success of a scheme. The coordination of all actors through cross-cutting institutions or partnerships allows the implementing organization to increase the technical and financial validation of the scheme. Choosing the right intermediary or organization with high local acceptability and recognition is the most fundamental step in the development of a PWS.

Institutional interplay: PWS schemes generally have high transaction costs, as it adopts a complex and multi-layered approach to communicating with stakeholders. Communicating the idea of PWS in the right way and with the right actors is a fundamental first step. The second fundamental step to obtaining a positive institutional interplay is to identify and involve key experts from national/ regional administrations at an early stage. This will help to have a clear picture of the natural assets and its relationship with existing actors and institutions.

Among the national authorities in Eastern Europe, Caucasus and Central Asia, there is a limited interest for PWS approaches and economic instruments in general. The focus is on "command and control" policy tools, with the resulting legislation not well adapted to the establishment of PES schemes. While legislation may partly be in place, the low political priority attached to environmental protection, and weak institutions in many countries in the region limit the enforceability of legislation. Even though recent policy developments point towards integrated water resources management, policy implementation is generally weak and specific objectives similar to those set out in the EU Water Framework Directive are lacking. Furthermore, long-term environmental, water ecosystem protection is frequently considered as being less important than the immediate needs of the irrigation and hydropower sectors. There is also a limited willingness of various stakeholders and sectors to pay for ecosystem services because their economies are underdeveloped (Rubel, 2012).

PWS should accurately study all institutions that could affect the development of the scheme, not only within the water sector but also within those institutions involved in forestry, agriculture, biodiversity conservation and environmental compensations. One of the main success factors of PWS seems to be related to the extent to which a scheme can engage and create synergies with institutions from other sectors (horizontal interplay); these institutions could include Natura 2000, environmental compensations funds, the EU's CAP, and the building sector.

Payment design: Win-win approaches with farmers and forest owners are one of the best solutions to decrease negotiation costs, as well as reducing the length of the negotiation process. Landowners want to see which benefits they can gain from participating in the scheme – not simply through any payment they may receive but also from the lessons they can gain in improving their management activities. Rationalization and chemical input savings, organic farming, sustainable forest management, capital works improvements have been demonstrated to be effective. Since scheme managers do not have perfect information about the landowners' cost baseline, the risk of market distortions and over-compensation exists. Therefore, structuring the right design system is of paramount importance. For example, in the case of Fowey River in south-west England, the auction system stimulated competition between farmers by only funding bids that offer the best value for money for South-West Water.

Monitoring through third-party certification standards: Some scheme managers use commodity certification standards (organic agriculture, sustainable forest management) as a tool for decentralized compliance monitoring and to increase win-win benefits for farmers and forest owners. Two examples stand out among the portfolio of management practices: The region of Lower Saxony and the City of Munich schemes in Germany provide a payment for organic agriculture on groundwater recharge areas. Norda Water (Monticchio Gaudianello) in Italy has a scheme based on organic certification of spring water catchments; it is promoted on the label of its bottles and used to show its customers its corporate environmental responsibility credentials. At the global level, the Forest Stewardship Council has launched ecosystem services certifications and several pilot studies have been put in place. This could be a promising area of work to decentralize the monitoring of forest management hydrological service provision. It is thus recommended that PWS practitioners engage as much as possible with cross-sectoral initiatives such as third-party

certification standards to create the synergies needed for successful implementation.

Capacity and scale: Capacity and scale matters as public bodies are the most frequent scheme manager (and buyer) followed by cross-scale partnership (examples of this are included in Annex 1). Since forest-related PWS are complex systems that have to respond to different geographical, administrative and institutional scales, cross-scale institutions are usually better equipped to cope with multiple scales of intervention. When the private sector is involved, only large multinational companies, such as Coca Cola, Danone, and Bionade, are able to manage PWS. Therefore, PWS should preferably be managed either by a public organization, or by an organization with a strong financial, technical and management capacity. PWS based on public budget allocation are often undermined by political instability that could affect the allocation of resources depending on availability and political decisions. To avoid instability public PWS should be coupled with regulations that set financial instruments, such as water charges or funds that systematically raise financial sources to run the scheme. Schemes that are based on water charges are run on a long-term basis and appear to have a bigger scale and impacts.

Multiple benefit partnerships: These PWS schemes are characterized by a partnership-based model which, in addition to the provision of hydrological services, they seek to provide clear multiple co-benefits (such as biodiversity conservation, climate change adaptation and socio-economic opportunities for landowners). The model bases its viability on guaranteeing multiple source of funding, and ensuring territorial collaborative learning processes, through the establishment umbrella organizations, partnerships or cross-cutting institutions, representing the interests of all involved actors. Multiple benefit partnerships are successful as they recognize the multiple benefits of PWS, which are implemented, locally with the participation of relevant actors; they also provide an in-depth identification of potential buyers/beneficiaries, and a diversified and locally adapted portfolio of service providers and management practices. The recognition of the multiple benefit partnership provides social collaboration among different actors, improve synergies among CSO, regulators, private business and existing institutions and policy tools. Therefore, the multiple benefits concept introduces the idea of co-funding and networking and transforms the traditional idea of PES (*i.e.* a bilateral agreement between a service provider and a service buyer) into a watershed network where shared hydro-geological goals are funded and supported by multiple actors collaborating in a 'win-win' relationship.

7.4 Effective/Efficient/Equity payment mechanisms (Transaction costs)

Supporters of PES schemes emphasize that making benefits directly contingent on the provision of outcomes could, under some circumstances, turn out to be more effective than alternative approaches (*e.g.* top-down approaches or integrated conservation and development projects), and that enabling competition among possible service providers could also improve efficiency (Martin *et al.*, 2014). Empirical evidence of this, however, is still limited (Miteva *et al.*, 2012). Ideally, PES schemes should integrate ecosystem services into markets, internalizing externalities (Farley and Costanza, 2010). This builds on the assumption that effective legal structures and enforceable policy rights overcome problems connected to market failures (Coase, 1960). Several studies, however, highlighted that the Coasean and pure market approach underpinning the PES theory cannot be easily implemented in practice (Leimona *et al.*, 2015; Muradian *et al.*, 2013). Nevertheless, many schemes bypass a conceptual (Coasean) method, and opt instead for heuristic approaches. This indicates that it is important to decouple practice from theory in cases where theory proves inappropriate.

