Ecosystem services from improved soil and water management: creating a return flow from their multiple benefits

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Abstract

Soil and water conservation practices (SWCP) provide multiple onsite and offsite benefits, which can be economically significant, including regulation of the flow of water and sediment, reduced agricultural water demand, storage of carbon in soil, reduced vulnerability to drought and flooding, and higher farm productivity. Payments or other forms of compensation for environmental services (PES) have been directed primarily at forest conservation to protect offsite benefits that are associated with regulation of the flow of soil and water but have been hindered by difficulties of quantifying them, and of assuring potential buyers that they will have access to them in the future. Onsite productivity benefits of SWCP are more demonstrable, can provide greater motivation for adoption, and can play an important role in poverty alleviation. However, adoption still presents institutional challenges and has upfront costs. Therefore, this review suggests that, if PES is to play a critical role in enabling a transition to sustainable rural development, it will be necessary not only to demonstrate the offsite benefits of soil and water conservation practices, but also the onsite benefits, as well as to understand what it will require to motivate farmers to adopt them at a large enough scale to deliver valued services. This will require a better understanding of the local context, beginning with choices that upland communities have for meeting their most immediate needs and for responding to threats to livelihood security, as well as the economic incentives that influence specific land use practices. To the extent that these practices can be connected to offsite impacts, and to broader social benefits, it will be possible to make a stronger case for external support, through various forms of payment arrangements. By starting with the livelihood needs and direct benefits to upstream communities, links to downstream benefits can proceed incrementally as understanding is gained, and as institutions are developed or strengthened in upland areas that enable collaboration at the scale necessary to deliver benefits. This approach also provides those downstream with a greater opportunity to learn about connections between these services and their well-being, and to reconsider the values placed on them. It may also then be possible to make payments contingent on service delivery.

Introduction

Soil and water conservation (SWC) practices in upland areas can foster the production various kinds of ecosystem services that have both upstream and downstream benefits. By implementing practices that maintain or restore the capacity of soil to retain water along with nutrients and organic matter, farmers can dramatically reduce agricultural water demand, reduce vulnerability to climate extremes of drought and flooding, and also increase soil carbon storage, as well as their own productivity. By reducing runoff and the need for fertilizer inputs, they can also improve downstream water quality (CA 2007).

On site productivity has not generally been sufficient to create an incentive for widespread adoption of these practices. This is in part because there are often high upfront costs and risks for land users. In addition, practices are often promoted with insufficient attention to whether they are really appropriate for the diverse socioeconomic and biophysical conditions that characterize many upland farming environments. Adoption sometimes occurs when farmers are paid to adopt, but when payments cease the practices are usually abandoned (Hellin and Schrader 2003).

Limitations of regulatory approaches to land management, and greater awareness of downstream benefits, are driving the exploration and development of market-based payment arrangements, in which payments are, at least in theory, contingent on the provision of well-defined and measurable ecosystem services. These are most commonly referred to as Payments for Ecosystem or for Environmental Services (PES), but also with the more comprehensive term, Compensation and Rewards for Environmental Services (CRES) (Swallow, Kallesoe et al. 2007).

Ideally, PES consists of voluntary transactions in which land users are paid for valued environmental services by those who benefit (Wunder 2005). Examples of services include regulation of the flow of water and sediment, and storage of carbon, through protection of forests or adoption of other sustainable management practices. The approach is conceptually appealing because the economic incentive for adoption would, unlike in the case of pure subsidies, come directly from those who benefit from the services and would therefore be sustainable. PES is looked to as a way to finance conservation, and at the same time support poverty alleviation in remote upper watershed areas. In practice, there are often trade-offs between these diverse objectives, and it is difficult to quantify levels of service provision.

In what has been a partial approach, PES initiatives in developing countries have primarily been directed at covering the opportunity costs of upland forest conservation, and have been financed mainly by governments or NGOs, with the justification that there were exploratory or that the spillover social benefits warranted public investment. However, the offsite or downstream cumulative impacts of forest clearance have been difficult to quantify and, where they have been, it is not clear that they are economically significant for individual watershed services at the scales of interest to potential buyers (Aylward 2004). In addition, because of higher opportunity costs of forest protection for small holders, and various kinds of institutional barriers to participation in these programs, these payment schemes have not necessarily benefited the poor (Grieg-Gran, Porras et al. 2005) (Miranda, Porras et al. 2003).

Recent scientific research also questions the common wisdom and universal applicability of assumptions about forest and water relationships that have driven watershed PES initiatives e.g. (Bruijnzeel 2004). A conclusion from this research is that, regardless of the presence or absence of trees, greater emphasis should be placed on management of soil and ground cover which are the major factors that control flows of water and sediment. There is also a considerable amount of emerging agricultural research which makes a case for investments in an ecosystem approach to agriculture and PES as a way to jointly provide both agricultural commodities and ecosystem services (CA 2007) (Buck, Gavin et al. 2004) (Sakuyama 2007) (Stringer and Pingali 2004) (Pingali 2006) (World Bank 2007) (FAO 2007).

