Ecosystem-based adaptation to climate change: what scope for payments for environmental services?

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Abstract

In recent years, there has been a growing interest in payments for environmental services (PES) for ecosystem-based adaptation (EBA).. So far, however, experiences and theoretical analyses of PES specifically for adaptation have not been well documented. This paper addresses this gap by analyzing the opportunities and constraints of PES as an instrument for EBA. Specifically, we examine the potential for PES to address key elements for adaptation by focusing on three pathways: the user side, the provider side, and institutional and societal change. In addition, we assess whether PES fulfils key requirements for adaptation policy instruments, notably effectiveness, efficiency, and equity and legitimacy. We find that PES are not a panacea for all environmental services and country contexts, but can be promising adaptation policy instruments where certain preconditions are met and synergies prevail. We conclude on four points especially relevant for the practical scope for PES-adaptation synergies: (i) natural adaptation co-benefits (where the targeted environmental service serves a dual function, e.g. secured water quality and increased adaptive capacity), (ii) piggy-backing (where adaptation benefits are coincidental outcomes), (iii) adaptation-relevant institutional and sectoral spillovers from PES schemes, and (iv) direct payments for adaptation benefits.

Keywords

Payments for environmental services (PES), ecosystem-based adaptation (EBA), adaptation.

1. Introduction

Adaptation to climate change is emerging as a new challenge for public policy. While until recently efforts to reduce current impacts of climate change have primarily focused on mitigating the accumulation of greenhouse gases in the atmosphere, adaptation is now recognized as fundamental (Pielke et al., 2007). According to the IPCC, adaptation can be defined as the 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploit beneficial opportunities' (IPCC, 2001). It requires investments into what Adger et al. (2005) coined as the 'cornerstones of adaptation': altering exposure to hazards (e.g. relocating people from flood-prone areas), reducing sensitivity to their effects (e.g. planting drought-resistant crops) and increasing adaptive capacity (e.g. raising human capital).

In recent years, there has been a growing interest in ecosystem-based adaptation (EBA). EBA addresses the role of environmental services in reducing the vulnerability of natural resource-dependent societies to climate change in a multi-sectoral and multi-scale approach (Vignola et al. 2009). In short, EBA can be defined as measures using environmental goods and services for societal adaptation. It builds on the increasing evidence that natural resources can play an important and cost-effective role in adaptation (ten Brink 2011; Turner et al. 2009; Campbell et al., 2009). While early calls for EBA originated primarily from environmental organizations (e.g. IUCN, 2008; Colls et al., 2009; Hale et al., 2009) and academia (Turner et al., 2009; Vignola et al., 2009; Locatelli and Pramova, 2010), EBA is increasingly also advocated by international fora and organizations (e.g. World Bank, 2009; UNCBD, 2010; ten Brink 2011).

Payments for environmental services (PES) are viewed as promising instrument for EBA (e.g. ten Brink 2011; World Bank, 2009; Colls et al. 2009; Vignola et al., 2009). However, experiences and theoretical analyses of PES specifically for adaptation have not been well documented (Locatelli et al., 2008a). This paper addresses this gap by analyzing the opportunities and constraints of PES as an instrument for EBA.

This paper is organized as follows: Section 2 introduces the concept of PES. Section 3 analyzes the effects of PES on providers and beneficiaries of environmental service beneficiaries, as well as on the wider society. Section 4 discusses whether PES can be an effective, efficient, equitable and legitimate adaptation policy instrument for ecosystem-based adaptation. Section 5 compares PES with two main policy alternatives, taxation and command and control regulation. Section 6 comprises concluding remarks.

2. Payments for environmental services (PES): scope and definition

The concept of payments for environmental services (PES) has emerged over the last 15 years and figures among the most prominent innovations in conservation. The core idea of PES consists of external service beneficiaries making direct, contractual and conditional payments to local landholders in return for adopting land use practices that secure environmental conservation and restoration. PES link the beneficiaries ('demanders') with providers ('suppliers') of environmental services through conditional payments.

Both broad and narrow interpretations of the PES concept coexist. The broader umbrella may include for example product eco-certification, park entrance fees, and tradable development rights (Engel et al., 2008). The narrower definition, based on the theoretical literature, uses five criteria (Wunder, 2005):

(1) *A voluntary* transaction in which
(2) a well-defined *environmental* service (or a land use likely to secure that service)
(3) is bought by a (minimum of one) *service buyer*
(4) from a (minimum of one) *service provider*
(5) if and only if the provider continuously secures the provision of the service (*conditionality*).

Four types of environmental services are currently being traded (carbon, watersheds, biodiversity, and scenic beauty), but the latter two have been slower to expand than the others.

For PES to function, certain preconditions must be met. These can be grouped into four dimensions (Wunder, 2008b): economic (willingness to pay exceeds willingness to accept), informational (manageable transaction costs, well-defined baselines and land use linkages), institutional (secure land tenure, trust between buyers and sellers), and cultural preconditions (social acceptance of service payments).