Additional discussions have arisen on equity issues, *i.e.* how costs and benefits connected to PWS are distributed among different actors participating in these mechanisms. According to Pascual *et al.* (2010) efficiency and cost-effectiveness are often given more emphasis than equity. The effectiveness and efficiency of PWS initiatives rely on their design, and implementation should be considered within the specific political, socio-economic and environmental context of the PWS, as elaborated in Chapter 4. Cost-effectiveness represents a key issue when designing a PWS. Apart from opportunity costs associated with the delivery of ecosystem services (*i.e.* the opportunity cost of alternative land uses), the implementation and operational costs of land use changes and the transaction costs associated with the development of an exchange mechanism between buyers and sellers needs to be carefully taken into account (Wunder, 2007).

Focusing on ecosystem service bundling, *i.e.* a single ecosystem delivering multiple services that are sold together or combined in a single credit, is a recommended approach to making PWS more cost-effective (Deal *et al*., 2012; Robertson *et al*., 2014). A forest area could, for example,provide a bundle of ecosystem services, including drinking water, carbon sequestration, biodiversity habitat, provisioning services (*e.g.* firewood or mushroom production), and cultural services (*e.g.* environmental education and recreational opportunities). The relative proportion of each service might vary from one ecosystem to another, from one site to another, and over different periods (Farley and Costanza, 2010), but the full set of (potential) services and the characteristics of their bundling should be taken into consideration to maximize the benefits to society, and avoid trade-offs and perverse incentives. Moreover, by promoting a more holistic approach to the management of natural ecosystems, service bundling can increase and differentiate income opportunities (Deal *et al*., 2012; Kemkes *et al*., 2010), thus mitigating risks (Robertson *et al*., 2014) and transaction costs (Wendland *et al*., 2010) associated with PWS investments. Experiences of ecosystem service bundling in other regions, including the case of FONAFIFO in Costa Rica, as well as the Counting on The Environment (COTE) standards (Oregon), the Conservation Marketplace and the American Farmland Trust (both in Minnesota), show that there is much potential for efficiency.

7.5 Monitoring

Monitoring for forest-water interactions is challenging. There is often inappropriate or absent monitoring and evaluation in PWS schemes (Asbjornsen *et al*., 2015). Despite the increasing number of PWS experiences and the growing global attention given to PWS by scientists, practitioners and policymakers, several studies have reported that the progress made in targeted hydrologic outcomes has not been adequately documented (*e.g.* Brouwer *et al*., 2011; Kroeger, 2013; Reed *et al*., 2014), and has resulted in undesirable social, economic and environmental side-effects (*e.g.* Goldman-Benner *et al*., 2012).

There is a need for practical monitoring solutions, including models, as current monitoring systems are often expensive, require technical training and/or are not always reliable. A properly defined monitoring system coupled with a clear identification of proxy indicators and ecosystem service metrics are essential for system performance and durability (Keeler *et al*., 2012; Lu and He, 2014; Sandin and Solimini, 2009). This calls for the identification and definition of baseline conditions to be used as a reference for future monitoring of the contractual obligations. Monitoring results also calls for setting down the actions to be taken in case of non-compliance (e. penalty clauses, *etc.*) in order to ensure the system meets expected performance levels and, if possible, can be improved over time.

The transaction, and indeed the whole PES design, should be based on a 'well-defined' ecosystem service, which would be

the subject of the contract. Specific metrics and monitoring process and output indicators should be identified in order to verify the type of land use likely to secure the service and measure the final service provided to beneficiaries.

The definition of a monitoring system coupled with a clear identification of a proxy indicator and ecosystem service metrics are essential to avoid contractual disputes and for the performance of the whole system (Sandin and Solimini, 2009; SCBD, 2011; Lu and He, 2014; Keeler *et al.*, 2012). Therefore, monitoring and outcomes are often reported in terms of hectares of reforested areas, wetlands restored, etc., rather than in terms of hydrological attributes and services. Special attention has to be given to identify the actual "environmental benefit" for the service user and to the management practice that is more likely to deliver that specific benefit (Keeler *et al.*, 2012). However, when it comes to monitoring the effects of a scheme within a forest catchment, project managers have tended to experience difficulties when setting the baseline scenarios. In fact, high variability of climate conditions (abnormal increases of annual rainfall, droughts, etc.) might change the hydrological baseline for certain parameters (*e.g.* pollutants concentration might vary depending on the annual rainfall). Given the uncertainty of climate change and conditions, it is difficult for project managers to demonstrate payments outcomes, particularly in the context of hydrological services (Leonardi 2015).

All water utilities are legally obliged to monitor water quality and potential shortage risks. However, when it comes to monitoring the effects of a catchment management scheme, project managers experience problems when setting baseline scenarios. In fact, high variability of climate conditions (abnormal increase of annual rainfall, droughts, *etc.*) might change the hydrological baseline for certain parameters. Yet, the annual monitoring of the effects of a certain indicator might vary depending again on climate conditions. Given the uncertainty of climate change, it is rather difficult for project managers to demonstrate project outcomes in terms of a hydrological response to the management practices induced with the payments. Therefore, monitoring and outcomes results are often reported in terms of hectares of woodlands, wetlands restored, hectares of farmlands under the schemes, *etc.* rather than in term of hydrological attributes and services.

Integrated water resource management calls for a multi-sectoral collaboration between forestry, land and water resource management to develop adaptive management strategies of forest, water and land resources. As such, water-related ecosystem services should be integrated into forest management objectives. Successful integration may require broad paradigm shifts within the forest and water sectors.

7.6 Commodification

Some critics have argued that narrowing down the complexity of ecosystems to a single service carries with it immense technical difficulties, as well as ethical implications on the way that humans relate to nature (Kosoy and Corbera, 2009). PES often implies trading of single exchange-values, which can lead to overlooking the multiplicity of values that can be attributed to ecosystem services and hence result in their commodification. In fact, critical scholars argue that the ecosystem services approach risks reducing complex ecosystems to simple market logic in the name of profit (Dempsey, 2016). Nevertheless, as the case study analysis and observations in earlier chapters have shown, valuation of nature is often necessary for recognizing the importance of ecosystem services within the current economic system, and bringing this to the attention of policymakers and planners. Importantly, PES scheme design and implementation needs to incorporate measures that fully recognize the potential limitations and challenges inherent in economic valuation, as well as the multiplicity of values and the exclusion of local communities, and take into account the structural factors influencing PES outcomes.