Soil and water conservation (SWC) practices are the foundation of an ecosystem approach because, unlike precipitation, temperature, or global financial flows, they can be managed. Their inclusion in a more integrated approach to PES initiatives has the potential to help overcome some of the limitations of previous approaches, both in on-farm soil and water conservation and in PES. There are lower trade-offs between SWC and uses of land for livelihood needs than uses for forest conservation. In frontier agricultural areas, strengthening of institutions may also help to limit further clearance of forests. By providing more choices to small farmers in the most marginal and erosion prone areas, payments to support agricultural soil and water conservation can also be expected to improve livelihood security (CA 2007). But they also present a special set of challenges.

This paper explores the potential for various kinds of payments for ecosystem services to motivate the adoption of soil and water conservation practices, with an emphasis on developing countries. It begins with background information on why SWC practices have not been more widely adopted, the ecosystem services associated with them, the consequences of poor agricultural soil and water management in upland areas, and the potential advantages of a PES approach. The next section reviews selected case studies that involve the use of PES to support SWC. This is followed by discussion of some of the lessons that can be learned from experience with these and other cases that is relevant to improving the management of soil and water in agriculture, and the kinds of information needed to support the development of PES initiatives. It concludes with recommendations for a way forward in which SWC provides a point of departure for an integrated, place-based, livelihood centered approach necessary to understand the context, and create conditions that enable and motivate farmers not only to adopt SWC practices, but to also participate in the development and monitoring of more efficient and cost-effective delivery of services.

Background

Barriers to the adoption of soil and water conservation practices

In theory, those who farm in upland areas should already have an incentive to adopt soil and water conservation practices since such practices should improve productivity and profit. In practice, they often do not, in part because the SWC technologies that are promoted do not always lead to noticeable productivity improvements, or may only do so over a longer period of time that is too long for farmers given their high discount rates.. Given limits on land, labor and capital, smallholders often have less flexibility and greater aversion to risks and uncertainties that accompany changes in technologies or practices (Hellin and Schrader 2003).

A review by Hellin and Schrader (2003) found that the technologies are often not suited to specific biophysical conditions nor to the needs of farmers. These technologies often consist of structural measures to control soil erosion which is often not the main concern of farmers and, by themeselves, do not raise productivity, which also relies on the capacity of the soil to store water and nutrients.

There may also be high upfront costs. For example, when converting to organic agriculture, yields can be expected to initially drop, but pick up as soil recovers organic matter content and suppressed microbial populations (Buck, Gavin et al. 2004). Leaving land in fallow and use of crops as “green manure” requires land to be taken temporarily out of production. In agroforestry, there is a lag time for trees to grow. In addition there are institutional barriers that prevent land users from access to future benefits of conservation practices, such as lack of tenure security, lack of access to markets, greater management complexity, labor requirements that may compete with other livelihood activities, and the need for technical assistance to learn about new practices. Where extensification into uncleared areas remains an option, it may be cheaper than more intensive use and adoption of SWC practices (Hellin and Schrader 2003).

Landscapes also contain many unproductive areas where farmers have no incentive to implement SWC practices simply because they are not expected to result in returns to productivity. These areas are likely to be the ones that contribute the most to watershed degradation, e.g., steep slopes, foot paths, gullies and other marginal areas that are de facto open access (Swallow, Garrity et al. 2001). On a national scale, upland areas themselves have been neglected and were by passed by the Green Revolution because they were regarded as having a low return on investment. Uplands have also been neglected because of underinvestment in the agricultural sector, which has driven development of other sectors (World Bank 2007).

Payments to farmers for adopting SWC practices was one way to overcome their unattractiveness to farmers. Payments were often justified with the argument that once farmers had experience with the practices, they would continue to use them, setting an example for other farmers. However for reasons described above, this generally didn’t work and the practices were usually dropped when payments stopped (Hellin and Schrader 2003).

Although impacts of soil and water degradation have historically brought down entire civilizations, improvement of land management practices in marginal upper watershed areas did not become a broader social and environmental concern until offsite impacts became regarded as a threat to downstream interests of national economic significance. These include hydroelectric generation, municipal water supplies and disaster reduction, as well as regional and global environmental concerns (Kaimowitz 2004). Consequently, the problem became embedded in the broader framework of watershed management, in which the flow of water links upstream land use practices to downstream concerns.

