

Commentary

Can Payment for Ecosystem Services Schemes Be an Alternative Solution to Achieve Sustainable Environmental Development? A Critical Comparison of Implementation between Europe and China

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Abstract: The term “Ecosystem Services” was coined to indicate “all the multiple benefits humans obtain from ‘natural capital’ (i.e., the world’s stock of natural assets—geology, soil, air, water—including living things and beings)” that make human life possible, such as natural water purification, flood control by wetlands, and others. The concept expanded to include, nowadays, socio-economic and conservation objectives, and has been further popularized by the Millennium Ecosystem Assessment (MEA) in the early 2000s, as well as by the “Paris Agreement” reached at the 2015 UN Conference on Climate change (COP21). Payments for Ecosystems (or Environmental) Services (PESs) are financial incentives given directly to landholders to compensate them for implementing good land management, including conservation activities. Such compensation encourages them to “voluntarily” provide (or continue providing) such services, instead of monetizing their “natural capital” otherwise. This approach has been figuratively described as “*making trees worth more standing than cut down*” Examples of important PES schemes, implemented in China and in Europe, are described and analyzed in this paper, focusing on the methods applied, to assess their evolution over time, and attempt to identify which solutions could be most effective.

Keywords: environmental services; ecosystems; compensation; Payment for Ecosystem Services; biodiversity; economic value

1. Introduction

In the past fifty years, humans have impacted ecosystems more rapidly and extensively than in any comparable period in human history, with considerable loss of species and ecological functions. Loss of biodiversity at such unprecedented rates also causes many previously available Ecosystem Services to rapidly deteriorate [1]. The term “Ecosystem Service” (ES) was initially coined to indicate “all the multiple benefits humans obtain from ‘natural capital’” (i.e., the world’s stock of natural assets—geology, soil, air, water—including living things and beings) that make human life possible, such as natural water bodies self-purification, flood control by natural riparian zones/wetlands, soil erosion control and hillside protection by afforested areas, etc. [2]. Another definition of ES may be “the direct and indirect contribution of ecosystems to human well-being” [3].

Since its introduction in the 1970s [4], this concept has continued to expand, and nowadays includes socio-economic and conservation objectives, and has been further popularized by the Millennium Ecosystem Assessment (MEA) in the early 2000s [5], as well as by the “Paris Agreement” reached at the 2015 UN Conference on Climate change (COP21) [6], recognizing ESs roles in mitigating climate change. ESs were initially grouped into four broad categories: provisioning (production of

food and water), regulating (control of climate and disease), supporting (nutrient cycles and crop pollination) and cultural (spiritual and recreational benefits). The European Environmental Agency (EEA) recently supported a re-classification of ecosystem services (CICES—Common International Classification of Ecosystem Services) in an attempt to be more comprehensive than MEA and TEEB (The Economic of Ecosystems and Biodiversity) classifications [7].

Ecosystem-embedded capital and its flows are, generally, still poorly understood. To help decision-makers in reaching informed choices, many ESs have been assigned economic values, by attempting to correlate current-versus-future costs and benefits, organizing and translating scientific knowledge into economics, and articulating the consequences of societal choices in comparable units of impact on human well-being [8,9].

While, as pointed out by Salles [10] “*the total value of biodiversity is infinite, so having debate about what is the total value of nature is actually pointless, because we can’t live without it*”, the underlying idea of value assignment is that some trends may reveal aggregative preferences of society, from which economic value of services could be inferred and assigned [11]. Six major methods for valuing ESs in monetary terms are:

- (1) *Avoided costs*: ESs allow society to avoid costs that would have been incurred, in the absence of those services (e.g., self-depuration of water pollution by natural mechanisms in wetlands/water bodies that ought to be replaced by constructed treatment plants).
- (2) *Replacement costs*: ESs could be replaced with man-made services, at a cost.
- (3) *Missed income*: ESs may provide an enhancement of income to landowners or people earning their living from environmental resources (e.g., improved fisheries productivity and higher recreational opportunities).
- (4) *Travel costs*: Satisfaction of ESs demand by users may require travel, whose costs can reflect an implied value of the service (e.g., the value of ecotourism is *at least* what a visitor would be willing to pay to get to a specific location for that purpose).
- (5) *Hedonic pricing*: ESs demand may be reflected in the prices people will pay for associated goods (e.g., coastal/river or lakeside real estate prices usually exceed that of inland homes).
- (6) *Contingent valuation*: ES demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives (e.g., visitors willing to pay for access to national parks/reserves).

Costanza et al. [12] provided estimates of ESs and land use changes to assess the global magnitude of eco-services (Figure 1). Their assessment was that ESs had a global worth US\$ 125 trillion/year in 2011, and that their accrued loss from 1997 to 2011 due to land use modification/degradation reached US\$ 20.2 trillion/year. These values reveal the astonishing impact of ESs on global economy, especially when compared with the World Bank estimate of the 2010 nominal GWP (Gross World Product) at approximately US\$ 62.2 trillion [13]. Global Ecosystem Services magnitude is thus estimated equal to roughly twice the GWP and, more importantly, their loss due to (mis)management of the natural capital is equivalent to one third of the annual GWP.

Within this reference framework, Payments for Ecosystems (or Environmental (the two terms Ecosystems and Environmental are often freely exchanged, with the same meaning, when talking about the PES concept)) Services (PESs) are financial incentives given directly to landholders to compensate them for implementing good (or comparatively “better”) land management, including conservation activities, to “voluntarily (voluntarily in this case does not imply “freely” or “without a return”)” provide (or continue providing) certain required (by private or public entities, as explained later) services instead of monetizing their “natural capital” otherwise. This mechanism has become one of the most popular market-based instruments around the world, defined as “*a transparent system for the additional provision of environmental services through conditional payments to voluntary providers*” [14]. A PES usually covers a situation that is not otherwise regulated (or is regulated unsatisfactorily for the buyer) by applicable environmental national/local rules, and may be very useful where relatively small financial incentive can stimulate significant desired changes [15].

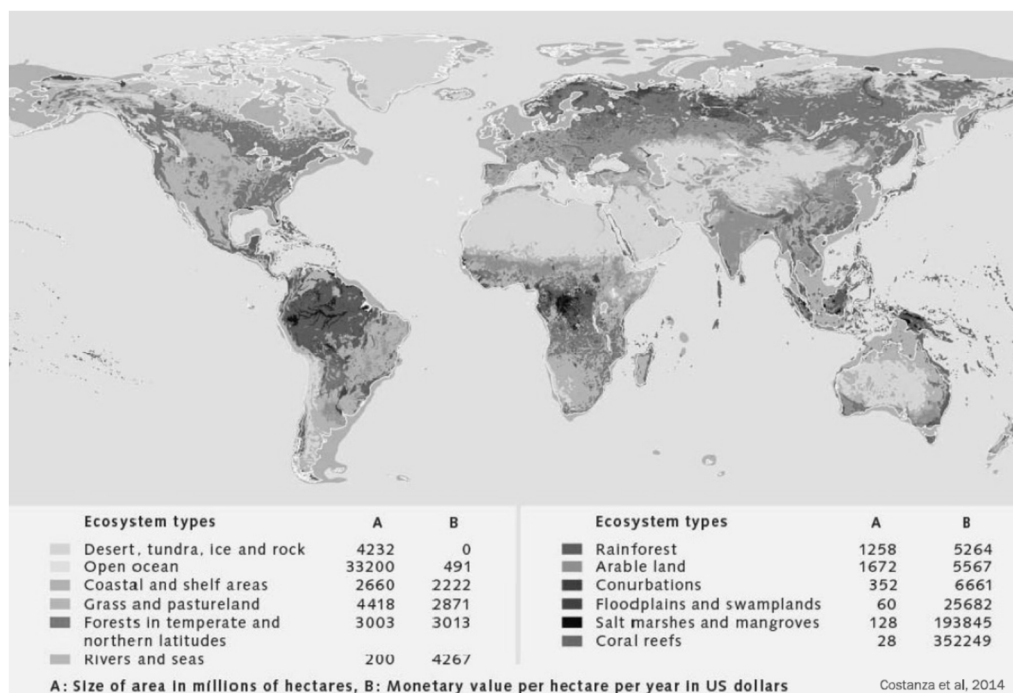


Figure 1. Global estimated monetary value of ecosystems (from [12]).