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ANNEXES

Annex 1: List of Case Studies

The following table presents a non-exhaustive list of payment for forest and water ecosystem services schemes. An initial comprehensive inventory of the 56 UNECE countries was carried out based on previous work by ETIFOR Srl (for the provision of the European region) and Ecosystem Marketplace (for the provision of North American). The inventory found that 23 of the 56 UNECE member States have no reference to forest and water ecosystem services schemes.[53] Nevertheless, a total number of 259 schemes were identified in the remaining countries. These were split into two main categories, active and non-active schemes (including pilot, design phase, and unknown). Considering the focus of this report, only the active schemes were included, and resulted in a total number of 178 active schemes. These were classified per country, regions and locations. Each scheme received a reference code. The list of case studies also includes the names of the scheme and programme administrators. One important part of the classification was the application of the governance model and funding types presented within the report; these were defined by the classification presented in Leonardi (2015). Finally, the reference sources for information linked to the associated URLs were also included. The following collection, although non-exhaustive, is likely the most complete and up to date for the UNECE region.

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
1	AU1	Austrian Agri-environmental program ÖPUL	Agri-environmental scheme	U/PBA and AESP	Austrian Rural Development Programme	EU	Austria	State-wide	UNECE Report, 2005
2	AU2	Vienna Source Water Protection	Avoid impacts, bilateral agreements	U/PBA and AESP	City of Vienna	EU	Austria	Vienna	Vienna Water Protection
3	AU3	WWF Danube-Carpathian Programme	Multiple benefits partnerships	I/N/EU F	WWF Danube-Carpathian Programme	EU	Austria	Danube areas	WWF Danube Basin
4	BE1	Fagne Catchment/Spa Watersource Protected Area	Avoid impacts, bilateral agreements	PBA	SPADEL water company	EU	Belgium	Walloon Region	Watersource ES, Belgium
5	HR1	Strengthening the Institutional and Financial Sustainability of the National Protected Area System – PARCS project	Compensation for legal restrictions	I/N/EU F	Government-initiative (Public and private partnership)	EU	Croatia	State-wide	PARCS mid-term report PARCS initiative
6	DN1	Water Supply Act Catchment Levy	Avoid impacts, bilateral agreements	U/PBA	Waterworks	EU	Denmark	National	EC, Groundwater Report, 2009

53 These countries were: Andorra, Belarus, Bosnia, Cyprus, Czech Republic, Estonia, Greece, Iceland, Ireland, Kazakhstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Monaco, Norway, Russia, San Marino, Slovakia, Turkmenistan and Vatican City.

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
7	DN2	Aalborg cooperative agreements	Avoid impacts, bilateral agreements	U/PBA, CWL/F and I/N/ EU F	Aalborg City Council (Drastrup project)	EU	Denmark	North Jutland	Alborg Coop Agreements
8	DN3	Copenhagen Energy Corporation	Avoid impacts, bilateral agreements	CWL/F	Copenhagen Energy Corporation	EU	Denmark	Region Hovedstaden	EC, Groundwater Report, 2009
9	DN4	Danish reforestation project	Avoid impacts, bilateral agreements	CWL/F	Public water works	EU	Denmark	National wide	Danish National Forest Program Report
10	DN5	Danish groundwater protection agreements	Avoid impacts, bilateral agreements	CWL/F	Public water works	EU	Denmark	National wide	EC, Groundwater Report, 2009
11	FR1	The Vittel Scheme	Avoid impacts, bilateral agreements	PBA	Vittel (Nestlé Waters)	EU	France	Lorraine	Vittel Case, 2006
12	FR2	Evian Catchment Protection Partnership	Multiple benefits partnerships	U/PBA and PBA	Association for the Protection of the Impluvium of Evian Mineral Water (APIEME) (Evian Company - Danone Group)	EU	France	Rhône-Alpes	Evian PES, 2011
13	FR3	Volvic Catchment Protection Partnership	Multiple benefits partnerships	U/PBA and PBA	Environment Committee for the Protection of Impluvium Volvic (CEPIV) - (Volvic - Danone Group)	EU	France	Auvergne	Evia-Volvic Scheme, FAO Report on PES
14	FR4	Badoit Green Bubble Partnership	Multiple benefits partnerships	U/PBA and PBA	Badoit (Danone Group)	EU	France	Loire	Evia-Volvic Scheme, FAO Report on PES
15	FR5	Salvetat PEP'S Partnership	Multiple benefits partnerships	U/PBA and PBA	PEP'S Association (La Salvetat - Danone Group)	EU	France	Salvetat	Le Salvetat scheme
16	FR6	Naussac and Villerest dams schemes	Avoid impacts, bilateral agreements	U/PBA and CWL/F	Etablissement Public Territorial de Bassin Loire (EPTB Loire)	EU	France	Loire	Loire Dam scheme
17	FR7	Golfe de Saint Tropez fire protection scheme	Avoid impacts, bilateral agreements	U/PBA	Union for the drinking water distribution of the Corniche des Maures (SIDECM)	EU	France	The Var	EC/SYLVAMED Report, 2011 PES for fire defense
18	FR8	Coca Cola -Pennes-Mirabeau Partnership	Multiple benefits partnerships	PBA	Coca Cola France	EU	France	Bouches-du-Rhône	Coca-Cola web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
19	FR9	Eau de Paris drinking water protection zones	Compensation for legal restrictions	U/PBA	Eau de Paris	EU	France	Paris	Paris Water Report, a public service, FAO Report, PES for city water provision
20	DE1	Munich water protection payments	Avoid impacts, bilateral agreements	U/PBA and CWL/F	Stadtwerke München (SVM or Munich City Utilities)	EU	Germany	Bavaria State	Grolleau, 2012
21	DE2	Bionade-Trinkenwasserwald	CSR offsetting	PBA	Bionade Corporation	EU	Germany	Rhoen region	EC, Groundwater Report, 2009
22	DE3	Lower Saxony cooperation model	Water charge - public bilateral agreements	CWL/F and AESP	Lower Saxony Government (NLWKN)	EU	Germany	German provincial state of Lower Saxony (Niedersachsen)	Bluemling and Horstkoetter, 2007
23	DE4	SchALVO - Baden-Wurttemberg	Avoid impacts, bilateral agreements	CWL/F	Baden-Württemberg Government	EU	Germany	Baden-Württemberg State	German Regional PES initiative
24	DE5	Augsburg scheme	Avoid impacts, bilateral agreements	CWL/F	City of Augsburg	EU	Germany	South-west of Bavaria	EC, URBEM Report
25	DE6	Northeim model project, Germany	Environmental benefits bilateral agreements	U/PBA	Northeim	EU	Germany	Lower Saxony	Deltares PES report
26	DE7	Hanover	Water charge - public bilateral agreements	U/PBA	Stadtwerke Hannover AG	EU	Germany	Hanover	Hanover City Energy Report
27	DE8	Eco-Farmer Program	Avoid impacts, bilateral agreements	U/PBA	Stadtwerke München	EU	Germany	Munich	Munich Municipal Services Report
28	HU1	Liberty Island	CSR offsetting	I/N/EU F and PBA	WWF Hungary	EU	Hungary	Danube	WWF, Danube River Plan
29	IT1	Forest Infiltration Areas (Bosco Limite)	Multiple benefits partnerships	U/PBA, AESP, I/N/EU F and PBA	Lowland Basin Authorities	EU	Italy	Veneto Region	Bosco Limite
30	IT2	Piedmont and Veneto Region water levies	Water charge - public bilateral agreements	CWL/F	Piedmont Region Council	EU	Italy	Piedmont Region	Pettenella et al, 2012
31	IT3	Romagna Acque Water Fund	Avoid impacts, bilateral agreements	U/PBA	Romagna Acque Spa	EU	Italy	Emilia Romagna Region	Pettenella et al, 2012
32	IT4	Hydroelectric power compensation	Compensation for legal restrictions	CWL/F	Mountain Basin Authorities (FEDERBIM)	EU	Italy	National wide	Pettenella et al, 2012
33	IT5	Land stewards	Avoid impacts, bilateral agreements	U/PBA, AESP, I/N/EU F	Comunità Montana Media Valle del Serchio	EU	Italy	Tuscany	Pettenella et al, 2012