One response to the recognition of the off site impacts is regulation of land use in upper areas. Regulation of land use practices alone, however, is often ineffective since monitoring and ensuring compliance is costly and difficult. In addition, it is often inequitable since it places a disproportionate share of the burden on upstream land users without giving them a corresponding access to benefits. In the most extreme cases, they are excluded altogether. For example, it is common for states to claim ownership of forested areas, and to protect watersheds through policies that exclude local populations from access to resources on which they have traditionally relied, which may lead them to occupy more marginal land areas (Tomich et al., 2004).

An additional challenge to achieving watershed scale impact via adoption of SWC practices is the need to implement the practices at a scale large enough to detectably reduce cumulative downstream impacts, which will require broad participation of farmers. Given the heterogeneous nature of landscapes, patterns of land uses can be more important than area size for the delivery of services (van Noordwijk, Poulsen et al. 2004). The resulting uneven distribution of costs and benefits among stakeholders can make it difficult to establish equitable arrangements, without which it is difficult to obtain collaboration (Kerr 2007).

Limitations on both regulatory approaches and on payments for adoption of practices have led to growing interest in payments or other forms of compensation for environmental services (PES), in which payments are contingent on the delivery of valued services. To the extent that payments can actually be linked to outcomes rather than simply to adoption of practices, it would also encourage innovation by farmers, to achieve more efficient and cost effective delivery of services (Shabman 2006). However, this implies the need to demonstrate measurable and economically significant benefits, and to provide stakeholders with confidence they will have access to them. These remain the key challenges to implementing a PES approach.

Given the emphasis on support for forest conservation and on the offsite regional and global benefits of doing so, PES initiatives have, so far, had more limited influence on agricultural practices in developing countries. However, mosaics of agroforestry, upland cropping and forestry are more typical of traditional upper watershed land use systems and can support denser populations than forested areas (ICRAF 2006). In an integrated landscape approach to conservation that aims to improve rural livelihoods and sustain agricultural production as well as provide ecosystem services, services produced by agriculture are critical and serve as a complement to forest conservation (McNeely and Scherr 2003).

An agricultural focus is also a more pro-poor approach because it avoids or reduces trade-offs between environmental and income/production objectives. In addition, by increasing the livelihood security and choices available to small farmers, and by clarifying rights to ecosystem services, SWC practices that increase on-site production of ecosystem services can provide a point of departure for demonstrating their offsite benefits and for farmer collaboration in watershed management. Payments for downstream and offsite benefits can be added incrementally, as they are demonstrated and as they come to be valued by their beneficiaries. This can in turn provide a point of departure for farmer collaboration in a landscape approach in which their contributions to offsite benefits are valued. By strengthening rural institutions, and increasing resilience to climatic extremes (i.e., drought and flooding), SWC practices that increase farm productivity can also be expected to strengthen the capacity of rural areas to respond to global climatic and economic changes that are otherwise beyond their control.

Ecosystem Services associated with soil and water

Soil and water are the building blocks of a number of ecosystem services that are the foundation of human well being. Ecosystem services consist of various forms of direct and indirect benefits that ecosystems produce for people, providing that they are economically significant, and that users actually have access to them. In the framework developed by the Millennium Ecosystem Assessment, which draws directly on the work of Sen (1999), human well-being is defined to include: the abilities to earn a livelihood, to maintain health and good social relations, and to be secure. However, underlying all of these aspects of well-being is a more basic one, to have freedom of choice and action as to how these different kinds of needs are met (MA 2003). These choices, and ways of life, are both enabled and constrained by ecosystem conditions. Ecosystem conditions are influenced by natural and human-induced drivers. One of the key human-induced drivers are the institutions or “rules of the game” that govern the management of soil, water and other natural resources, and influence land use decisions (see Figure 1).