Compliance PESs provide a way for certain parties bound by regulatory obligations to compensate others for similar activities aimed at maintaining or enhancing comparable ESs, in exchange for a standardized fee. This includes, for example, water quality trading, wetlands mitigation schemes, and the perhaps more familiar EU emissions trading scheme for greenhouse gases (GHGs). Several examples of important PES schemes exist in Asia, Europe, Latin America and Africa and have been widely studied and analyzed. The watershed management sector is today the most developed in terms of economic value (about US\$ 24.7 billion, in 62 countries, in 2015) [16]. Currently, almost 400 watershed PESs are running, almost equally split between privately and publicly financed. Figure 2 represents the geographical distribution of watershed-protections PESs in 2009 [16].

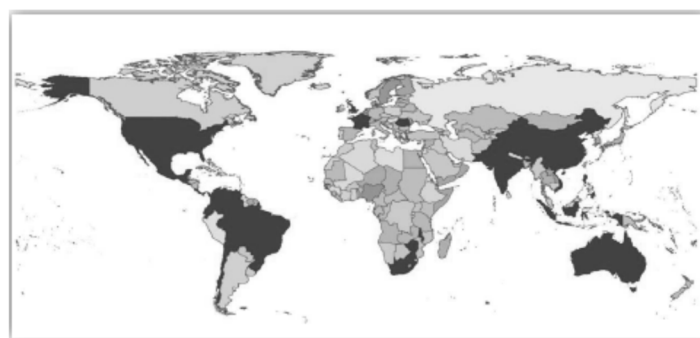


Figure 2. Countries adopting watershed-protection PESs in 2009 (dark areas). Other grey areas indicate PESs schemes adoption in other, non-water related contexts [16].

In this paper, examples of PES cases in Europe and in China are illustrated, focusing on the methods applied, trying to determine their evolution over time, and attempting to establish which solutions are most effective.

2. PESs “101”

As previously mentioned, Payments for Ecosystem (or Environmental) Services are instruments through which beneficiaries of such services reward providers, financially or in-kind, through “voluntary transactions” with at least:

- One well-defined environmental service (e.g., land management to avoid groundwater contamination);
- One buyer, or user (e.g., a town using that groundwater); and
- One provider, or seller, distinguished from the former (typically a landowner, or group thereof).

The main goal of these instruments is to make conservation attractive to private and communal landholders (*service providers*) from an economic perspective, by internalizing the positive externalities attached to the conserved resources [15]. For PESs to work, the scheme should be more cost-effective than alternative mechanisms (e.g., strict regulatory enforcement, or artificial provision of that service), and transaction costs ought to be manageable. Typically, PESs can be very useful where relatively little additional incentive can stimulate buyer-desired changes. For them to be effective, proper monitoring is needed, as well as enforcement of sanctions for contractual non-compliance on the part of the provider.

Assuming that the instrument will actually deliver the intended results, it is important to evaluate how much of this will occur because of the introduction of the payment, and to what degree this could have eventually happened anyway, to avoid making payments for nothing, or paying for the adoption of practices that, while being beneficial to the provider himself, would have been adopted in any case. PESs should not be applied to situations where the entire outcome is mandated by environmental regulations, but could be applicable where a small intervention in excess of that mandated by law, could provide significant benefits for a subject (buyer) willing to pay for them. Permanence (whether the program could improve ESs provision in the long run, even after payments have ceased), and side effects (negative (“leakage”) or positive (“spillage”) externalities in areas outside of the program’s specific domain) must be also considered.

PESs can be classified based on different aspects (more than one can apply):

- (1) *Service provided*: Carbon sequestration; biodiversity protection; watershed protection; landscape beautification.
- (2) *Source of financing*: Fund-based approaches; market-based approaches; phased approaches.
- (3) *Stakeholders involved*: Buyers could be user-financed (private/public users, firms, Non Governmental Organizations (NGOs)) or third-parties (governments, international agencies). Sellers (providers) could be private landowners/land users (individuals or private conservation groups), communal landowners (farmers living in communal land), informal occupiers of public lands, or NGO’s managing protected areas. Intermediaries and facilitators could be groups or institutions bridging the gap between service providers and buyers (such as NGO’s, donors, government groups, academic sector, trusts and user associations).
- (4) *Time scale*: Short-term or long-term commitment and implementation are possible.
- (5) *Geographical scale*: Local or global (for public good benefits) or local, national, international (for specific relevant services).
- (6) *Payment*: Ex-ante, ex-post, or iterative, continuous, dependent on service provision, or at fixed times to support transitions to improved practices. Payment can occur in kind, in cash, or as a combination thereof.

Usually, in public projects, the State (or local Governments, or NGOs) acts on behalf of ESs buyers through general budgets (taxes, fees, grants from international institutions or ad hoc donations) paying providers directly for agreed-upon services. In private schemes, the user can be a private company paying providers for the service (as in Vittel’s case analyzed later). Particular examples of private financial schemes include those in which revenues (i.e., taxes, fees, or profits from tourism) in the PES-affected area are used for financing the program itself.

From an efficiency point of view, the buyer of a PES scheme would want to compensate enough (although not necessarily all) providers to form a resilient conservation alliance. A typical PES problem is that, to be considered “fair”, it would have to compensate all the losers (e.g., landowners that stand to *not* gain their fair share from the scheme), and most times this would be prohibitively expensive. Whom exactly to compensate is a question of negotiation, political feasibility, legality and possibly also ethics, since some parties may lose illegal revenues, corruption payoffs, and iniquitous profits [17]. Payments should be applied strategically in those cases where additionality of the program effects can clearly be demonstrated (Figure 3). It is important to remember that payments are not done for the ecosystem itself but for a change in its delivered quantity and quality of services.