PES schemes can fundamentally be distinguished by the financing source into government- and user-financed schemes (Engel *et al.* 2008): In a 'user-financed' scheme, the buyers are the actual users of an environmental service. In 'government-financed' PES programs, a public sector agency or international organization acts on behalf of service users (Engel *et al.*, 2008). The latter are typically larger in scope (province or nation-wide) and often pay for multiple environmental services.

An environmental service can be marketed individually or jointly with other services. For example, conserving a forest may be targeted mainly to biodiversity conservation, but provide additional benefits of carbon, watershed and landscape beauty protection. Selling environmental services jointly could add financial resources and make conservation a more competitive land use option. In practice, three main strategies of joint service sales have been applied: bundling, layering and piggybacking. In the case of bundling, a package of services from the same land area is sold to the same single buyer. In the case of layering, several services from the same land area are sold to different buyers. In the case of piggybacking, one service is sold as an umbrella service and other environmental services are either 'free riders' or only temporarily remunerated (Wunder and Wertz-Kanounnikoff, 2009).

3. Potential effects of PES on adaptation to climate change

There is growing evidence that the provision of environmental goods and services can play a role in reducing the vulnerability of societies to climate change (Sudmeier-Rieux *et al.*, 2006). The concept of ecosystem-based adaptation (EBA) has recently emerged in the international discussion on climate change and on biodiversity (e.g. IUCN, 2008). The Ad Hoc Technical Expert Group (AHTEG) on Biodiversity and Climate Change (under the Convention on Biological Diversity) defined EBA as "the use of sustainable ecosystem management activities to support societal adaptation" (CBD, 2009). This approach to adaptation can sometimes be more sustainable than infrastructure-based adaptation (e.g. build river embankments or dams), although pros and cons still need to be explored in greater detail

(World Bank, 2009). EBA can also complement other adaptation approaches in an overall adaptation strategy, because of its cost-effective contribution to adaptation and its societal benefits (World Bank, 2010).

PES appear as relevant policy instruments for EBA because of their effects on ecosystem conservation, and thus the provision of goods and environmental services for adaptation. In addition, PES may have side effects on the adaptation of service providers and on the strengthening of institutions relevant for adaptation. To analyze the opportunities and constraints of PES for the adaptation to climate change, we consider three pathways (see Figure 1):

A. *User side*: Effects of environmental goods and services on the adaptation of the users of these goods and services
B. *Provider side*: Effects on the adaptation of sellers of environmental services
C. *Institutional and societal change*: Effects on the development of institutions relevant for adaptation

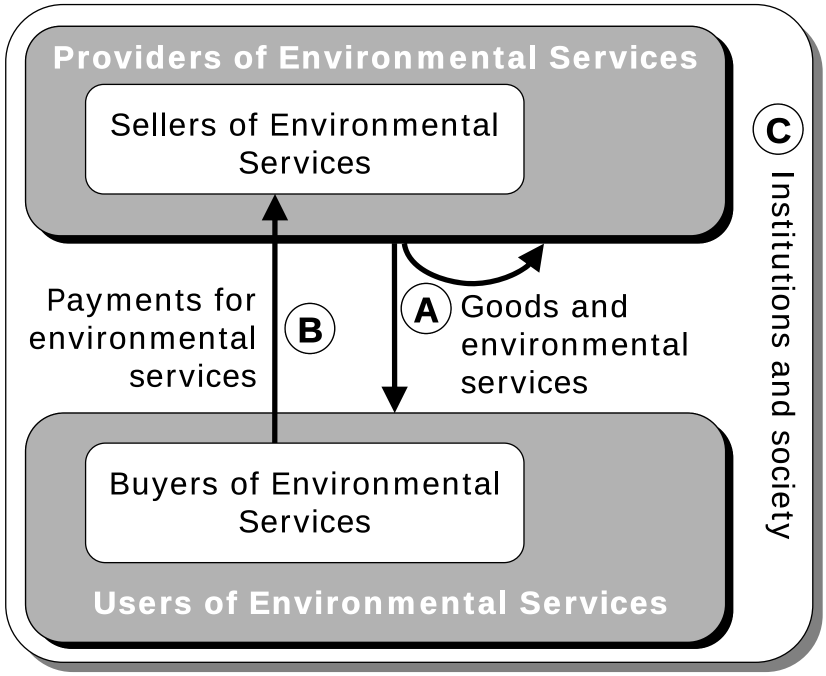

Figure 1 - Three effects of PES on adaptation on service users, providers, and institutions and society

3.1 Effects of goods and environmental services on the adaptation of service users

The first category of effects refers to those on the users or beneficiaries of environmental goods and services (see A in Figure 1). Examples include downstream individual residents, hydropower plants, or water bottling companies – all benefiting from water quantity and quality services provided by well-conserved upstream forests. Environmental goods and services can also be self-used; for example a landowner can sell hydrological services from a conserved forest, yet still collect non-timber forest products (e.g., mushrooms or game) or local crops can benefit from forests' pollination or pest regulation services.

As indicated in figure 1, commonly only a subset of service beneficiaries are actually paying. The predominance of non-paying users, i.e. free riders, may undermine overall long-term willingness to pay for environmental services.