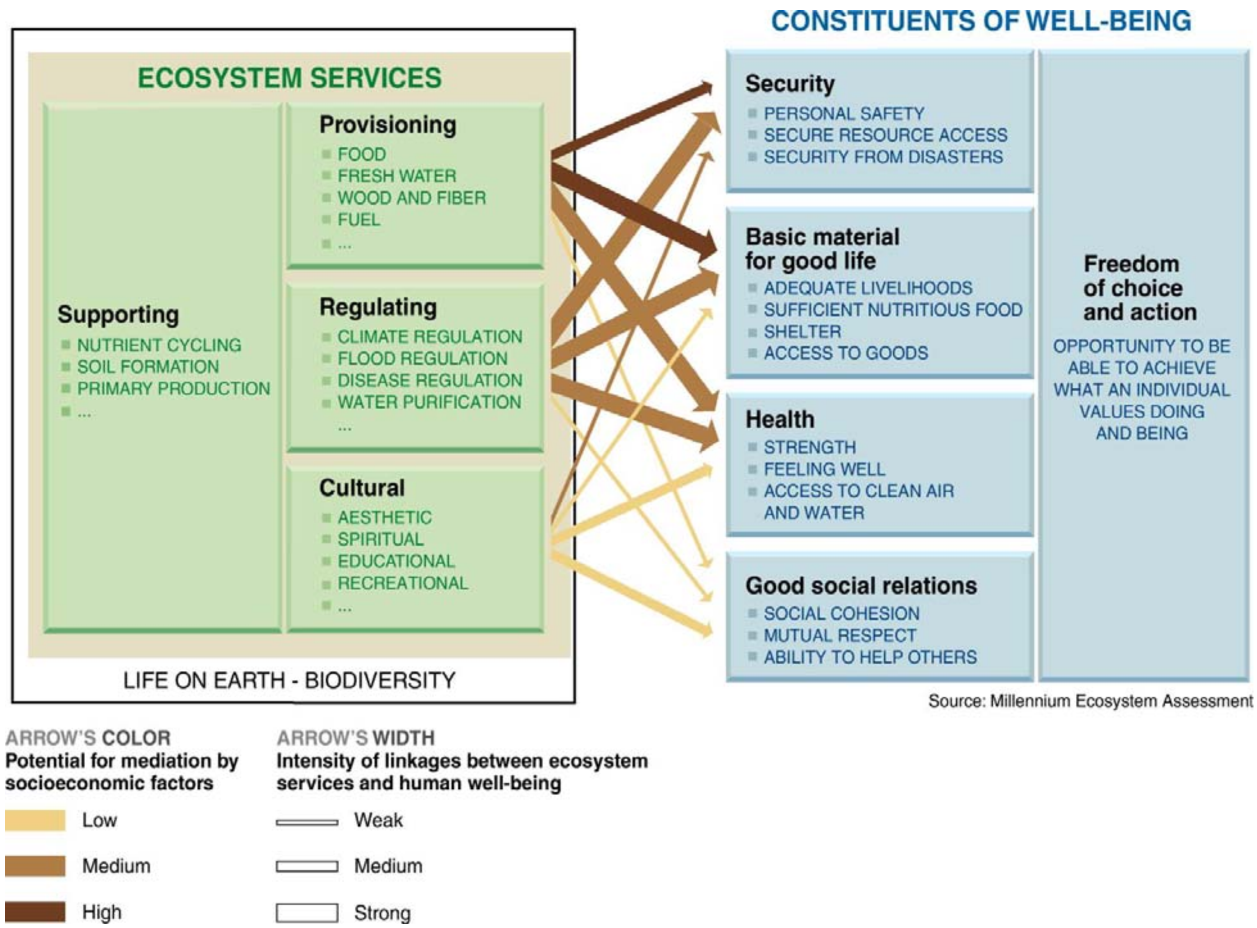

Figure 1: Relationship between ecosystem services and human well-being (MA 2003)

The various types of ecosystem services can be distinguished as provisioning, regulatory, cultural and supporting, as outlined in the following examples of ecosystem services associated with soil and freshwater:

Provision of food and freshwater – for direct uses (e.g., domestic, agricultural, and industrial);

Regulation of flows of water and sediment - organic matter in soil increases the infiltration and storage of water - thereby reducing evaporation and mean surface runoff that erodes soil, increases groundwater recharge, maintains soil moisture, increases carbon storage and productivity, and, by storing nutrients, helps to maintain water quality. Depending on the scale, and on the amount of water consumed by vegetation and other site-specific factors, flow regulation properties can provide a buffer against peak or flood flows, as well as base or dry season flow and drought conditions. The flow regime or pattern also supports diversity of habitats in wetland, riparian, freshwater, estuarine, and marine areas that are linked to it;

Cultural services or support for recreation, tourism, aesthetic values, indigenous ceremonial uses, livelihoods and ways of life that depend on the natural resources; and

Supporting services - these are the complex patterns of interaction between various ecosystem components that drive ecosystem processes that result in soil formation, nutrient cycling, primary production, and biodiversity, all of which underlie or support the regulating provisioning and cultural services. For example, soil is the product of interaction between climate, water, material eroded from parent rocks, organic matter, and soil organisms that decompose organic matter and engineer soil structure (Wall et al 2004). Flow regimes are the product of interaction between climate, precipitation, topography, vegetation, and human alterations. Biodiversity, which is most highly concentrated in soil, also increases the capacity of the system to cope with changing conditions, i.e., its resilience and therefore its capacity to provide other kinds of services.

These various kinds of services are interdependent, in that there are synergies and trade-offs not only between different uses, but also between the different types of services. For example, the capacity of a river basin to *provide* clean freshwater for direct uses, or for soil and water to provide food, or for human beings to choose a way of life, depends on the existence of the *regulatory* and *supporting* services, or on expensive and unsustainable technological substitutes for them, such as artificial fertilizers and water filtration plants, all of which give rise to other trade-offs. As the supply of any of these services becomes more limiting, human well-being will increasingly depend on achieving an acceptable balance between these trade-offs (Aylward et al, 2005).