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
34	IT6	Norda Bottle Water	Avoid impacts, bilateral agreements	PBA	Monticchio Gaudianello S.p.A. (Gruppo Norda)	EU	Italy	Basilicata	Forest Trends Report on State of Watershed Investments
35	IT7	Stewardship and improvement of water resources: Misura 214/g	Agri-environmental scheme	AESP	Veneto Region	EU	Italy	Veneto Region	Italian Regional (Veneto) Misura 314 Pages
36	IT8	Integrated Constructed Wetlands - Lombardy Region	Agri-environmental scheme	U/PBA	Lombardy Region	EU	Italy	Lombardy Region	Lombardy PES Initiative Article
37	IT9	ECOPAY CONNECT	Multiple benefits partnerships	AESP and PBA	Oglio Sud Regional Park	EU	Italy	Lombardy Region	ECOPAY CONNECT
38	IT10	MGN Monte Carpegna Potable Water	Avoid impacts, bilateral agreements	U/PBA	Parco interregionale del Sasso Simone e Simoncello	EU	Italy	Emilia Romagna - Marche Regions	Life (Making Good Nature) Web Pages
39	IT11	MGN Lanca di Gerole	Avoid impacts, bilateral agreements	PBA	River Po Basin Authorities	EU	Italy	Lombardy Region	Life (Making Good Nature) Web Pages
40	NL1	Dutch groundwater protection zones	Compensation for legal restrictions	CWL/F	Water companies	EU	Holland	National wide	EU Water Policy Publication
41	NL2	Agricultural Claims Water extraction Drentsche Aa	Compensation for legal restrictions	CWL/F	Groningen water	EU	Holland	Province of Groningen	FAO Water Reports, 2008
42	NL3	Active strips management Brabant	Avoid impacts, bilateral agreements	U/PBA	Brabant water boards	EU	Holland	North-Brabant	De Groot et al, 2009
43	NL4	Nature friendly banks Midden Delflan	Avoid impacts, bilateral agreements	U/PBA	Midden Delflan water boards	EU	Holland	Midden Delflan	De Groot et al, 2009
44	NL5	Kennemer Dunes and the Noord-Holland Dune Reserve/ Forest & dune maintenance for water quality (near the Hague)	Public bilateral agreements	U/PBA	Provincial Water Supply Company North Holland	EU	Holland	North Holland	Kennemer Dunes Watershed Presentation
45	NL6	Drentsche Aa Compensation Scheme	Avoid impacts, bilateral agreements	PBA, I/N/ EU F	Groningen Water Company	EU	Holland	Drentsche	Drentsche Web Pages
46	PT1	Coca Cola Groundwater Compensation	CSR offsetting	PBA	APF Certifica Group Scheme (APFC)	EU	Portugal	Alentejo and Ribatejo regions	Coca cola project/WWF pub