Yet PES schemes seldom target all benefits obtained from ecosystems. In user-financed schemes, typically just one service is paid for, such as watershed or carbon services. Still, the conservation from these single-service payments can protect multiple environmental services which basically free-ride on the payments for an umbrella service (Wunder and Wertz-Kanounnikoff, 2009). Hence, PES can provide important side-effects of delivering non-targeted and free incremental services to service users.

But PES only has a role for adaptation if they conserve environmental goods and services that are relevant for adaptation. In this section, we investigate the role for adaptation of the four main categories of goods and environmental services proposed by the Millennium Ecosystem Assessment (MEA, 2005): regulating services, provisioning services, cultural services and supporting services (Table 1).

Service category	**Relevance of category for adaptation**	**Scope for PES to affect service category**
Regulating services (e.g. water purification, disease regulation)	Potentially high	High if link between service and ecosystem management is clear.
Provisioning services (e.g. food, wood and fibre)	Potentially significant	High if PES promotes productive land uses.
Cultural services (e.g. aesthetic, spiritual, recreational services)	Unclear	Little, due to lack of evidence
Supporting services (e.g. nutrient cycling, soil formation)	High indirect effects through increasing the resilience of ecosystems.	Some synergies, but low scale due to limited willingness to pay for supporting services.

Table 1 – Environmental goods and services, their effect for adaptation, and scope for PES

Regulating services

Regulating services can reduce the exposure of the society to climate-related extreme events: they can moderate the force of waves in coastal areas or winds anywhere (Adger *et al.*, 2005) and reduce temperatures during heat waves, for instance in urban areas (Gill *et al.*, 2007). In Costa Rica, because currently increasing rainfall intensity increases erosion and siltation in hydroelectricity facilities, ecosystem conservation in the watersheds upstream the hydroelectric dams is seen as a measure to adapt to climate change (Vignola and Calvo, 2008).

Where the link between ecosystem management and resulting regulating services is clear, for example for the regulation of water quality, – or perceived clear -, the establishment of PES as mechanisms for ecosystem-based adaptation is generally feasible. In this case, PES for ecosystem-based adaptation should address issues of scale and spatial prioritization. Typically it is the government-financed PES schemes that have reached large-scale levels (Wunder *et al.*, 2008). If a PES scheme induces improved ecosystem management only in a few places scattered in a landscape, it may have limited impacts on the provision of regulating services and, thus, the adaptation of service users. Spatial prioritization may help targeting payments to high-services and high-threat areas, for increasing the effects of PES on the provision of services. Depending on its objective, a PES scheme could identify and target areas of high soil erodibility or high potential for aquifer recharge and for reducing the force of waves (e.g. mangroves and coastal forests in low-lying areas). So far, most government-financed PES schemes have used little spatial targeting, but examples are emerging, such as in Mexico's national watershed protection programme (PSA-H, Pago de Servicios Ambientales Hidrológicos) (Muñoz-Piña *et al.*, 2008).

Yet, where land–use service links are uncertain, it may be more difficult to mobilize willingness to pay for service provision. For watershed environmental services, there is sometimes disagreement over the extent or nature of some services (Porras *et al.*, 2008). Relevant for the purpose of adaptation is the emergence of 'risk-reducing' PES schemes. In Ecuador's Pimampiro watershed scheme, for example, municipal water users have since 2000 paid upstream farmers for reversing an ongoing land-colonisation process. This was done without precise prior knowledge about the hydrological linkages at hand, based basically on precautionary principle considerations on behalf of the Municipality (Wunder and Albán, 2008).

Provisioning services

Provisioning services are the products obtained from ecosystems, such as firewood, fruits, and game. Since the generation of products entails on-site benefits – appropriated by the proper landowner – these environmental goods are not an externality. This is why there has been contention as regards the utility of “provisioning services” as a concept (Buyers, 2007; Engel *et al.*, 2008). When PES schemes protect existing ecosystems from degradation and conversion, they often contribute to the sustainable supply of goods, which can go hand in hand with adaptation goals. For example, African rural communities use non-timber forest products for direct consumption or for trading when agriculture or livestock is affected by climate events (Paavola, 2008). Some goods may help local people adapting to future changes for instance through medicinal plants for emerging diseases or other goods that have an option value vis-à-vis climate change. But product supply for external users will typically be reduced by conservation PES, because there is a trade-off between delivering provisioning and other services from the landscape. Conversely, when PES are used to regenerate degraded landscapes, e.g. through agroforestry or plantation establishment, then more “provisioning services” will be the outcome, at least in the medium run.

Hence, provisioning services are only indirectly affected by PES, since they are not externalities, and make the proper landowner the “service user”. These indirect effects may be negative or positive. Designing PES for ecosystem-based adaptation should include an analysis of the trade-offs associated with harvesting ecosystem goods, which contribute to the adaptation of local people but can jeopardize the provision of environmental services useful for the adaptation of other actors and necessary for the viability of the PES scheme.

Cultural services

Cultural services, such as spiritual and religious values, contribute to human well-being and social cohesion, and are thus in principle important determinants of adaptation. However, the link between cultural wellbeing and adaptation is not well documented and further evidence to understand the cultural dimension of adaptation is needed (Seppälä *et al.*, 2009). Additionally, PES schemes have seemingly so far not been used for preserving cultural services. Specific native ecosystems, e.g. sacred forests, may well provide essential cultural services to local communities. But these benefits are internalized locally, so there is no clear reason why outsiders should remunerate their conservation. Therefore, it is also unlikely that PES has the potential to become an important adaptation instrument for conserving cultural services.