To be properly considered “services” it is also necessary to demonstrate that the ecosystem provides benefits that have economic significance for particular stakeholders (Aylward 2004). Therefore, site-specific assessments are necessary to identify benefits that are provided in a specific context, their range of variability, and the scale at which they can be detected. This then provides a basis for identifying the distribution of costs and benefits, and for stakeholders to consider the value of the service, or what trade-offs they are willing to make. This is usually expressed in terms of their willingness-to-pay for conservation measures necessary to provide the service, and the levels of compensation needed to cover the costs of those measures, without which there would be no economic incentive to implement them, i.e., to produce the services.

Consequences of poor soil and water management

Land use change and freshwater diversions support food production but have also been key direct drivers of the degradation or loss of the full range of ecosystem services. Globally, food production alone accounts for 70% of the withdrawal of freshwater, and has come at the expense of other services for which freshwater is a limiting factor, from consumptive uses to maintaining wildlife habitat (CA 2007). It has also had direct impacts on aquatic ecosystems as a result of dams and irrigation infrastructure built to support the Green Revolution (Buck, Gavin et al. 2004).

Demand for croplands and pastures, which currently occupy approximately 40% of the global land surface, is expected to rise as existing croplands are lost to salinization, erosion and urban expansion, and food demand grows as a results of both population growth and increased incomes (CA 2007). In addition there is increasing demand for land for biofuel production that has already contributed to rising food prices (Blas 2007). According to FAO estimates, there will be demand for additional 120 million ha of crop land in the next 30 years. Although there are exceptions, in many parts of the world the costs associated with additional land conversion or further development of water resources, will be increasingly difficult and unacceptable because of conflicts with development as well as with conservation, recreational and aesthetic uses (Buck, Gavin et al. 2004). Increases in willingness-to-pay for ecosystem services suggest that the latter uses are also increasing in value as they become more threatened and scarce.

Soil organic matter stores approximately 40% of the terrestrial carbon pool, or twice the amount contained in the atmosphere, and increases both land productivity and water use efficiency because it serves to retain soil moisture and cycle nutrients, (Robbins, 2004, cited in (CA 2007) (Foley, DeFries et al. 2005). Under prevailing agricultural practices, it is a significant source of carbon emissions and is not eligible for credits under the Kyoto protocol. As soil organic matter has declined, artificial fertilizer inputs have increased 7 times over the past 50 years but provide diminishing returns in that production has increased by only 2.5 (Tilman, Cassman et al. 2002). Fertilizers are the main causes of eutrophication or low oxygen conditions found in water bodies, which have created deadzones in several inland seas and nearshore marine areas, now found in most regions of the world and reported in up to 200 places which include the Gulf of Mexico, the Chesapeake Bay, and the Black Sea (UNEP 2006). They are also the source of additional greenhouse gas emissions. Production of biofuels from food crops rather than perennial species are expected to exacerbate these trends as well as lead to increases in food prices. In 2006, 20% of the US Corn crop was consumed for biofuel production and led both corn and wheat prices to an 11 year high (Blas 2007).

Pesticides reduce water quality and are also providing diminishing returns, in part because monocrops are more vulnerable to pests, and in part because pests develop resistance. Impacts of land use on the flow and quantity of water are site specific and more difficult to make general statements about because it depends on factors such as vegetation and whether or not the roots are deep enough to reach the water table.

The offsite/downstream impacts and reduced onsite productivity occasioned by soil loss may have economy-wide impacts. In a study of Ghana, it was estimated that land degradation will reduce agricultural income by US$4.2 billion in the 2006-2015 period, which is approximately 5% of the country's total agricultural GDP, and to increase the poverty rate by 5.4%, further concentrating it in the already poorest regions of the country. Conversely, it was estimated that soil and land management practices could reverse the trend and generate US$6.4 over the same period (Diao and Sarpong 2007).

In other words, the narrow focus on inputs and outputs in the form of agricultural production alone has delivered cheap food at the expense of the capacity of the ecosystem to support and regulate provision of these more direct benefits, for which costs have not been fully counted (Waltner-Toews 2000). To some extent, these inputs of inorganic fertilizers, pesticides and irrigation have served as a substitute for these services, but because of rising costs, the trade-offs described, are not sustainable. For some services, such as erosion control, there are no substitutes (Donaldson 2003).

Given that this narrow focus on productivity has largely been made possible by subsidies that are being removed as part of trade liberalization policies (Buck, Gavin et al. 2004), as well as by trade-offs that have increasing implications for human well-being, it is unlikely to be an option for the future. Therefore, for better or worse, agriculture is at a turning point.

Although there are limits on further appropriation of freshwater and land for human uses, a growing body of research suggests it is still possible to increase the production of food as well as other ecosystem services with existing levels of resource use, by managing soil and water for multiple functions - to produce ecosystem services as well as food (CA 2007). The challenge is primarily an institutional one.