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
47	ES1	Special Plan for the Upper Guadiana (SPUG)	Regulated trading initiatives	WR/T	Special Plan for the Upper Guadiana	EU	Spain	Upper Guandiana	Dumon et al, 2011 UPM Report FAO web pages
48	SE1	Nordic Shell Holdings	Avoid impacts, bilateral agreements	U/PBA	Lysekil local authority	EU	Sweden	Lysekil	EC, Groundwater Report, 2009
49	UK1	The English Woodland Grant Scheme	Agri-environmental scheme	AESP and PBA	Forest Commission Yorkshire and The Humber Region	EU	UK	Yorkshire and The Humber Region	Forest Research Publication, 2011
50	UK2	Voucher angling schemes (7 schemes in UK)	User funded schemes	WR/T	The Wild Trout Trust and the The Rivers Trust	EU	UK	National wide	Severn Fisheries Angling Schemes
51	UK3	Westcountry Rivers Trust's Upstream Thinking	Multiple benefits partnerships	U/PBA, AESP and I/N/EU F	South West Water	EU	UK	South West England	DEFRA Publication, PES case studies UK, 2013
52	UK4	Exmoor Mires Project - Upstream Thinking	Multiple benefits partnerships	AESP, I/N/EU F and PBA	South West Water	EU	UK	South West England	Upstream thinking web pages
53	UK5	Working Wetlands Upstream Thinking	Multiple benefits partnerships	AESP, I/N/EU F and PBA	South West Water	EU	UK	South West England	Upstream Thinking web pages 2
54	UK6	Otter Valley - Upstream Thinking	Multiple benefits partnerships	AESP, I/N/EU F and PBA	South West Water	EU	UK	South West England	Southwest catchment web pages
55	UK7	Wild Penwith - Upstream Thinking	Multiple benefits partnerships	AESP, I/N/EU F and PBA	South West Water	EU	UK	South West England	Southwest Water Catchment Areas web pages
56	UK8	Pumlumon Project	Multiple benefits partnerships	I/N/EU F and PBA	Montgomeryshire Wildlife Trust	EU	UK	Wales	Montgomeryshire trust web pages
57	UK9	Visitor Payback - Nurture Lakeland Scheme	User funded schemes	I/N/EU F and PBA	Birmingham City University	EU	UK	North West of England	DEFRA web pages
58	UK10	Slowing the Flow at Pickering	Multiple benefits partnerships	U/PBA, AESP and I/N/EU F	Forest Research	EU	UK	North Yorkshire	Foretry Comission web pages
59	UK11	Sustainable Catchment Management Programme (SCaMP)	Multiple benefits partnerships	U/PBA, AESP and I/N/EU F	United Utilities	EU	UK	North West of England	Tinch, R., 2009
60	UK12	The Catchment Sensitive Farming Capital Grant Scheme (CGS)	Agri-environmental scheme	AESP and I/N/EU F	Environment Agency and Natural England	EU	UK	National wide	Natural England web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
61	UK13	Wessex Water's catchment management programme	Multiple benefits partnerships	U/PBA	Wessex Water	EU	UK	South West England	Wessex water web pages
62	UK14	Ouse Upstream Thinking Project	Multiple benefits partnerships	U/PBA	South East Water	EU	UK	South East England	Wastewater web pages
63	UK15	Yorkshire Water catchment investment	Avoid impacts, bilateral agreements	U/PBA	Yorkshire Water	EU	UK	Northern England	Yorkshire water web pages
64	UK16	Wicksters Brook nitrate scheme	Avoid impacts, bilateral agreements	U/PBA	Bristol Water	EU	UK	South West England	Bristol water report
65	UK17	Metaldehyde action project	Avoid impacts, bilateral agreements	U/PBA	Bristol Water	EU	UK	South West England	Bristol water web pages
66	UK18	Slug It Out Campaign	Avoid impacts, bilateral agreements	U/PBA	Anglian water	EU	UK	Canbridgeshire	Anglian water web pages
67	UK19	Holnicote project	Public bilateral agreements	U/PBA and I/N/EU F	The national trust	EU	UK	Selworthy	UK Government report on PES Ecosystem knowledge web pages
68	UK20	Catchment Partnership Fund	Public bilateral agreements	U/PBA	DEFRA	EU	UK	National based in London	UK Government report on PES
69	UK21	Countryside Stewardship Grants	Public bilateral agreements	U/PBA	DEFRA	EU	UK	National based in London	Forestry Commission web pages
70	EU1	European Agricultural Fund for Rural Development 2014-2020	Agri-environmental scheme	I/N/EU F	European commission	EU	EU-wide	EU-wide	EU web pages
71	SH1	Switzerland's National Nitrate Strategy	Compensation for legal restrictions	U/PBA	Federal Government, cantons and water supplier	EFTA countries	Switzerland	National wide	Swiss Federal Water Division Water Strategy Report
72	SH2	Henniez SA	Avoid impacts, bilateral agreements	PBA	Henniz SA	EFTA countries	Switzerland	Broye-Vully	UNECE report, 2014
73	SH3	Basel water supply (Langen Erlen catchment)	Avoid impacts, bilateral agreements	CWL/F	Basel water	EFTA countries	Switzerland	Basel	UNECE report, 2014 Waldwissen web pages
74	SH4	Winterthur Water Source Protection Zones	Water charge - public bilateral agreements	U/PBA and AESP	City Water Service of Winterthur	EFTA countries	Switzerland	Winterthur	UNECE Swiss National ES Report, 2005
75	SH5	Lausanne water supply	User funded schemes	CWL/F and I/N/EU F	Lausanne water	EFTA countries	Switzerland	Lausanne	FAO web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
76	SH6	Water utility Baden	Multiple benefits partnerships	PBA	City utility Basel	EFTA countries	Switzerland	Baden	Baden State Report
77	IS	Forest and Green Innovations (no mention of water regulation)	Multiple benefits partnerships	I/N/EU F	Jewish National Fund	Israel	Israel	Nationwide	JNF web pages
78	CA1	Ecological Services Initiative	Multiple benefits partnerships	PBA	Ecological Services Initiative	North America	Canada	BC and Alberta	Cattlemen web pages
79	CA2	Alternative Land Use Services	Multiple benefits partnerships	PBA	ALUS Canada	North America	Canada	Country-wide	Alus web pages
80	CA3	Assiniboine River Watershed	Multiple benefits partnerships	PBA	ALUS Canada	North America	Canada	Assiniboine	OECD 2010 Assiniboine web pages
81	US1	Upper Neuse clean Water Initiative (raleigh, NC)	Multiple benefits partnerships	CWL/F	Upper Neuse Clean Water Initiative	North America	USA	North Carolina	CTNC watershed plan
82	US2	Clean Water Services	Multiple benefits partnerships	PBA	Clean Water Services	North America	USA	Washington	Clean Water Services Report Clean Water Services web pages
83	US3	Clean Water Services-Tualatin Basin Water Supply Project Partnership	Avoid impacts, bilateral agreements	U/PBA and CWL/F	Clean Water Services	North America	USA	Oregon	Tualatin water supply web pages
84	US4	Tree For All	Avoid impacts, bilateral agreements	U/PBA and PBA	Clean Water Services	North America	USA	Oregon	Tree for all web pages
85	US5	New York City Watershed Program	Avoid impacts, bilateral agreements	U/PBA, CWL/F and I/N/EU F	New York City Department of Environmental Protection	North America	USA	New York	NYC web pages
86	US6	The Ashland Forest Resiliency Stewardship Project	Avoid impacts, bilateral agreements	PBA	Ashland Forest Resiliency Stewardship Project	North America	USA	Oregon	Ashland web pages
87	US7	The Environmental Quality Incentives Program	Environmental benefits bilateral agreements	I/N/EU F	Government-initiative (Public and private partnership)	North America	USA	Country-wide	Claassen et al, 2007
88	US8	Conservation Reserve Program	Multiple benefits partnerships	PBA	Natural Resources Conservation Service - Government-initiative (Public and private partnership)	North America	USA	Country-wide	Claassen et al, 2007 State Government web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
89	US9	The Wetlands Reserve Program (Compensatory wetland mitigation)	Compensation for legal restrictions	AESP	Natural Resources Conservation Service - Government-initiative (Public and private partnership)	North America	USA	Country-wide	OECD 2010
90	US10	Chesapeake Bay Fund	Avoid impacts, bilateral agreements	U/PBA and PBA	Chesapeake Bay Foundation	North America	USA	Multi-state	Stanton *et al.* 2010 Ecosystem Marketplace Chesapeak Bay web pages
91	US11	Quabbin and Wachusett Watersheds (Massachusetts)	Multiple benefits partnerships	U/PBA and PBA	Massachusetts Water Resources Authority	North America	USA	Massachusetts	Stanton *et al.* 2010 Massachusett Government water plan
92	US12	Cedar River (Washington)	Multiple benefits partnerships	U/PBA	Seattle Public Utilities	North America	USA	Washington	Stanton *et al.* 2010 Seattle Govermnetment web pages
93	US13	Watershed and environmental Improvement program (San Francisco, CA)	Multiple benefits partnerships	U/PBA	San Francisco public utilities commission	North America	USA	California	San Francisco Water web pages San Francisco watershed report plan San Francisco water web pages
94	US14	EPA's 319 Program	Public bilateral agreements	U/PBA and AESP	Environmental Protection Agency - Government-initiative (Public and private partnership)	North America	USA	Country-wide	Stanton *et al.* 2010
95	US15	Water Source Protection Plan	Avoid impacts, bilateral agreements	CWL/F	Carrol County Source water protection plan	North America	USA	Georgia	Carroll County Water Protection Plan
96	US16	San Antonio Source Water Protection Program (San Antonio, TX)	Avoid impacts, bilateral agreements	CWL/F	San Antonio Source Water Protection Program (San Antonio, TX)	North America	USA	Texas	EPA project report SAN Antonio web pages
97	US17	San Antonio Source Water Protection Program- Edwards aquifer (San Antonio, TX)	Multiple benefits partnerships	CWL/F	San Antonio Source Water Protection Program (San Antonio, TX)	North America	USA	Texas	San Antonio local government web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
98	US18	Minnesota clean Water fund-Lambert creek (Saint Paul)	Multiple benefits partnerships	I/N/EU F	Minnesota Board of Water and Soil Resources	North America	USA	Minnesota	Source Water Collective Report St. Paul Government web pages
99	US19	Minnesota clean Water fund (statewide)	Multiple benefits partnerships	I/N/EU F	Minnesota Board of Water and Soil Resources	North America	USA	Minnesota	Minnesota CWF Report Minnesota government web pages
100	US20	Mountain Island lake (Charlotte-Mecklenburg county)	Avoid impacts, bilateral agreements	I/N/EU F	The Trust for Public Land	North America	USA	North Carolina	TPL web pages
101	US21	Green river Watershed Management plan (Tacoma, WA)	Multiple benefits water partnerships	U/PBA	Tacoma Public Utilities	North America	USA	Washington	MYTPU web pages
102	US22	Lake Whatcom Watershed land acquisition and preservation program (Bellingham, WA)	Avoid impacts, bilateral agreements	CWL/F	City of Bellingham	North America	USA	Washington	COB Brochure COB web pages
103	US23	Salt lake city Watershed Management plan (Salt lake city, UT)	Multiple benefits water partnerships	CWL/F	Salt lake city Watershed Management	North America	USA	Utah	Salt Lake City plan
104	US24	Watershed Management (Los Angeles, CA)	Multiple benefits partnerships	U/PBA	Upper Los Angeles River Watershed Management Group	North America	USA	California	Watershed Management presentation LA Government water plan web pages
105	US25	Colorado Springs Utilities-Coalition of the Upper South Platte Forest Treatments	Avoid impacts, bilateral agreements	U/PBA	Colorado Springs Utilities	North America	USA	Colorado	CUSP Report
106	US26	Colorado Springs Utilities-USFS Watershed Protection MOU	Avoid impacts, bilateral agreements	U/PBA	Colorado Springs Utilities	North America	USA	Colorado	CSU Report
107	US27	Onondaga County's Green Improvement Fund (GIF)	Avoid impacts, bilateral agreements	U/PBA	Onondaga County and City of Syracuse	North America	USA	New York State	STR Onondaga-lake web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
108	US28	Milwaukee River Pay for Performance Project	Avoid impacts, bilateral agreements	PBA	Winrock International, Sand County Foundation, and Delta Institute and Great Lakes Protection Fund	North America	USA	Milwaukee	Winrock International web pages
109	US29	Nisqually Environmental Services Project	Environmental benefits bilateral agreements	PBA	Nisqually Land Trust	North America	USA	WA	NLT web pages
110	US30	Public Utilities Water Rights and Watershed Purchase Fund	Avoid impacts, bilateral agreements	U/PBA and PBA		North America	USA		Carpe Diem Utah Report
111	US31	Salt Fork River Watershed	Avoid impacts, bilateral agreements	U/PBA	Salt Fork Implementation Committee	North America	USA	Illinois	Salt fork river watershed implementation Report Saltfor River web pages
112	US32	San Luis Valley Showcase Barley Farm	Avoid impacts, bilateral agreements	PBA	MillerCoors	North America	USA	Colorado	Millercoors web pages
113	US33	Silver Creek Showcase Barley Farm	Avoid impacts, bilateral agreements	PBA	MillerCoors	North America	USA	Idaho	Nexus Solutions Millercoors Report
114	US34	Suffolk County Drinking Water Protection Program	Avoid impacts, bilateral agreements	U/PBA	Suffolk County	North America	USA	New York	Suffolk County web pages
115	US35	Water Resource Review Program	Avoid impacts, bilateral agreements	PBA	Nestlé Waters North America	North America	USA	Nationwide	Nestle Water Management web pages
116	US36	Bonneville Environmental Foundation Water Restoration Certificates	Regulated trading initiatives	PBA	Bonneville Environmental Foundation	North America	USA	Nationwide	BEF web pages
117	US37	Central Valley Improvement Act 3406(b)(3) Water Acquisition Program	Public bilateral agreements	U/PBA	Mid Pacific Region	North America	USA	Mid-Pacific Region	Mid-Pacific Government web pages
118	US38	Clark Fork Coalition	Environmental benefits - Bilateral agreements	PBA	Clark Fork Coalition	North America	USA	Western Montana and northern Idaho	Clark Fork web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
119	US39	Colorado Water Conservation Board Instream Acquisitions & Leasing	Avoid impacts, bilateral agreements	U/PBA	Colorado Water Conservation Board	North America	USA	Colorado	Colorado State water web pages
120	US40	Flowing Waters Partnership	Environmental benefits bilateral agreements	PBA	Colorado Water Trust	North America	USA	Colorado	CWT web pages
121	US41	Columbia Basin Water Transactions Program-Upper Snake Irrigation Project Flow Augmentation	Environmental benefits bilateral agreements	PBA	Upper Snake Irrigation Project AND Bureau of Reclamation	North America	USA	Oregon, Washington, Idaho and Montana	Upper Snake River Report Upper Snake Government web pages
122	US42	Columbia Basin Water Transactions Program	Environmental benefits bilateral agreements	PBA	Bonneville Power Administration (BPA) and National Fish and Wildlife Foundation (NFWF) AND Bureau of Reclamation	North America	USA	Oregon, Washington, Idaho and Montana	Hardner and Gullison Evaluation Report
123	US43	Deschutes Groundwater Mitigation Program	Public bilateral agreements	U/PBA	Water Resources Commission (Oregon Government)	North America	USA	Oregon	Oregon Deschutes web pages
124	US44	Deschutes Groundwater Mitigation Program-Pelton Round Butte Water Rights Fund	Avoid impacts, bilateral agreements	U/PBA and WR/T	Portland General Electric Company (PGE) and the Confederated Tribes of Warm Springs	North America	USA	Oregon	Deschutes River web pages
125	US45	Water Rights Leasing & Transfers/Water Rights Transfers	Avoid impacts, bilateral agreements	WR/T	Deschutes River Conservancy	North America	USA	Oregon	Deschutes SRP River web pages
126	US46	Dungeness Water Exchange	Avoid impacts, bilateral agreements	U/PBA	Washington Water Trust	North America	USA	Washington	WWT web pages
127	US47	Groundwater offset requirements in the Paso Robles groundwater basin	Regulated trading initiatives	WR/T	Department of Planning and Building	North America	USA	California	Paso Basin web pages
128	US48	Water Transactions Program	Regulated trading initiatives	WR/T	Klamath Basin Rangeland Trust	North America	USA	Oregon	Oregon WTP web pages
129	US49	Living River Fund	Avoid impacts, bilateral agreements	U/PBA	Water Authority	North America	USA	New Mexico	Living River Fund web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
130	US50	Middle Rio Grande Endangered Species Act Collaborative Program	Avoid impacts, bilateral agreements	U/PBA	Collaborative program	North America	USA	New Mexico	Local Government web pages Middle Rio Collaborative Program
131	US51	Western Water Project	Environmental benefits bilateral agreements	PBA	Trout Unlimited	North America	USA	Montana	Trout Unlimited web pages
132	US52	Shasta River Water Transactions Program	Avoid impacts, bilateral agreements	PBA	Shasta Valley RCD	North America	USA	California	SRT web pages
133	US53	Strategic Water Reserve	Public bilateral agreements	U/PBA and WR/T	Strategic Water Reserve	North America	USA	New Mexico	NM SWR Report
134	US54	The Freshwater Trust Instream Leasing/ Acquisitions	Avoid impacts, bilateral agreements	PBA	The Freshwater Trust	North America	USA	Oregon	FWT Report FWT web pages
135	US55	Upper Kittitas Water Exchange	Avoid impacts, bilateral agreements	PBA and WR/T	Washington Water Trust	North America	USA	Washington	Fortress Washington Water Report
136	US56	Walker Basin Restoration Program	Avoid impacts, bilateral agreements	U/PBA and WR/T	Walker Basin Restoration Program through Bureau of Reclamation	North America	USA	Nevada	Walker Basin Report
137	US57	Walla Walla Exempt Well Mitigation Program	Avoid impacts, bilateral agreements	WR/T	Walla Walla Watershed Management Partnership	North America	USA	Washington	WWW web pages
138	US58	Washington Water Trust Instream Leasing & Acquisitions	Avoid impacts, bilateral agreements	PBA and WR/T	Washington Water Trust	North America	USA	Washington	WWT web pages
139	US59	Agricultural Water Enhancement Program (AWEP)	Avoid impacts, bilateral agreements	U/PBA	Natural Resources Conservation Service-Government-initiative (Public and private partnership)	North America	USA	Nationwide	NRCS web pages
140	US60	Emergency Watershed Protection Program	Avoid impacts, bilateral agreements	U/PBA	Natural Resources Conservation Service-Government-initiative (Public and private partnership)	North America	USA	Nationwide	NRCS web pages
141	US61	Emergency Watershed Protection Program - Floodplain Easement Option (EWP-FPE)	Avoid impacts, bilateral agreements	U/PBA	Natural Resources Conservation Service-Government-initiative (Public and private partnership)	North America	USA	Nationwide	NRCS web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
142	US62	Indiana Conservation Partnership	Environmental benefits bilateral agreements	PBA	Indiana Conservation Partnership	North America	USA	Indiana	Indiana Conservation Partnership web pages
143	US63	Iowa Water Quality Initiative-Benton/ Tama Nutrient Reduction Demonstration Project	Avoid impacts, bilateral agreements	U/PBA	Clean Water Iowa	North America	USA	Iowa	Benton Tama web pages
144	US64	Iowa Water Quality Initiative	Avoid impacts, bilateral agreements	U/PBA	Iowa Water Quality Initiative	North America	USA	Iowa	Clean Water Iowa web pages
145	US65	Minnesota Agricultural Water Quality Certification Program	Avoid impacts, bilateral agreements	U/PBA	Minnesota Agricultural Water Quality Certification Program Advisory Committee	North America	USA	Minnesota	Minnesota DA Water Report
146	US66	National Water Quality Initiative	Avoid impacts, bilateral agreements	U/PBA	Natural Resources Conservation Service-Government-initiative (Public and private partnership)	North America	USA	Nationwide	NRCS web pages
147	US67	Collaborative Forest Landscape Restoration Program - Colorado Front Range	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	Colorado	USFS web pages
148	US68	Collaborative Forest Landscape Restoration Program - Grandfather Restoration	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	North Carolina	USFS web pages
149	US69	Collaborative Forest Landscape Restoration Program - Kootenai Valley Resource Initiative	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	Idaho	USFS web pages
150	US70	Collaborative Forest Landscape Restoration Program - Longleaf Pine Restoration & Hazardous Fuels Reduction	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	Multi-state	USFS web pages