Supporting services

Supporting services, such as soil formation and nutrient cycling, are those that are necessary for the production of all other environmental goods and services (MEA, 2005). They differ from the other service categories since their utility for people is indirect. These services are closely related to the diversity of genes and species in an ecosystem, which influences ecosystem resilience (Loreau *et al.*, 2002; Chee, 2004). Although supporting services are not used directly by people, they are important for the resilience of ecosystems in a context of climate change. For instance, providing habitat for facilitating the migration of species can facilitate the adaptation of ecosystems to climate change (Pearson and Dawson, 2005; Williams *et al.*, 2005; Hannah *et al.*, 2007).

In a climate change context, conserving supporting services and biodiversity for their role on ecosystem resilience ultimately ensures the sustained provision of other goods and environmental services to the society. However, these indirect benefits from ecosystems often attract only limited willingness to pay. According to Rodríguez *et al.* (2006), the societal preferences for the services provided by ecosystems focus less on supporting services than other services, in part because supporting services are "taken for granted". In principle however a PES for adaptation could address ecosystem resilience when there is sufficient willingness to pay for option values, i.e. the role of ecosystems in the adaptation to future climate change.

However, even though supporting services and the role of biodiversity in ecosystem resilience are not directly targeted by PES, the beneficial side-effects of PES should not be overlooked. Projects dealing with ecosystem services contribute largely to biodiversity conservation, because they are likely to attract more funding than traditional biodiversity projects and because they encompass human-dominated landscapes as well as protected areas (Goldman *et al.*, 2008). This could help implementing conservation efforts at the scale to facilitate the adaptation for ecosystems to climate change. In addition, many biodiversity PES are carried out by conservation organizations for the sake of existence values, i.e. the non-use benefit humans derive from preserving species on this planet (Milne and Niesten, 2009). There is likely a high synergy between existence and option values, and thus also an indirect link to supporting services, resilience, and adaptation.

3.2. Effects of PES on the adaptation of providers

The second category of PES effects is on the adaptation service providers (see B in Figure 1). Those include landowners or land managers who receive PES and through their land use choices influence service supply.

Hardly all providers of environmental services participate in a PES scheme. This is because of eligibility, economic and capacity reasons. Eligibility reasons include legal requirements (e.g. land titles) and location specifics (e.g. areas are truly threatened, and provide high-value services). Economic reasons are whether the benefits of participation outweigh the costs (payments versus opportunity, protection and transaction costs). Capacity reasons refer to the ability of negotiating deals and entering a PES contract.

This section examines the PES effects on adaptation, specifically adaptive capacity, of service sellers. We regrouped a list of factors originating from the adaptation literature (Adger *et al.*, 2005; Tompkins and Adger, 2004; IPCC, 2001, 2007) into four main categories (Table 2): assets and wealth; human capital, technology and infrastructure; cognitive factors and skills, and empowerment.

Factors	Relevance of factors for adaptation	Scope for PES to affect factors
Economic assets and wealth	Highly relevant, increases ability to cope with climate change	PES can typically provide small but positive contributions
Human capital, access to technology and infrastructure	Highly relevant, provides soft skills and engineering solutions to cope with climate change	PES not relevant, unless when accompanied by training or extension
Cognitive factors and skills	Relevant in shaping perceptions and knowledge regarding environmental change	Most PES schemes raise environmental awareness and engagement of providers.
Empowerment and local governance	Highly relevant to define and decide on sustainable adaptation strategies, information sharing and social learning to cope with climate change	Most user-financed PES schemes have empowered service providing land stewards, and in various cases helped consolidating land rights

Table 2 – Factors determining the adaptive capacity of service providers, and the role of PES

Economic assets and wealth

Assets and wealth are important economic determinants of adaptation (IPCC, 2007). Poverty reduces the ability to adapt: poor communities and households have limited access to services and other resources for coping with climate change.

Initial empirical evidence suggests that PES can help improving the livelihoods of poor providers of environmental services (Bond *et al.*, 2009; Wunder, 2008a; Grieg-Gran *et al.*, 2005). Income generation is one general benefit of PES, which is exemplified in Costa Rica and the case of Pimampiro in Ecuador where PES is popular with farmers despite seemingly low payments levels (Bond *et al.*, 2009; Wunder and Albán, 2008). There is little data on the derived PES effects on local prices and employment (Wunder, 2008a).

Human capital, access to technology and infrastructure

Human capital (education, health), technology and infrastructure are further important factors enabling adaptation. Education and health can increase the ability to cope with climate change (Seppälä *et al.*, 2009). Water pumping infrastructure, for example, can reduce the vulnerability to drought. Health infrastructure can decrease the impacts of climate-related diseases. Similarly, roads can increase access to support services needed to cope with climate-related disasters.