Managing for multiple objectives

Ecosystem Services flow from stocks of natural capital, the loss of which directly undermines the Millennium Development Goals, and is felt most directly by the poor, for whom natural capital is the major asset (Sachs and Reid 2006). Protecting these services is therefore the foundation for effective development strategies (World Bank 2006). Agriculture accounts for the largest share of natural capital, and supports most of the 70% of the world's poor who live in rural areas (Thompson, Millstone et al. 2007). Given that 60% of global agricultural production and 80% of food in developing countries is provided by small holders (CA 2007), the development of incentives for the adoption of soil and water conservation practices can be expected to have far reaching effects that further both development and conservation objectives as well as human security.

According to estimates of the Comprehensive Assessment of Water Management in Agriculture, 75% of additional food needs could be met just by raising the productivity of low-yield farmers in rain-fed farming areas. This could be achieved through practices that conserve soil moisture complemented by supplemental irrigation, and would lift the greatest number of people out of poverty (CA 2007). Improvement of water productivity can range from 70-100% in rainfed systems, and 15-30% in irrigated systems – through the use of techniques such as conservation tillage that improve water infiltration, reduce evaporation, and increase the capacity to retain both water and nutrients (CA 2007). It has also been estimated that adoption of conservation tillage, now practiced on 110 million ha, on all cropland (1600 million ha) could store up to 25 billion tons of carbon by 2054 (Pacala and Socolow 2004). In addition to reducing atmospheric carbon, this also appears to be an important strategy for responding to now unavoidable climate change in that, by boosting retention of water, it would reduce vulnerability to climate extremes.

There is also a body of research into indigenous land management practices that have been found to increase carbon sequestration in soil as well as increase productivity. Among these is a practice of amending soil with a form of charcoal, commonly referred to as "biochar", which is produced from biomass waste burned at low temperatures in a process that also sequesters more carbon than it releases (Lehmann 2006; Lehmann (in press)). It is thought to have accounted for high productivity that supported dense and sedentary populations on otherwise poor soils in parts of the Amazon where it was found (Smith 1980). Research suggests that the main obstacle to more widespread adoption of this practice is that soil carbon sequestration is not eligible for credits under the Kyoto protocol. Estimates based on the volume currently traded on the Chicago Climate Climate, (US $4/ton) suggest it would become feasible at $37/ton (Renner 2007).

There may be many more lessons that can be learned from traditional land management systems. One current initiative aims to demonstrate landscape level benefits of the Quesungal Slash and Mulch Agroforestry System (QSMAS). This is a traditional approach practiced by over 6000 small farmers on 7,000 ha in the Lempira region of Honduras, in which a permanent cover of native trees is maintained, and which does not involve burning. Among its onsite benefits are a greater resilience to extreme climatic events of both drought and excess water, as was witnessed during the 1997 El Nino event, and Hurricane Mitch in 1998. It has also resulted in lower rates of erosion and higher storage of water in the soil, as well as the socioeconomic benefits of improved grain storage and better education. Combined, these benefits have doubled the productivity of crops and increased the profitability and food security of farmers. According to Matilde Somarriba, coordinator of the Integrated Soil Management (MIS) Consortium, the challenge now is to demonstrate the benefits in downstream areas for which this watershed supplies 60% of the water supply and supports the generation of 57% of the hydropower. Also, to determine what kinds of economic incentives, capacity building and technical innovations will be required for this system to expand to nearby areas. Equally important will be to show decision-makers the potential value of supporting these kinds of changes in practices among small farmers (Somarriba 2006).

In a survey of 286 sustainable agriculture initiatives in poor countries that have adopted a variety of best practices, Pretty et al (2006) found that these initiatives resulted in increases in average crop yields of 79%, significant but highly variable water use efficiency gains that were highest in rain-fed crops, and, in 77% of the initiatives, a 71% decline in pesticide application, while still generating a gain in crop yields of 42%. Gains in carbon sequestration averaged between .05 and .5 tons/household/year, and totaled 11.4 MT/year across the 37 M ha that were part of the survey. This suggests that this service could offer income generating opportunities – providing that soil sequestration is included in carbon trading schemes.

The projects reviewed made use of a variety of resource-conserving technologies and practices that were not limited to soil and water management practices. These included: integrated management of pests and nutrients, conservation tillage, agroforestry, aquaculture integrated with farming systems, water harvesting in dryland areas, and zero-grazing livestock. An additional advantage is that these kinds of strategies may also work best in remote areas where most of the poor are found. These areas were passed over by the Green Revolution because monocultures aren't competitive, But the diversity found in these areas can be favorable for product diversification and the development of niche markets, providing that certification and marketing obstacles can be overcome (Buck, Gavin et al. 2004).