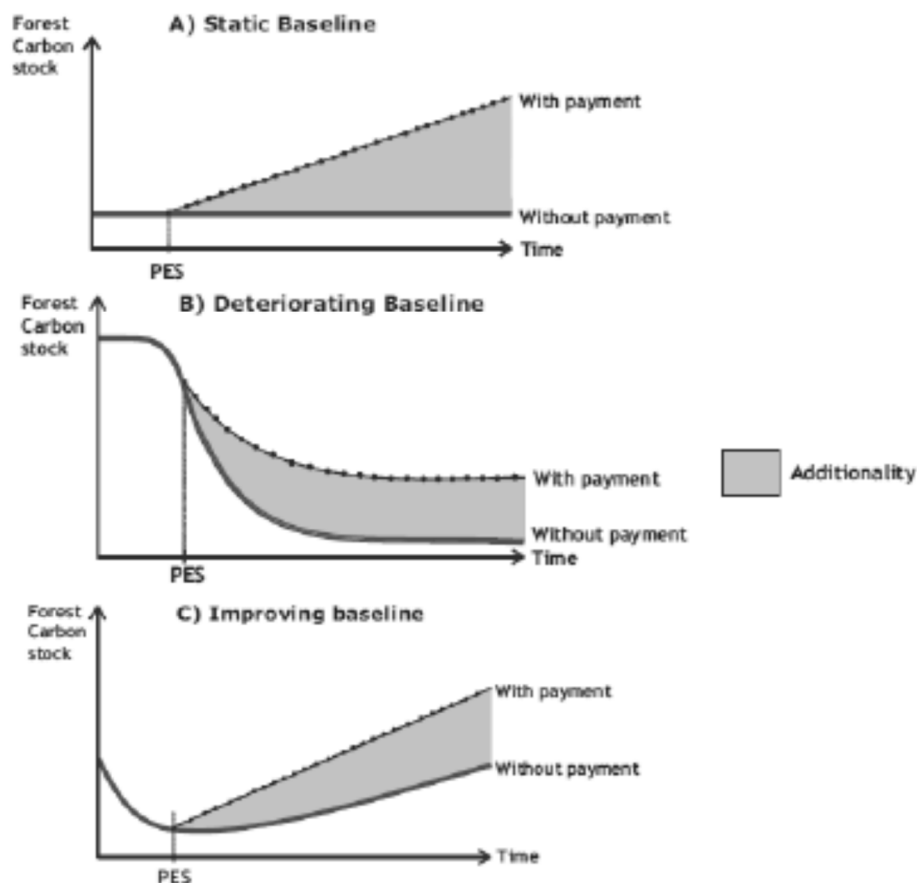


Figure 3. Different types of ESs baseline, additionality and response in PESs applications.

Effectiveness and efficiency of PES programs depends on how successful they avoid leakage, ensure additionality, and minimize waste of resources. To evaluate that, they need to be consistently monitored and evaluated for service delivery and for distribution of benefits, in accordance with the initial agreement between buyers and providers. Third-party assessment may also be required to ensure a program is meeting its objectives. A counterfactual baseline is needed to understand what would have happened in the absence of a program. Definition of this baseline has an enormous impact on the evaluation of any PES project. It determines how additionality is measured, and helps establish the fair value of compensation to providers [18]. The baseline can be static (no foreseen improvement in ES without intervention), deteriorating (degradation of ES without intervention) or improving (improvement of ES even in the absence of intervention). In all cases, a PES is justified if it improves expected ES performance compared to expectations, as illustrated in Figure 3.

3. European Cases Studies

In Europe, examples of PES considered as voluntary payment for an Environmental Service are not very common, since rights and duties of the parties involved are generally fixed by very precise environmental regulations, not by two-party contracts. However, some examples of such schemes in Europe exist and will be described, to highlight developments in the techniques used. One scheme, in Western Europe, is old (1990s), while more recent schemes are from former Eastern-European Countries where stringent environmental legislation was implemented not long ago, mostly during their accession to the European Union.

3.1. The Vittel Case (North-Eastern France, 1992)

The internationally renowned Vittel mineral water originates at the “Grande Source” (“Great Spring”) located in the town of Vittel at the foot of the Vosges Mountains in north-eastern France. Water comes from a 6000 ha aquifer 80 m below the ground, and is lifted naturally to the surface through a natural geological fault.

Vittel water is labeled and sold as “natural mineral water”. This implies that it must come from a well-protected, specific underground source. Its composition must be stable in time, and the water must be bottled at the source. Vittel water is characterized by a total absence of nitrites and a particularly low level of nitrates, which have strongly influenced its commercial success.

In the early 1980s, the de la Motte family, then owner of the Vittel brand, realized that agricultural intensification in the Vittel catchment posed a risk to existing low nitrate and pesticides level at the Grande Source, and consequently to the brand itself, should they continue rising. Specific studies of the aquifer area had shown that increased nitrate levels were caused primarily by heavy leaching of fertilizers from barren maize fields in winter, and overstocking and poor management of animal waste [19,20].

Since French legislation prohibits any process treatment of Natural Mineral Water-labeled products (apart from the elimination of naturally unstable elements, such as iron and manganese), the company, after a comprehensive evaluation of different possibilities, decided to offer incentives to farmers to voluntarily change their ongoing practices. Farmers were invited to participate in the preliminary study action program and work with Vittel researchers to identify acceptable conditions for a new set of farming procedures that would be compatible with both their crops and cattle, and with Vittel’s objectives of product quality assurance. Ten years were necessary to complete the bargaining process, and convince all farmers in the area to adhere to it. The negotiated levels of compensation could not be set lower than the opportunity cost of change for the farmers, plus enough additional amounts to provide a strong incentive for practice modification. At the same time, its upper limit was the opportunity cost to the buyer, or in other words, the value of Vittel water linked to its persisting qualities.

Ultimately, a package of incentives was agreed upon, including: long term investment protection (18- or 30-year contracts to farmers); partial land acquisition directly by Vittel (left in use to farmers for up to 30 years); an initial five-year subsidy (about 200 €/ha/year) to ensure providers a guaranteed income during the transitional period, and up to 150,000 € per farm to cover the cost of new suitable farm equipment for modernization; and free labor to apply compost and fertilizers in farmers’ fields according to suggested practices (needed to address a labor bottleneck and ensure application of optimally calculated amounts for each plot), and free technical assistance to individual farmers.

By 2004, all 26 farms in the area had adopted the new farming system; 1700 ha of maize were eliminated, and 92% of the sub-basin was eventually protected. This privately funded PES scheme was a success: the same goal could not have been achieved under applicable legislation, and the case still constitutes a perfect textbook example of a PES implementation between a private buyer and a group of independent providers.

3.2. Case study Lonjsko Polje, Croatia

The Lonjsko Polje area, covered by grassland, arable and forest areas, hosts one of the largest remaining naturally-inundated areas in the Danube River catchment. The area has a significant potential for eco-tourism and recreation. Land abandonment is particularly strong in local grassland and forest areas, where traditional, labor-intensive land management practices related to maintenance of pastureland (e.g., grazing and mowing) are becoming less and less popular among farmers. Modern agricultural practices, partly intensive in terms of fertilizer loads, have limited negative effects on biodiversity, their intensification could lead to drastic changes for habitats and species, due to the loss of (semi)natural ecosystems and destruction of landscape elements crucial for biodiversity [21].

The Lonjsko Polje project investigated the use of PES as an incentive to avoid land abandonment and loss of traditional management practices, with the final goal of maintaining biodiversity (and related ESs), and avoiding further intensification of maize and wheat production. Opportunity costs were calculated for grassland (using maize intensive farming as a benchmark), arable areas and forest. During the study, it was determined that land abandonment in Lonjsko Polje was more a social than an economic issue. Younger generations moved from the countryside to the closest urban areas for social and cultural reasons, as they found urban life and related opportunities more attractive. In this case, offering PES for maintaining existing agricultural practices may not have been sufficient, alone, to reverse the negative trend.