PES does not directly affect human capital, technology and infrastructure access, since these factors do not usually make part of a PES agreement. However, monetary payments can improve health and education of service providers by enabling them to spend more resources on these items. In addition, to the extent that reformed production practices are a target of PES, training may be provided along with the payments, whether for beekeeping in Bolivia’s Los Negros valley (Asquith *et al.*, 2008), tree planting in Ecuador’s highlands (Wunder and Albán, 2008), or silvopastoral adoption in Colombia, Nicaragua and Costa Rica (Pagiola *et al.*, 2004). PES can also sometimes facilitate information sharing and social learning capacity. A review of experiences from Latin America suggests that PES had positive effects on the animation of social learning in and across rural communities (Rosa *et al.*, 2005). Yet on aggregate, PES are little relevant for this category of adaptation determinants.

Cognitive factors and skills

Interpretations of danger and risk associated with climate change are context-specific, and adaptation responses to climate change can be limited by human cognition (Lorenzoni *et al.,* 2005; Grothmann and Patt, 2005). Strengthening cognitive factors and skills are therefore fundamental to enhance the adaptive capacity of societies. Examples of such cognitive factors and skills include information sharing, and the capacity of social learning to become ‘flexible within cultural traditions’ (Tompkins and Adger, 2004).

PES can play a role in enhancing cognitive skills relevant for adaptation in communities selling services because PES generally raise awareness on environmental issues (e.g. in Costa Rica, Locatelli *et al.*, 2008b) and have the potential to facilitate information sharing and social learning (Tschakert, 2007).

Empowerment

To adapt successfully, local stakeholders must be engaged in defining strategies and making decisions (Tompkins and Adger, 2004). Empowerment of local landholders and communities is therefore an important mean to adaptation, e.g. through consultation in land use decision-making processes, or formalization of land-use and tenure rights. Land titling may promote more sustainable land uses and longer-term planning, which are relevant factors for adaptation (Toni and Holanda, 2008).

PES schemes can have a positive effect on securing land tenure for service-providing communities, e.g. through better enforcement of existing land rights in Bolivia (Asquith *et al.*, 2008). In addition, conditional land tenure has emerged as one experimental way to reward the provision of environmental services by the Rewarding Upland Poor for Environmental Services Programme in Asia (Huang *et al.*, 2009).

3.3. PES effects on institutions for adaptation

We have seen above that effective service provision depends on adequate institutional contexts. Conversely, however, PES can also change institutions in ways that impact wider society, including its adaptive capacity (see Effect C in Figure 1).

Generally governance and institutions are seen as instrumental for a society's adaptive capacity (Boyd, 2008; IPCC, 2001), but the nuts and bolts remain unclear. One important feature of adaptive governance is allowing for flexibility in the institutional design (Folke *et al.*, 2005).

We distinguish four pathways of how PES potentially could alter the institutional preconditions for adaptation: local institutions, intra-sectoral linkages, and cross-scale linkages (see Table 3).

Factors	Relevance of factors for adaptation	Scope for PES to affect factors
Local institutions	Highly relevant: to increase ability to cope with climate change	PES can have significant positive effects on the organization of both service users and providers
Inter-sectoral linkages	Highly relevant: to ensure policy coherence	Possible, since inherent to most PES
Cross-scale linkages	Highly relevant: to ensure coherence in decision-making across scales	Possible, in government-financed schemes, less in user-financed schemes

Table 3 – Institutional determinants of adaptation and the role of PES

Local institutions

Local institutions are recognized as key for adaptation as they mediate impacts of climate change and vulnerability at the local level, frame possible adaptive responses, and influence the outcomes (Christoplos *et al.*, 2009; Agrawal, 2008; Folke *et al.*, 2002). They can further function as mechanisms for collective action (Tompkins and Adger, 2004). Examples include social networks resulting from social cohesion or induced by external institutions.

In principle, PES schemes can contribute to the strengthening of existing or establishment of new institutions. For example, service buyers or sellers may group in an association, or NGOs are created to mediate between buyers and providers of environmental services. In the Costa Rican national PES scheme, institutions enabling collective contracting with groups of small farmers (*contratos globales)* were established, yet forcing the groups to internally collaborate in order to collectively comply with contracts (Pagiola, 2008). In Villa de Leyva (Colombia), two heterogeneous groups of water users – peasants and recreationists – jointly formed five associations around a PES scheme to secure clean and reliable water supply through collective action (Moreno-Sánchez *et al.*, 2009).

Inter-sectoral linkages

Adaptation to climate change requires cross-sectoral approaches, because climate change impacts will also cut across sectors, thus calling for coherent policy design environmental awareness in multiple sectors. The need for linking sectors is even clearer in the case of EBA, which lies at the interface between ecosystem managers and other sectors of the society.

Inter-sectoral linkages are an integral part of PES schemes, as they link people managing ecosystems with people benefiting from environmental services: services providers are farmers or forest managers; beneficiaries are typically from energy (hydropower companies), industry (water-bottling companies), tourism (agencies), or urban residents (potable water users). In exceptional cases, PES operate intra-sectorally, e.g. in Los Negros (Bolivia) where downstream irrigators pay upstream farmers to change land-use practices (Asquith *et al.*, 2008).