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
151	US71	Collaborative Forest Landscape Restoration Program - Southwestern Crown of the Continent Collaborative	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	Multi-state	USFS web pages
152	US72	Collaborative Landscape Forest Restoration Program - Deschutes Collaborative Forest Project	Multiple benefits partnerships	U/PBA	The Nature Conservancy	North America	USA	Oregon	USFS web pages
153	US73	Colorado Big Thompson Headwaters Partnership	Avoid impacts, bilateral agreements	U/PBA	Northern Water	North America	USA	Colorado	Colorado Research Institute Web Pages
154	US74	Flagstaff Watershed Protection Project	Avoid impacts, bilateral agreements	U/PBA and I/N/EU F	Coconino National Forest/Flagstaff Watershed Protection Project	North America	USA	Arizona	FWP web pages
155	US75	Little Lake Wissota Stewardship Project	Avoid impacts, bilateral agreements	PBA	Lake Wissota Improvement and Protection Association	North America	USA	Wisconsin	Lake Wissota web pages
156	US76	Northern Arizona Forest Fund	Avoid impacts, bilateral agreements	U/PBA and PBA	Salt River Project and the National Forest Foundation	North America	USA	Arizona	National Forest web pages
157	US77	United States Forest Service Watershed Protection Program	Avoid impacts, bilateral agreements	U/PBA	Pueblo Board of Water Works	North America	USA	Colorado	US Forest Service Report World Resources Institute Report
158	US78	Restoring America's Headwaters	Environmental benefits bilateral agreements	U/PBA	National Forest Foundation	North America	USA	Nationwide	National Forest Report
159	US79	Rio Grande Water Fund	Avoid impacts, bilateral agreements	U/PBA and PBA	Rio Grande Water Fund	North America	USA	New Mexico	PNM Resources Foundation Report
160	US80	Scituate Reservoir Water Quality Protection Program	Avoid impacts, bilateral agreements	U/PBA	Providence Water	North America	USA	Rhode Island	University of Rhode Island Report
161	US81	Stormwater In-Lieu Fee Special Purpose Revenue Fund	Avoid impacts, bilateral agreements	PBA and WR/T	Department of Energy and the Environment	North America	USA	Washington	Washington DC Stormwater Report