A preliminary study tried to estimate how much of a payment would have been necessary to make grassland farming practices more attractive. A PES ranging from 200 to 900 €/ha was calculated, under the assumption that, if a more biodiversity-friendly practice was slightly more profitable than intensive ones, a farmer would opt for the former [22]. A slight mark-up was then added to the estimated income from intense practices: 10% for keeping the existing practice, or 15% for also introducing organic methods—to further promote biodiversity-friendly options.

Information on existing agricultural subsidies was compared to PES calculations in an attempt to identify financing sources for the scheme. In some cases, agricultural subsidies already in place seemed sufficient to cover most or all of the proposed PESs. For instance, subsidies for organic farming of maize and wheat (400 €/ha) were far above the suggested payment identified in this study (about 200 €/ha), showing that financial resources could be available for promoting this type of practice. The scheme proved to be successful upon implementation.

3.3. Case Study Oas-Gutai Plateau Area, Romania

The Oas-Gutai Plateau, situated in the Northwestern Carpathians (Maramures County), is characterized by high natural biodiversity, scenic landscapes and unique cultural heritage. The existing ecosystems provide several services that support human wellbeing in the area, including: retention and filtration of fresh water, prevention of soil erosion and flooding, tourism and recreation. One of the largest peat bog formations in Romania is present in the area, and plays an important role in supporting natural carbon sequestration, and mitigating climate change [23].

Increased overgrazing of grasslands in proximity to villages, and gradual land abandonment in less accessible areas were threatening existing conditions. Continuation of traditional farming practices would be crucial in assuring conservation and related ESs, therefore the goal of the program was to explore the suitability of PES schemes to support such continuity in the area.

As in the previous case, socio-economic reasons were the main cause for land abandonment. Estimated opportunity costs for keeping current extensive practice, instead of switching to intensive ones, allowing only partial abandonment ranged from 200 to 330 €/ha. The assumptions behind these calculations were that applied PES should be enough to guarantee farmers an income comparable to that of otherwise more profitable intensive practices. To further encourage farmers preference of extensive practices over intensive ones, a 10% mark-up was added to this figure, on top of the opportunity cost. The foreseen PES ranged from 261 €/ha to 359 €/ha for keeping less intensive practices (grazing or mowing), and from 232 €/ha to 326 €/ha for reducing abandonment. Government

subsidies promoting Good Agricultural and Environmental Conditions (GAEC) were already available, but were insufficient to completely cover the costs of the scheme. Additionally, in this case, economic incentives alone might not have been sufficient to prevent land abandonment—since additional cultural and social implications influenced the farmers’ decision making. Therefore, other supporting measures should have been introduced to complement the scheme, however they were never implemented.

3.4. “Sustainable Catchment Management Programme”, UK (2005–2010)

The Sustainable Catchment Management Programme (SCaMP) was created to secure proper management of two key inland areas (20,000 ha in total) supplying a large portion of drinking water to 7 million people in the northwest of England. Much of this area was of high conservation importance, dominated by upland moorland, farmed primarily for sheep, cattle grazing, and woodlands, mix of native forest and conifer plantations. The intervention area included 45 land holdings and two farms, with the former economically marginal, depending on agro-environment payments for survival. This land also supported extensive recreational uses, with much of it having high scenic value [24]. Like many upland areas in Britain, much of the land in the SCaMP consisted of peaty, wetland soils. These retain, filter and clean rainwater, releasing it gradually into local reservoirs and rivers. Thus, a major “use” of the land was to gather water for human consumption. In addition, peat soils could store huge quantities of carbon. Significant ecological values were therefore at stake, associated with the role of SCaMP land in regulation of rainfall and greenhouse gases. Key ESs provided by the area included:

- a. Water supply, including both quantity and quality regulation;
- b. Recreation, including general outdoors and associated economic activities;
- c. Farming and associated economic activities (dairy, etc.);
- d. Greenhouse gas mitigation; and
- e. Biodiversity conservation.

Objective of the program was to develop an integrated approach to catchment management, incorporating sustainable upland farming with the aim of delivering:

1. Government targets for SSSIs (Sites of Special Scientific Interest);
2. Biodiversity plans for priority habitats and species;
3. Improved raw water quality; and
4. Viable living for tenant farmers.

This was achieved by entering into long-term agreements with tenant farmers to develop farming plans compatible with those objectives. The main activities undertaken by the program included:

- i. Blocking drainage ditches to re-flood drained peat bogs, creating new habitats for wildlife;
- ii. Restoring areas of eroded and exposed peat and moorland;
- iii. Re-establishing woodlands by planting new trees and replacing timber harvest with native species;
- iv. Providing new waste management facilities to reduce run-off pollution of water courses; and
- v. Fencing areas to keep livestock away from protected areas near rivers and streams, and from special designated habitats.

United Utilities (UU), one of UK’s largest listed water and utility companies and a major landowner in the northwest of England, was a leading SCaMP’s lender, working in association with the Royal Society for the Protection of Birds (RSPB), local farmers and a wide range of stakeholders. The program ran from 2005 to 2010.

Protecting and improving water quality was one of the main aims of this intervention program, although this was the least certainly quantifiable in terms of timescale, as it would be a by-product of habitat improvement. UU, working with farmers to develop individual farms plans, identified

environmental restoration steps required to improve habitat status, changes in farming practices required to secure restoration, and modifications to farms' infrastructure to allow execution of the proposed practices. Plans were also based on giving tenants the best opportunities to access high level agro-environmental support grants, ensuring that they were both environmentally and economically sustainable. Costs of SCaMP activities were split between UU own funds (£9 m) and public support contributions (£3.5 m). SCaMP's final success was probably in large part due to UU's own large land-holdings, and to the clear link between ESs and expected benefits.

3.5. Some Considerations on European Case Studies

For each PES project previously reviewed, a radial graph was drawn, in which a value from 0 to 10 was assigned to each main ES affected by the project (Figure 4). An ES assigned a value of 0 was not involved in the PES scheme (i.e., the PES not only was not designed to specifically protect that ES, but also had no influence on it). On the opposite side, an ES given a value of 10 was totally involved in the PES scheme and the scheme itself was designed to improve it. An intermediate value means that the ES was involved/affected to a lower or higher degree, depending on local priorities. The bigger is the area enclosed in the graph, the bigger was the spectrum of action of the project on the environment as a whole. Figure 4 shows the graphs for the four EU case studies reviewed.