The extent to which PES can foster intersectoral linkages depends on the type of PES scheme. When service beneficiaries originate from many different sectors, government-financed schemes will have greater authority in enabling cross-sectoral coordination. One of the reasons behind the emergence of the national PES scheme in Costa Rica was the fact that the same ministry was in charge for both environment and energy. Hence, policies could be designed coherently, with a fossil fuel tax (energy sector) to pay for forest environmental services (C. Rodriguez, pers. communication).

Cross-scale linkages

Cross-scale linkages between stakeholders from the local to the international level are important for creating social resilience through networking, e.g. between communities and regional or national government, or international agencies (Tompkins and Adger, 2004). While adaptation is inherently local, the enabling institutional environment usually covers multiple scales. Planning and implementation of adaptation strategies is often needed at local or municipality level, but enabling regulations and broader polices need to be formulated at the national scale. However, a cross-scale interaction is often hindered by hierarchical power structures (Tompkins and Adger, 2004; O'Brien *et al.*, 2004; Næss *et al.*, 2005).

If PES schemes cut across scales, they might enhance interaction between them. But only national schemes, generally government-financed, have this potential. Here local service providers are connected to national service users, e.g. through a government entity such as

Costa Rica's National Fund for Forest Financing (FONAFIFO) that purchases services on behalf of users.

4. Scope for PES as cost-effective policy instrument for adaptation

The previous section showed that PES has some potential to address key elements for adaptation. This section assesses whether PES also fulfils key requirements for adaptation policy instruments and shows that it has the potential to be a cost-effective and equitable instrument for adaptation.

Successful adaptation policy needs to fulfil the following requirements: effectiveness, efficiency, equity and legitimacy (Adger *et al.*, 2005). Adaptation needs to be cost-effective in decreasing vulnerability to climate change impacts – even though effects of adaptation are uncertain, depend on actions taken by others and an unknown future state of the world, and can include unintended side-effects. At the same time, adaptation actions need to be legitimate which means acceptable to participants and non-participants that are affected by those actions.

The potential of PES to be a cost-effective and equitable instrument has been widely discussed in the literature (e.g. Kemkes et al., 2010; Engel *et al.*, 2008; Wunder, 2007; Ferraro and Simpson, 2002). To assess the scope of PES against Adger's requirements for successful adaptation policy, we distinguish again between user- and government-financed PES.

Effectiveness

Effectiveness refers to whether a certain target is achieved. As regards adaptation, effectiveness can be gauged through reducing vulnerability and impacts, for example reducing exposure or sensitivity and strengthening adaptive capacity (Adger *et al.*, 2005).

Effectiveness of PES for adaptation is a function of: (1) their influence on sustainable land-use, (2) the links between land use and the provision of environmental services, (3) the role of environmental services in adaptation.

The effectiveness of a PES scheme in influencing sustainable land use or ecosystem management is closely related to the issue of additionality. It is high where payments make an actual difference compared to the 'business as usual' scenario. However, although there are very few schemes (apart from carbon payments) that undertake systematic efforts to formally quantify additionality of various environmental services providers, anecdotal evidence suggests that user-financed schemes tend to have higher additionality than government-financed schemes (Wunder *et al.*, 2008).

A clearly established link between land uses and environmental service provision co-determine PES effectiveness (Wunder, 2007). While there is strong scientific evidence for some generalizable links (e.g. between forest conservation and water quality, biodiversity conservation, and carbon storage), it is highly site-specific and variable for others (e.g. forest conservation and seasonal run-off or flood control). Spatial targeting can increase the effectiveness of a scheme. User-financed schemes tend to be focused (e.g. on one environmental service) and in general more keen than government-financed PES in getting the link right between land use and environmental service provision and spatial targeting. But targeting high-service areas is also emerging in government-financed schemes. In Mexico's hydrological PES scheme (PSA-H), cloud forests are paid a premium price, because of their alleged special hydrological importance (Muñoz-Piña *et al.*, 2008).

The effectiveness of PES for adaptation also depends on how rewarded land uses or ecosystem management reduce social vulnerability. In Costa Rica, Nicaragua and Colombia, the Global Environment Facility-financed "Regional Integrated Silvopastoral Approaches to Ecosystem Management" project has implemented a PES scheme for promoting silvopastoral systems adoption. These systems are also acting as adaptation measures, because under extreme rainfall and temperature conditions, silvopastoral systems are less vulnerable than treeless pastures. The role of goods and environmental services for adaptation depends whether rewarded land uses are productive or not, who has rights and access to goods produced by rewarded land uses, and the location or scale of the rewarded land uses in a landscape.

For the effectiveness of PES as adaptation instrument, flexibility to adapt to changing conditions is needed. The question is how PES can respond to changing vulnerabilities, climatic and socio-economic conditions, on the demand and supply side. Since PES schemes are supposed to be voluntary, changing demands for environmental services will be reflected in the changing willingness to pay for these services. This flexibility is especially present for user-financed schemes where conditions are (re-)negotiable because the interaction between buyers and providers of environmental services is likely to be more direct and closer.