N°	Code	Scheme name	Governance Model	Funding type*	Programme administrator	Region	Country	Location	Reference
162	US82	Alpine Dairy (formerly Alpine Cheese Company)	Private Trading initiatives	PBA and WR/T	Alpine Cheese Company	North America	USA	Ohio	Ohio State University Presentation
163	US83	Bear Creek Watershed Association	Private Trading initiatives	WR/T	Bear Creek Watershed Association	North America	USA	Colorado	Bear Creek web pages
164	US84	City of Medford Temperature Trading Program	Regulated trading initiatives	U/PBA and WR/T	The Freshwater Trust	North America	USA	Oregon	FWT web pages
165	US85	Connecticut Nitrogen Exchange Program	Regulated trading initiatives	U/PBA and WR/T	Connecticut DEEP and New York DEC	North America	USA	Connecticut	Pace University Report
166	US86	Great Miami River Watershed Water Quality Credit Trading Program	Regulated trading initiatives	WR/T	Water Conservation Subdistrict (WCS) of The Miami Conservancy District (MCD)	North America	USA	Ohio	Miami Conservancy District Report Ecosystem marketplace web pages
167	US87	Lower Boise Effluent Trading Demonstration Project	Regulated trading initiatives	WR/T	Idaho Clean Water Cooperative	North America	USA	Idaho	Idaho Government web pages
168	US88	North Carolina Nutrient Mitigation Program, Division of Mitigation Services	Regulated trading initiatives	PBA and WR/T	North Carolina Nutrient Mitigation Program,	North America	USA	North Carolina	North Carolina Government web pages
169	US89	North Carolina Nutrient Mitigation Program, Nutrient banking	Regulated Trading initiatives	WR/T	North Carolina Nutrient Mitigation Program,	North America	USA	North Carolina	North Carolina Government web pages
170	US90	Ohio River Basin Trading Project	Regulated trading initiatives	WR/T	Electric Power Research Institute	North America	USA	Ohio	EPRI web pages
171	US91	Oregon NPDES Water Quality Trading	Regulated trading initiatives	WR/T	Oregon Environmental Quality Commission	North America	USA	Oregon	Oregon Department of Environmental Quality
172	US92	Pennvest Nutrient Credit Trading Program	Regulated trading initiatives	WR/T	Pennsylvania Infrastructure Investment Authority	North America	USA	Pennsylvania	Pennsylvania Authority web pages
173	US93	Santa Rosa Nutrient Offset Program	Regulated Trading initiatives	WR/T	North Coast Regional Water Quality Control Board	North America	USA	California	Santa Rosa City Offset Program California Government web pages