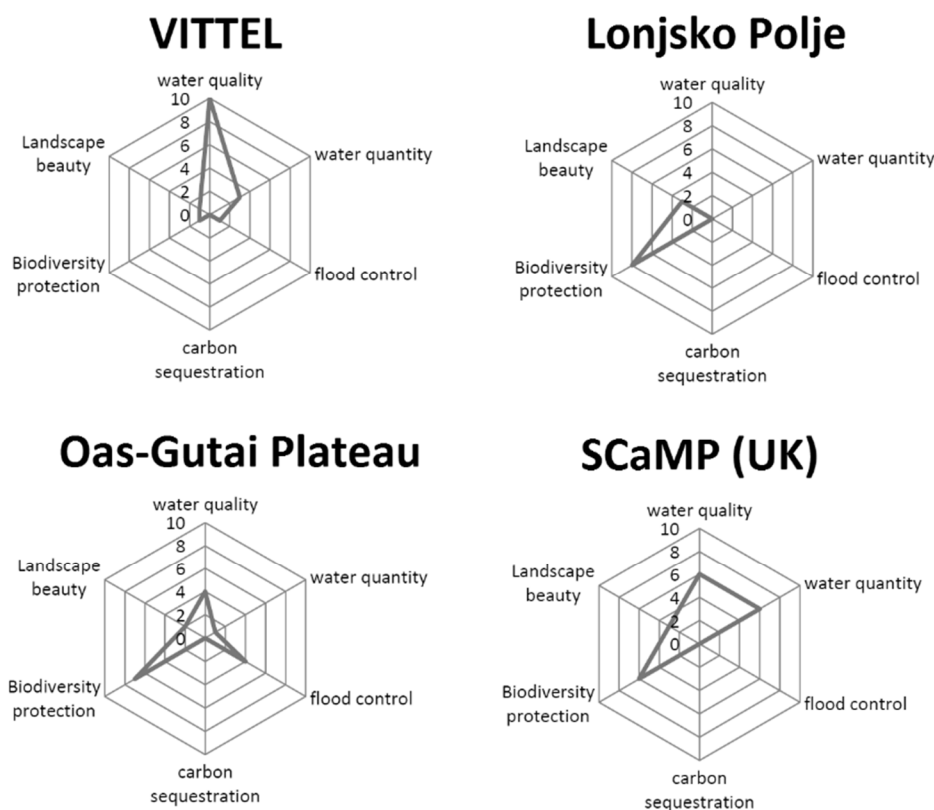


Figure 4. Representation of the Environmental Services addressed by four PES schemes in EU.

The SCaMP and Vittel PES schemes had the highest overall impact on the environment, even though the former did not address *primarily* any of the ESs (water quality, biodiversity and water quantity are only affected, at an intermediate level: scores = 6), while the latter was almost completely focused on maintaining aquifer water quality, with minor impacts on water quantity, flood control, and biodiversity. The Lonjsko Polje and Oas-Gutai projects had lower quantifiable impacts on ESs although they may have had a major social component, not addressed in the above graphical

description, concerning the resident population. In all cases farmers appeared as service provider in the projects, whether publicly or privately funded.

Social processes involved in the provision of ESs also have benefits on their own, allowing to maintain cultural practices otherwise destined to extinction. These could perhaps be seen as “positive externalities” of the Lonjsko Polje and Oas-Gutai Plateau projects, although their quantification may be subject to high uncertainty. It should be noted that the provision of ESs could benefit individuals (including individual wellbeing) and society as a whole beyond those services herein considered, to which however may be more difficult to assign economic value. Other PESs cases, not described in this paper, have been run/proposed in EU and neighboring States [25–28]. All of them have objectives and characteristics that are very similar to the ones herein mentioned.

4. Chinese Case Studies

The Chinese word indicating “eco-compensation mechanisms”, the local equivalent of PESs, is “*shengtai buchang jizhi*” (生态补偿机制). This encompasses PES-like agreements involving direct government payment to individuals or communities that agree to supply specific ecosystem/environmental services, as well as policies involving various governmental levels or institutions in developing cooperation agreements intended to finance and share environmental protection projects and related restoration costs.

In the last 30 years, Chinese policymakers have devised new approaches to implement environmental sustainability policies that address the many challenges present in the country as a consequence of its fast economic growth, while trying to avoid governmental resources constraints. Since the early 1980s, the Ministry of Water Resources contracted out the management of fragile lands in small watersheds directly to private households, with limited success [29]. These initiatives were later embodied in the Water and Soil Conservation Act of the P.R.C. (1991), one of the first pieces of legislation introducing market schemes into watershed management. As a consequence of this initial experiment, both central and local governments have gradually expanded the application of these policies and programs, under the general concept of “eco-compensation” projects, laying the basis for the further development of an internal ESs market. State Council release 39 “State Council Decision Regarding Using the Scientific Development View to Strengthen Environmental Protection” of 2005, says explicitly that government “... *should improve eco-compensation policy, and develop eco-compensation mechanisms as quickly as possible*”. China’s 11th Five-year Guidelines (2006–2010) called for environmental policy innovations, with development of test projects to accelerate eco-compensation mechanisms development, promote watershed-oriented or intra-regional eco-compensation mechanisms, and improve issues regarding conservation funding at different levels. China’s Ministry of Environmental Protection (MEP) issued as a response its “Guiding Opinions on the Development of Eco-compensation Pilot Work” [30], identifying four main areas of focus for the development test sites: (i) nature reserves; (ii) key ecological areas; (iii) mine activities developments; and (iv) riverine watersheds.

The Chinese government is already promoting some of the largest PESs in the world, with more than US\$90 billion in existing or planned schemes and market-based programs [29]. Local governments in China have also been important contributors to this process, rapidly adapting centrally designed “eco-compensation” programs to their own needs. The result is a highly diversified combination of initiatives and programs that attempt to incorporate market concepts in environmental projects at national, county and municipal levels.

The range of programs includes every possible ES, but most of them are targeted to improve water quality and quantity, to control soil erosion, and to promote eco-agriculture. Public interest about improving effectiveness and efficiency of these efforts, and of their and financial sustainability is high, and many administrations are exploring ways to expand market-based tools and regulatory innovation to improve addressing the country’s China’s challenges. Some examples of PES schemes in China will be illustrated herein.

4.1. Conversion of Cropland to Forest and Grassland Program (CCFG) (1999)

The idea of a Cropland Conversion Program was under evaluation by China's policymakers for a long time. Only after a severe Yellow River drought in 1997, and devastating floods in 1998 in the Yangtze River Basin and Northeast China did they finally decide to implement it. The CCFG Program (also known as "Sloping Land Conversion Program—SLCP" or "Grain for Green") has been the most important national Chinese government's eco-compensation effort, involving direct individual farmers' compensation. It was one of the first and certainly the most ambitious PES programs in China, and the largest land reforestation program in the developing world, with a goal of converting 14.67 million hectares of cropland to forests by 2010, and an additional "soft" goal of afforesting wasteland of roughly equal area at the same time. The plan stipulated that retirement of cropland was to take place until 2010, with the subsidy period ending in 2017.

CCFG was initiated with the stated environmental goals of reducing soil erosion and desertification, and increasing China's forest cover area by retiring steeply sloping and marginal lands from agricultural production. The program was implemented in more than 2000 counties across 25 provinces and involved the participation of tens of millions of rural households, with a total initial budget of RMB 337 billion.

The program targeted a wide array of ESs. Upper Yangtze and Yellow River Basin watershed services were the main focus of the program. CCFG also aimed to alleviate poverty and assist farm households in shifting to more sustainable production approaches. Targeting areas to be retired was conducted using a top-down approach, starting with quotas distributed from the central government to the provinces, followed by subsequent distribution down through counties, townships, and finally to participating villages. Subsidies were given both in cash and in kind. The program stipulated that farmers who converted degraded and highly sloping cropland back to "ecological forests" (timber-producing forests), "economic forests" (orchards, or forests with medicinal value) or grassland would be compensated with: in-kind subsidies of grain, cash subsidies, and free seedlings. All income derived from forests and grasslands planted as part of the program was to be exempt from taxation.