Efficiency

Efficiency refers to whether a certain target (adaptation, environmental service provision) is achieved at minimum costs. It thus directly depends on effectiveness (the physical target), but adds a cost layer. Implementing adaptation typically triggers transaction costs, opportunity costs, and costs of inaccurate prediction – compared to the benefits of reduced impacts or enhanced opportunities (Adger *et al.*, 2005).

It has been argued that user-financed PES are particularly likely to be efficient, as the actors with the most information about the value of the service are directly involved, have a clear incentive to ensure that the mechanism is well-functioning, can observe directly whether the service is being delivered, and have the ability to re-negotiate (or terminate) the agreement if needed. Conversely, in government-financed schemes, the direct user of the ES do not pay, they have no first-hand information on its value, and generally cannot observe directly whether it is being provided (Engel *et al.*, 2008). Governments have less direct incentives to ensure that the program is working efficiently; on the contrary, they are often under a variety of political pressures. Hence, it has been argued that such programs are less likely to be efficient (Pagiola and Platais, 2007). However, government-financed PES programs can be more cost-effective than user-financed PES because of economies of scale in transaction costs, including because existing government agencies may be able to act as implementers.

Efficiency is substantially influenced by payment design. An efficient payment scheme would pay an amount only marginally above the individual costs of providing the service by each landowner. In the face of spatial heterogeneity, payment differentiation (by opportunity costs) can dramatically increase the efficiency of a scheme, by aligning payments to the real costs. However, due to equity concerns and for ease of administration, government-financed schemes have so far preferred uniform payments (Engel *et al.* 2008).

One additional dimension of cost-effective PES design refers to the spatial scale at which service beneficiaries are located (Kemkes et al., 2010). For example, in the case of water services, beneficiaries tend to be local whereas beneficiaries of biodiversity conservation services are global. The design of PES for EBA purposes needs to account for these scale attributes to ensure effectiveness.

PES costs include transaction costs (searching suitable buyers and sellers, negotiation, information, opportunity-costs assessments, administration), plus the proper payments. Generally, PES face very high start-up and fairly low running costs (Wunder *et al.*, 2008). As mentioned above, larger-scale government-financed schemes, unlike most small-scale user-financed schemes, can benefit from economies-of-scale effect. Trying to address too many issues in PES (e.g. poverty reduction, institutional strengthening, cross-scale interactions, etc.) may also multiply costs and thus jeopardize their viability. High transaction costs can present an impediment for PES development.

Equity and legitimacy

The success of an adaptation action depends not only on its cost-effectiveness in meeting defined goals, but also on perceived equity and legitimacy of action. Equitable and legitimate adaptations can be evaluated from the perspective of outcome (who wins, who loses from the adaptation) as well as who decides on the adaptation to take place.

Initial experience with PES schemes has occasionally revealed the risk of not reaching out sufficiently to the poorest land users. Because of certain requirements for participation in PES schemes (e.g. land titles, upfront investments to finance licensing of land-use plans or necessary managerial skills), poorer land users can be disadvantaged – as was initially the case in Costa Rica for example (Zbinden and Lee, 2005). More recently, however, particular efforts are made to rendering PES pro-poor i.e. helping to ensure that the poor can participate, and that they will benefit (Wunder, 2008a). This can include targeting areas where poor and often most vulnerable providers of environmental services reside, and allow for collective contracts (Muñoz-Piña *et al.*, 2008).

But PES can also have indirect effects on the poor. In the aforementioned Bolivian case of the Noel Kempff Mercado Climate Action Project, for example, a logging ban made many local people lose the jobs they had with logging companies (Asquith *et al.*, 2002). In particular, such welfare effects can occur in activity-reducing schemes (pure forest protection), as opposed to activity-enhancing schemes (forest restoration), where payments are made without sufficiently attractive economic alternatives.

Overall, emerging practical evidence suggests that PES yield positive welfare effects, especially when poor people become service sellers and their participation is voluntary (Wunder, 2008a; Wunder et al., 2008). These can result in further indirect adaptation benefits, through enhanced adaptive capacity of the service providers (see section 3.2). Harnessing such synergies can help increase adaptation co-benefits from other investments in ecosystem management (e.g. Corfee-Morlot et al., 2002).

Another aspect relevant for the equity and legitimacy of adaptation policy refers to the potential of PES to empower service-providing communities. Especially when service providers are directly involved in the negotiation of PES deals – such as generally the case in user-financed deals – positive social empowerment effects are likely, which ultimately leads to collaborative decision-making. However, for these outcomes to materialize, balanced power structures and trust among the negotiating parties are an important precondition. Where PES is built from the demand side, the interests of buyers usually are better represented, since they have more bargaining power (Pascual et al., 2010). Intermediaries can hereby play a key role, such as shown by Thuy et al. (2010) for the case of Vietnam. In government-financed schemes, payment levels are often administratively determined leaving little opportunity to service providers to become actively engaged in the implementation of the PES scheme.

5. PES versus other policy instruments for adaptation

Adaptation policy can potentially be linked to an array of policy instruments to encourage land users to internalize the benefits provided by the ecosystems they manage. Here, we compare PES to the two most commonly discussed alternative approaches: environmental taxation and command and control regulation.