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174	US94	Southern Minnesota Beet Sugar Cooperative Phosphorus Offsets	Regulated trading initiatives	WR/T	Southern Minnesota Beet Sugar Cooperative	North America	USA	Minnesota	Conservation Fund Report
175	US95	Stormwater Retention Credit Trading Program	Regulated trading initiatives	WR/T	Department of Energy & Environment	North America	USA	Multi-state/ Washington DC	Washington DC Government web pages
176	US96	Virginia post construction stormwater offsets	Regulated trading initiatives	WR/T	State Water Control Board by the Department of Environmental Quality	North America	USA	Virginia	EPA Report Virginia Nutrient Trading Report
177	US97	Water Quality Credit Trading Program for the Lower St. Johns River	Regulated trading initiatives	WR/T	Florida Department of Environmental Protection	North America	USA	Florida	Florida Government Water Trading Report
178	US98	Well Compensation Grant Program	Avoid impacts, bilateral agreements	U/PBA	Wisconsin Department of Natural Resources	North America	USA	Wisconsin	Wisconsin State Government Web Pages

* The following abbreviations categorize the six different types of funding schemes used in this evaluation of payment for watershed schemes:

U/PBA	Utility, public budget allocation
CWL/F	Consumer water levy fees
AESP	Agro-environmental subsidy payments
I/N/EU F	International, National and European Union funding
PBA	Private budget allocation
WR/T	Water rights, trading

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