Program compliance was defined in terms of quality, type and survival rates of the trees/grass planted on the enrolled land, with survival rates adjusted for regional conditions. An additional stipulation was that, in conjunction with cropland retirement, a set proportion of wasteland was also to be afforested, though without survival rate conditions. Compliance was monitored through inspections conducted by various levels of government.

4.2. Natural Forest Protection Program (NFPP) (2000)

Similar to the CCFG Program, the NFPP started following major flooding events in the upper and middle Yangtze River, and in the Songhua and Nen Rivers (Northeast China) watersheds, which were subject to over-logging of state forest areas in previous years. A pilot phase was carried out from 1998 to 2000, while full implementation occurred from 2000–2010. NFPP encompassed forest areas in over 160 forestry departments, including 734 counties and 17 provinces in the upper Yangtze River watershed, the upper and middle Yellow River watershed, northeast China and Inner Mongolia. The natural forest areas covered by the NEPP were 73 million m², accounting for 69% of the country's total area. The total program budget was RMB 96.2 billion. The plan's ultimate aim was restructuring the state forest sector, emphasizing economic and environmental sustainability of forest resources management, for both timber production and ecological conservation. The main goals of the project were to:

- effectively protect existing forests;
- reduce consumption of forest resources;
- reduce commercial harvesting of timber;
- increase forest cover rate;

- reposition and/or lay off redundant forest workers, with adequate compensation; and
- change the production structure of forestry enterprises so they would become environmentally and economically sustainable.

For the implementation of these goals, the program stipulated payments (subsidies) by the government to participating administrations and local authorities for environmental and social tasks. Forest management labor was paid, in addition to subsidies for afforestation/reforestation tasks in the watersheds involved. Social expenditure was included in program areas, for re-education, public security and health costs, in variable ranges according to the actual area. One-time settlement for laid-off workers was set at 300% of the previous year's average annual salary.

4.3. "Paddy to Dryland" Beijing City-Hebei Province (2005)

In 2005, Beijing and Hebei Province developed a cooperation framework concerning water protection of two reservoirs in Miyun and Guanting, to ensure the quality and quantity of Beijing's water supply coming from those two regions (80% of the city's drinking water). The plan consisted of the conversion of over 10,000 ha of water-demanding rice paddies to lower water-use crops such as corn and other dryland crops. This conversion occurred over two periods (2005–2008 and 2008–2010). As part of the arrangement, annual "income loss" subsidies were foreseen for participating farmers (at the rate of RMB 6750/ha). At the same time, the water resources department assisted participants in adopting improved farming conditions and develop water-saving agricultural practices.

4.4. Min River Watershed Eco-Compensation (2005)

The Min River is the largest river in Fujian Province. The Min River Watershed Protection Special Fund Management Measures, initiated in 2005, was the response from the Fujian Environmental Protection Bureau to observed water quality problems. Implemented during the 11th Five-year Guidelines (2006–2010) period, the program followed the principle "The polluter pays, the beneficiary compensates."

The program covered 36 counties and municipalities in the Min River watershed. Cities in the lower Min watershed provided upper watershed cities (Nanping and Sanming) with an annual, special-purpose, ecological environment protection fund of RMB 10 million. Upper watershed cities, in turn, paid a fee of RMB 5 million annually to run the program, under the principle that local matching funds should be provided. In addition, if upper watershed areas created pollution affecting lower areas, they were held liable for additional compensation. Fujian Province's DRCEPB (Development and Reform Commission and Environmental Protection Bureau) earmarked RMB 15 million per year for introducing integrated management throughout the entire watershed. Polluting industries and cities had to pay compensatory environmental protection fees, based on ascertained damages.

4.5. Dongjiang Headwaters Eco-Compensation (2005)

The Dongjiang (jiang means river in Chinese) is a tributary of the Pearl River, and the most important water source to Guangzhou, Shenzhen, Dongguan, and Hong Kong, with an average flow of 29.7 billion m³/year. Over 80% of Hong Kong drinking water comes from the Dongjiang [30].

This Eco-compensation program aimed to protect the river source areas, and included nine other sub-programs:

- Ecological forest creation, giving priority to hillsides forestation, Grain for Green and shelter forest improvement in Pearl River (a continuation of the CCFG program);
- Prevention and control of soil erosion;
- Ecological rehabilitation of mining sites;
- Development of eco-friendly agricultural practices;
- Flood control and drinking water development: obstacle clearing in the river channel, and tap water sanitation;

- Development of integrated agricultural/rural non-point pollution control;
- Development of eco-tourism;
- Assistance for eco-migration (i.e., compensating the resettlement of households, away from fragile ecosystems); and
- Implementation of a system for environmental monitoring and related information management.

Interventions for pollution control included: a ban of wood-processing industries from riverhead areas, and the closure of more than 20 paper-making and 300 rare-earths enterprises in the watershed. The objectives included improving water quality, increasing forest cover and integrated soil erosion prevention areas.

Jiangxi Province invested RMB 14.2 billion during the first implementation period, from 2005 to 2010. This eco-compensation mechanism will be in place until 2025, with funding from central, provincial, municipal and county sources.

4.6. Beijing Organic Fertilizer and Safe Pesticide Subsidies (2007)

The program, started in 2007, promotes the use of safer pesticides and organic fertilizers in agriculture. Two schemes, the “Pesticide Use Subsidy” and the “Empty Bag Recovery”, foresaw that, as long as farmers used safe pesticides and/or organic fertilizers as recommended by the responsible authorities, the government would give them a corresponding subsidy.

The government of Beijing City earmarked RMB 20 million for the program, at a rate of RMB 250/ton, so that farmers participating in the program only needed to pay the balance towards the cost of pesticides/fertilizers, or about RMB 150/ton. The subsidies were not actually paid in cash, but rather as refund to a bank account. By returning a bag to the original place of purchase, farmers who signed up for the program were refunded 70% to 80% of the initial cost via direct transfer to their account, up to a maximum of 1800 RMB/ha. In 2009 the program was implemented on over 13,000 agricultural ha in 13 counties, 104 townships and 483 villages in the Beijing Municipality, with technical support provided by a service staff of 30 people. Table 1 summarizes these, and other PES schemes funded in China (sources [29,30]).

Table 1. Summary of reported PES case studies in China.