Creating incentives for agricultural soil and water conservation

In theory, market-based approaches are a more efficient and cost effective way to achieve conservation goals than regulatory ones because they create an economic incentive for them. In practice, they are often complementary to regulations necessary to create markets for resources that have public good and common pool characteristics, which make it difficult to exclude free-riders. These characteristics are often precisely the ones that make a PES based on internalizing externalities possible, however at the same time they give rise to a number of scientific and institutional challenges. Although many of these challenges are critical components of a PES scheme that are necessary to support innovation, they are generally categorized as transaction costs that should be kept to a minimum. Although unlikely to be recovered in a pricing scheme, it is important to keep in mind that resolving these challenges can also have considerable spin-off benefits.

In a watershed context, PES and other market-based approaches rest on the presumption that buyers can be provided with complete information about the service being provided. This implies that links can be established among the multiple causes and effects of watershed degradation that operate at different scales, as a basis for valuing services and getting the prices right. If these conditions hold, payments can then be made conditional on provision of a well-defined and measurable service. However, given the expense and amount of time necessary to obtain this information, which is always incomplete, and the high variability of upper watershed processes which are dominated by randomly timed and extreme events, links between upstream land use practices and downstream effects remain poorly quantified and are more often presumed than demonstrated. Still, it remains an important goal because levels of payments could then be tied to levels of service.

Given that watershed services are specific to places, another key limitation is demand, which may be small unless there are large populations or hydroelectric facilities downstream. In the absence of substitutes, the supply of ecosystem services depends on collaboration among upstream land users, who in such a case would have a natural monopoly. For example, in a case study that most resembles the ideal PES model, farmers were able to negotiate a good deal with the Vittel Company to change their practices because intensified farming practices threatened the sole source of Vittel mineral water - a high value product for which there were no substitute locations. The case study, more fully summarized below, also illustrates the kinds of challenges encountered in the establishment of a PES arrangement, which rely on much more than hydrological and economic information.

A broader framework referred to as Compensations and Rewards for Environmental Services (CRES), complements the concept of PES, in that it includes any kind of contractual arrangement or negotiated agreement among ecosystem stewards, beneficiaries of ecosystem services and intermediaries to enhance, maintain, reallocate or offset damage to ecosystem services in which compensation and rewards may take various forms (Swallow, Johnson et al. 2006). These are often in complex transactions in which payments may go either way - from downstream users to upstream land users as compensation for stewardship activities, or from upstream to downstream, as compensation for damages, consistent with the polluter-pays-principle. The CRES framework also explicitly recognizes the broader social and environmental context of these arrangements that drive changes in the production of ecosystem services. These include both the national and international political and economic environment as well as extreme events associated with both short and long term climate conditions (Swallow, Kallesoe et al. 2007). The framework could also be further expanded to include the knowledge and technologies that enable PES initiatives, and the importance of building relationships of trust, which is a fundamental to the development of institutional capacity.

In the CRES framework, market approaches are explicitly designed to support poverty alleviation and other social goals. This is in contrast with a narrower approach in which it is assumed that, by removing distortions and fully counting costs and benefits, ideal conditions can be created in which markets will automatically produce desired outcomes – a situation which has never occurred in the past and which, ironically, would require a significant amount of government intervention to achieve. Given the tendency of markets to favor those who are better off, the narrower approach has generated a not insignificant amount of fear and resistance among stakeholders because they fear loss of control when they enter into contractual agreements and in some cases, have a general distrust of markets (Porras and Miranda 2005) (Hope, Porras et al. 2005) (Condesan 2007) (Rosa 2006).

Regardless, whether or not there is a market-mediated incentive to manage land for the production of any of the various kinds of ecosystem services will depend on whether those who pay the costs also have access to the benefits, either directly or via some form of compensation. These incentives are often lacking because the costs and benefits of land use practices are separated between upstream and downstream, as well as between the present and the future. Particularly in the developing countries, there are also significant constraints on the ability of downstream beneficiaries to pay for services. Upstream, when property rights are poorly defined, land users may not be in a position to enter into agreements to implement specific management practices.

It has generally been found difficult to scientifically demonstrate economically significant links between management practices in upper watersheds and impacts on distant urban water supplies and sedimentation of hydropower dams, or to provide economic justification for interventions at a scale that would be necessary to address them (Aylward 2004). Even in the US and other OECD countries, which have been providing various forms of financial support for agricultural conservation practices, the problem of measuring offsite landscape level benefits is just beginning to be addressed, and is necessary to make payments contingent on performance, with respect to the level of service provision. This is considered important as an incentive for farmers themselves to bring innovation into their management practices, and to provide services more cost effectively, which is not achieved in cost-sharing that is contingent only on the adoption of specified practices (Shabman 2006). As a result, more attention is now also being given to the local level impacts within micro-watersheds, where land and water relationships can be better understood and stakeholders can be more directly engaged.