PES can be viewed as a conditional environmental subsidy targeted to increase environmentally beneficial activities (Engel et al. 2008). Although subsidies can suffer from several potential inefficiencies (e.g. lacking additionality, leakage, perverse incentives), they have at least two advantages over environmental taxes to regulate environmental service provision. First, tax policies require a strong institutional environment to monitor and enforce compliance (while the same can be said for subsidies, the voluntary nature of PES deals make cooperation more likely), a requirement that is hardly fulfilled in developing countries, and even less in most rural areas where it would be needed for EBA. Second, environmental taxes base on the 'polluter pays'-principle, which would impose the costs on land users. In many developing countries, service providers are often very poor people who would not be able to pay these additional costs, and who through historical practice have *de facto* acquired an 'entitlement to pollute' (e.g. to convert forestland). Consequently, due to these enforcement and distributional concerns, taxes would most likely also be ineffective in securing environmental outcomes (e.g. adaptation benefits). In these circumstances, PES-subsidies can be more effective and equitable instruments. But also in developed countries, payments (PES) are politically more feasible to implement (Kemkes et al., 2010). In addition, payments can incentivize environmental outcomes beyond what is already required by the law (ten Brink 2011).

Compared to command-and-control regulations, PES are considered to be more efficient, if the minimum requirements for PES are met (Engel et al., 2008). This is because regulations suffer from several inefficiencies including high administration costs and lacking flexibility (Sterner, 2003; Baumol and Oates 1988). In developing countries, these approaches are further hampered by weak governance, high transaction costs and information problems associated with the design of effective usage rules, monitoring, and enforcement (Baland and Platteau, 1996). In developed countries, the last decades have seen a shift from coercive or command-and-control style environmental governance towards a cooperative governance (Salamon, 2002; Héritier, 2001; Héritier and Lehmkuhl, 2008). However, investments in command-and-control can still be justified in situations where incentive policy instruments (including PES) are not applicable due to lacking preconditions (clear and secure land tenure, strong institutions for monitoring and enforcement, trust building possible, opportunity costs low enough to compensate), such as for example is the case in about two thirds of the Brazilian Amazon (Börner et al., 2010).

Even though PES offers important features for EBA, it is unrealistic to implement PES in isolation. Some environmental policy instruments already pre-exist (e.g. environmental regulations); other complementary instruments are needed in some regions or moments in time (e.g. command-and-control regulation where preconditions for PES are not met). In consequence, the fundamental question may often rather be how to combine PES with other instruments for effective adaptation outcomes.

6. Concluding remarks

After having identified the different potential pathways of adaptation-PES synergies, and shown that PES can fulfil the requirements for successful adaptation policy instruments, we conclude on four points especially relevant for the practical scope for PES-based EBA synergies.

First, *natural adaptation co-benefits*: There are potentially high direct synergies when the targeted environmental service is automatically also beneficial for adaptation. For example, if a watershed PES scheme promotes more environmentally benign land uses in the entire watershed to secure water quantity and quality, then this will also decrease the inhabitants' vulnerability to climate-related water problems.

Second, *piggy-backing*: Adaptation can also become an accidental co-benefit of PES schemes. For instance, if a PES scheme produces landscape beauty benefits for local ecotourism development, then service provision would not directly benefit livelihoods adaptation. Yet the indirect PES impacts, such as extra income and employment from a rise in ecotourism, may increase local adaptive capacity – although these impacts are mediated by, for example, the distribution and timing of revenues. And if protecting landscape beauty coincides with protecting the watershed (e.g. by leaving the tree cover intact also in strategic areas of steep slopes and fragile soils), an adaptation-relevant environmental service would indirectly come to 'piggy back' on PES. However, the potential for such piggybacking depends on the spatial overlap of the two environmental services --landscape beauty and watershed protection.

Third, *adaptation-relevant institutional and sectoral spillovers from PES schemes*: In theory, PES could also impact the wider governance and institutional framework, but in reality this scope is probably relatively limited. It depends on how likely PES institutions are to create significant sectoral spillover effects that are picked up by other sectors.

Fourth*, direct payments for adaptation benefits*: PES could in principle also service as a tool for direct investments in adaptation benefits, which would be the most direct contribution PES could make. However, due to the perceived uncertainties associated with the costs of climate change and adaptation benefits, the willingness to pay for adaptation-relevant environmental services are currently limited: ecosystem-based adaptation benefits nobody wants to (or can be expected to) pay for. This in turn may translate into a need for 'foresighted' public regulators who invest into these services on behalf of their end-users. At the same time, many watershed PES schemes are not built on solid science about service delivery, but exclusively rely on faith and the precautionary principle. This motivates the question: why is the same not happening for adaptation? Maybe local people don't see climate change as a credible threat, though recurrent natural events (floods, droughts, heat and cold waves) and their effects on people's wellbeing and livelihoods occur. Also, perhaps people perceive the adaptation concept as overly abstract or dependent on collective-action that voluntary initiatives, including "user-financed" PES schemes for adaptation, are unlikely to develop. Further research on the causes for the seemingly continuously low willingness to invest in adaptation may inform the practical feasibility of implementing adaptation and defining the scope of PES for ecosystem-based adaptation.

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