Name	Province	Start Year	ESs Involved	Source of Funding	Service Provider	Type of Payment	Duration
CCFG	Entire China	1999	Landscape protection, Carbon storage, Watershed protection	Central Government	Farmers	Cash and kind	10–18 years
NFPP	NE China	2000	Afforestation (flood protection), Landscape protection	Central Government	Local forest authority	Cash	10 years
Beijing Org. Fertilizer and Safe Pesticide	Beijing	2007	Green and organic Agriculture	Beijing Government	Farmers	Cash and kind	ongoing
Paddy to Dryland Beijing-Hebei	Hebei	2005	Watershed protection (quantity and quality)	Beijing Government	Hebei farmers	Cash and kind	5 years
Min River Watershed Eco-comp.	Fujian	2005	Watershed protection (quantity and quality)	Fujian Government, watershed cities, polluter industry	Nanping and Sanming cities	Cash	5 years
Dong River Watershed Eco-comp.	Jiangxi	2005	Watershed protection (quantity and quality), landscape protection	Central, provincial and local Governments	Farmers and mine owners	Cash	5 years

4.7. Considerations on Chinese Case Studies

Although following the same implementation foundations, eco-compensation in China embraced broader concepts than EU PESs, with built-in penalty concepts. The unique characteristics of PES projects in China are that they are subject to total governmental domination, with a focus on

institutional and policy aspects to determine appropriate compensation schemes. As there is a lack of a real marketing mechanism in the scheme, externalities cannot be solved by pure market instruments. It follows that a top-down PES implementation approach is adopted, which includes a penalty concept by adhering to the “damager pays” principle. Eco-compensation therefore may often fall into the “government compensation” category, rather than market compensation as determined in Western Countries. This involves also the integration of other well-known principles into a PES scheme:

- (1) the *Damager Pays Principle* (DPP, also known as the Polluter Pays Principle, PPP), whereby the damager is made to take responsibility for the negative impact of his activities;
- (2) the *Beneficiary Pays Principle* (BPP), whereby a beneficiary should pay the provider for ecological services, even though they might be “public goods”, such as ecological security, not necessarily deriving from personal or profitable use of resources (i.e., benefits such as clear air or water, landscape amenities, etc.); and
- (3) the *User Pays Principle* (UPP) which has users of ESs compensating the State (or public) for using scarce, public-owned resources.

The Government identifies who should be compensated and how much should be paid by “pricing” the ESs into consideration. By doing so, the Government (at various levels, as shown in Table 1) aims to ensure ecological security, social stability and regional development, adopting the appropriate financial instruments (direct subsidy in cash/kind, policy support, taxation reform) as compensation methods.

As indicated in Table 1, most of the PES programs in China are targeted to improve water quality and quantity, control soil erosion, or promote eco-agriculture production. In the absence of legislation similar to the EU’s Water Framework Directive and related enforcing instruments, even a PE approach can be useful in dealing with ecological and economic relationship between upstream and downstream watershed locations, to promote economic development, environmental protection and achieve sustainable development of the entire watershed. In China, these processes are carried out at three levels: the first is national projects, the second trans-watershed water rights trading and fiscal transfer projects (as in Zhejiang province), and the third is the watershed compensation system, like the one created by the Fujian provincial government. Figure 5 summarizes the impact of the six projects described in the previous pages on different affected ESs in China.

Close relation seems to exist between Chinese PESs and poverty alleviation (social) policies, although the former is quite different in its original scope from the latter. This impression could come from the fact that although most EU PESs are publicly funded, their objective is clearly targeted to achieve *additional* environmental service benefits from a mostly consolidated, and relatively uncompromised, situation, while Chinese PESs usually start from a severely degraded ESs baseline. Similar issues were also identified in some European PESs (e.g., the Romanian and Croatian cases), where ESs payments were actually increased beyond opportunity costs in an attempt to avoid land abandonment by marginal farmers. PESs schemes could also contribute to poverty reduction by making payments to poor or marginal farmers, however, these payments were always conditional on the achievement of specific results, even though they allow beneficiary rural dwellers to take up a new social role as ESs providers for systems under stress. This could have the ultimate consequence of alleviating rural poverty. However, PESs schemes should not be seen as targeted instruments for that purpose, but merely allowing beneficiaries to achieve the requested goals while financing a transition to more profitable and ecologically-friendly production systems for societal benefits.

Until now, farmers, foresters, state employees, and all other stakeholders, have enthusiastically participated to China’s governmental PES programs, achieving remarkable progress in their implementation. The Chinese government can therefore claim that both conditions of the ecosystems involved and people’s livelihoods have been significantly improved [31].

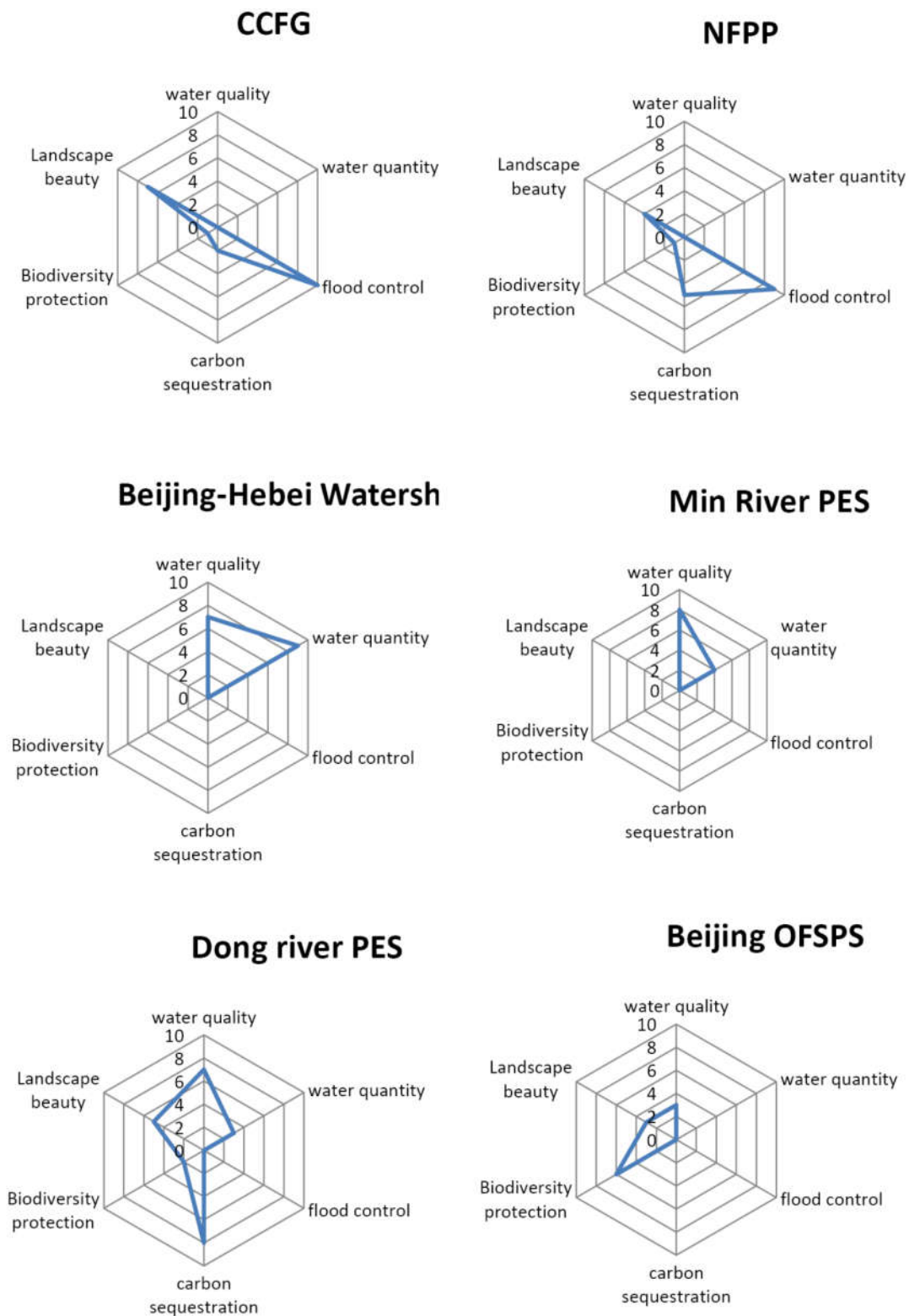


Figure 5. Representation of the Environmental Services addressed by six PES projects in China.

According to government reports, the status of natural resources has made substantial, forwards measurable progress due to the implemented PESs. From 1999 to 2006, China's forest area has increased by 8.1 million ha, and stocking volume grew by 466 million m³ in areas covered by the NFPP, against

a total production of commercial wood of 56.1 million m³ in 1997. In 2006, the total production of commercial wood was reduced to 13.5 million m³ across the program area.

Similarly, a large amount of degraded farmland and grassland has been converted and rehabilitated. Forest and grassland coverage has also expanded substantially through the implementation of other programs, (e.g., CCFG, FECE, and Beijing-Tianjin Sandstorm Source control Program). As a result, ecological and biodiversity conditions have also improved [30], as seen by the constant decline of soil erosion, expansion of wildlife habitats, and reduction in sandstorm and flood occurrences [31]. Ecotourism and related farming activities have gained popular recognition, and such activities are being undertaken by private enterprises, with diversification of local economies, acceleration of labor transfer to more productive sectors, increased income and living standards, and reduction of poverty as economic and social benefits. Beneficial effects were also observed by completion of afforestation programs in terms of flood, and river flow regime control [32].

5. PES Schemes Utilization Comparison

A comprehensive comparison between the utilization of PES schemes between Europe and China is difficult, due to large differences between these two regions. Europe is a union of individual member states that maintain a high degree of legislative autonomy, with Central organisms (European Commission) providing guidelines followed by member states in potentially different ways. China, instead, is a huge country guided by a central Government with considerable power not only to establish objectives, but also the ways to achieve them, and sufficient power to impose agreements between neighboring regions. The result is that often, in Europe, it can be more difficult for stakeholders to agree upon objectives and implementation of public projects, a condition essential for their successful outcome [33].

This situation influences another, significant difference: the spatial scales involved by PES schemes. In Europe, analyzed schemes are applied to relatively limited areas, usually very specific regions particularly sensitive to an individual ES. Due to the comprehensive environmental legislation in the EU, the recourse to PESs is usually limited to few cases where an intervention by the service providers, at low marginal cost, and in excess of other legislation requirements, can provide significant benefits to a locality, community or industry.

In China, a large part of the PES schemes are country-level PESs, meaning that the areas in which those projects are implemented are potentially tens to thousands of times bigger than in Europe. Needless to say, this directly affects the amount of funds necessary for their implementation, and administrative complexity of the schemes.

A second significant difference, related to the former, is the number of ESs addressed by implemented projects. In European cases, a PES scheme is designed around a specific, main ES and all the measures are geared to preserve it. Only in a few cases are they designed to protect multiple ESs. However, since different ESs are normally interconnected, it works out that protecting one of them, can also create benefits to others. In China, most PES schemes include different ESs, with a PES often including several sub-projects.

Another difference lies in the type of ESs providers (sellers) involved: in EU (France and UK) recipients of compensation were mostly large farms that were compensated for a change of practices to achieve specific environmental objectives (whether for public or private good), while, in Croatia and Romania, intended recipients were mostly small, subsistence farmers encouraged to maintain traditional practices, and not abandon land cultivation. The Chinese situation is more similar to the former Eastern Europe situation in that subsidy beneficiaries are mostly marginal farmers compensated to relocate or change practices. These payments, also improve economic, if not social, status of the latter.

A final difference in PES implementation is a logical consequence of political and economic history and traditions, namely, source of funding. In Europe, some of the main cases were privately funded, or promoted and funded through specific grants to NGOs (i.e., the World Wildlife Fund, WWF). In China, almost all schemes are directly financed by the central or the local governments (provinces,

counties or municipalities). Only recently, in a few cases, a mix of public and private funding was used, partially as loans from the World Bank, the Asian Development Bank and foreign governments.

In Europe, the first examples of PES date back to the early 1990s. In China, the idea of implementing PES schemes dates back to the same period, however the first examples arrived about ten years later. In both European and Chinese cases, the main form of payment is cash. There are only a few cases (more often in Chinese schemes than European) of cash complemented by payment in kind (mainly free technical assistance).

The ESs more often addressed by PES schemes in both regions were related to watershed and landscape functions (in Chinese cases, however, the majority of PES schemes included both). This may be due to the lack of specific legislation concerning the ESs involved or to specific issues about resources (whether public or private) protection for which regulation is not directly or efficiently applicable.

6. Conclusions

At the dawn of the third millennium, PESs were virtually unknown, with merely a handful of journal references existing up to 1999. Currently, there are over 500 such programs globally, steadily increasing in number, with total annual expenditures that could soon reach over US\$ 40 billion. In financial terms, these instruments aim at internalizing positive externalities (i.e., third-party benefits) generated by natural systems, incentivizing landholders' behavior in ensuring lasting provision of these services over time to the contracting party. In a sense, PESs could create additional revenue promoting environmental conservation versus exploitation, in a way aptly described as *"making trees worth more standing than cut down"* [34].

Various examples of PES schemes, both in Europe and in China, have been analyzed. Some differences between the regions have been highlighted, including spatial scale, number of ESs involved, and sources of funding. In both regions, the majority of schemes are designed to improve watershed ecosystems, especially in China where even PESs aimed at afforestation have as secondary goals flooding prevention and water quality improvement. Chinese PES schemes are geographically concentrated in the richer, coastal regions, with high variability in structure and practical implementation. Currently, China dominates publicly-financed watershed PESs in terms of number and resources, partly due to a series of major catastrophic events (floods and droughts) in the late 1990s that prompted the Chinese government to act, and partly due to China's unique centralized political system that allows it to start PES projects at a scale simply not imaginable in other countries. EU examples, in comparison, were either initiated by private initiative or studied with a dual ecological and social purpose in former Eastern Europe countries.

It is difficult to methodically describe the evolutionary timeline of these schemes in both regions, due to a lack of information and documented examples (especially in Europe, where these project types are seldom used due a more comprehensive and long established regulatory framework). In the Chinese case, a visible timeline can be seen: the first PES schemes were huge and implemented solely by the central government, while in time these became smaller (in terms of addressed area) and mainly directed by provincial governments, with the possible assistance of international organizations. It is likely that good results obtained by the initial cases convinced provincial governments to use more of those market-based instruments for environmental protection. A visible shift in the ESs involved was also noticeable: the first schemes were designed to improve afforestation, with a secondary aim of flooding protection. Gradually, the focus shifted to watershed protection (quality and quantity), indicating that central and provincial governments have become aware of the serious environmental problems affecting Chinese watersheds. Ecological engineering principles, traditionally defined as *"the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both"* [35], ought to be linked to the planning of PESs to ensure their profitable implementation.

Often, PESs were initiated to implement policies that could achieve both resources conservation and societal development goals, in substitution of a comprehensive regulation framework. Accounting for both present and future benefits and costs to stakeholders is an unavoidable necessity for these

initiatives. Occasionally, by failing to properly accounting for indirect costs (i.e., tradeoffs among different ESs that are possible under different land uses, or, more rarely, social issues), the analysis may turn out to be insufficient and schemes may achieve poor effects in the support of conservation, or may even fail to reach the implementation stage.

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