Overview of compensation approaches used to promote soil and water conservation

Payments for watershed services are essentially a contractual agreement between those "buyers" who benefit from and value a service that is contingent on management practices by upstream land users – or "sellers." These will take different forms, depending on the biophysical characteristics of the service, the scale of the relevant ecosystem processes that support it, and the socioeconomic context. These characteristics have implications for what actions will be required to insure provision, as well as to provide beneficiaries with confidence that these will be effective, and that they will have access to benefits. This section provides a brief overview of the kinds of arrangements that have been used in the context of selected case studies that illustrate how they have been implemented.

These arrangements may range from informal, community based initiatives, to more formal contracts between individual parties, and to complex arrangements among multiple parties facilitated by intermediary organizations. They may also include a mix of complementary market-based, regulatory and policy incentives that are more likely to become necessary at larger scales, when threats are beyond the response capacity of individual communities (Rose 2002), and when multiple services are involved. The government may play different kinds of roles depending on the type of arrangement, ranging from the enforcement of contractual agreements, to the creation of regulatory incentives, monitoring compliance, contracting with service providers, providing technical assistance, identification of priority conservation areas and practices to be supported, and the collection and allocation of funds. Some of these roles may also be filled by user or landowner associations or other non-governmental organizations, which often have the advantage of greater flexibility, and the ability to act more expediently. NGOs may also play the role of advocates on behalf of less powerful constituencies, so as to create political pressure that may be necessary for governments to recognize and enforce their rights and respond to their concerns.

The actual design of payment arrangements will also reflect policy decisions as to who should pay costs and who is entitled to benefits. The extent to which payments would amount to paying polluters or are considered appropriate to cover added costs of SWC practices, is ultimately determined by property rights as well as responsibilities and equity considerations. Whether to provide compensation when there are significant and costly changes in standards will also be a matter of policy.

Incentives for soil and water conservation practices are usually in the form of *Voluntary Contractual Arrangements*, in which contracts are negotiated directly among users, providers and intermediaries, or *Transfer Payments*, in which the payments to land users are made by the government, to achieve broader national policy objectives. *Acquisition* of land is occasionally used as a tool, because the land can then be sold or leased with easements that restrict future uses, made available to farmers contingent on the adoption of agreed upon management practices, or if necessary, taken out of production. *Certification and labeling* can be an important tool for marketing the products of organic farming. *Tradable permits* rely on a strong regulatory infrastructure and technical capacity to establish and enforce a cap and to verify credits, and are not found in any developing country case studies. However, they have been used to reduce salinity in Australian and are beginning to be used in the US to reduce nutrient pollution, though they face a number of obstacles.

Where payments are made, they are often in the form of *user fees* – which are only possible when benefits can be limited to those who pay for them, *taxes*, or *donations*. In cases that promote soil and water conservation, compensation is frequently in-kind rather than in cash, for example, by providing seeds, fertilizers, training and technical assistance, access to loans, or tenure security.

Where it is voluntary, provision of services may also depend on whether payments are sufficient to offset opportunity costs – which may be revealed by allocating contracts through a bidding process. In the case of certification and labeling, it may also depend on whether producers are able to benefit from price premiums. Other important considerations that present challenges for institutions and governance (further discussed below) are the relative power of stakeholders at the bargaining table, what information is available to them, and whether any significant stakeholders have been excluded. Another is whether land users have some form of property right or tenure security, without which they may not have authority to enter into contractual agreements or have access to the benefits. When they do not, participation in PES initiatives that offer compensation for soil and water conservation may be motivated by a fear of being expelled. This is typically the case among those who occupy publicly owned upland areas where existing uses of the land are technically illegal even if not enforced – a situation common in South East Asia (Kerr, Pender et al. 2006).

Fundamental to all of these instruments is the need for a consistent set of criteria and a transparent process for decision-making with respect to the establishment of priorities for allocation of the funds. It is also important to keep in mind that payments are not a substitute for regulations, which are sometimes used to create an incentive to find more cost effective ways of achieving compliance. For example, in the well-known case of New York City, the incentive for the city to negotiate with upper watershed communities and to pay for upper watershed conservation measures was created by new regulations that would have otherwise required much higher expenditures to construct a filtration plant (Perrot-Maître and Davis, 2001).

In general, benefits will be more tangible, and contractual agreements more feasible, at smaller scales, where links between causes and effects can be more readily established, and where property rights and stakeholders can be better defined. At larger scales, where it is harder to link causes and effects, and rights and responsibilities are harder to define because of public good or common pool characteristics of the service, or of multiple services, there will be a greater need for government involvement. Larger scales also offer a larger pool of buyers and sellers but are harder to tailor to local conditions (Rose 2002).

PES for soil and water conservation practices: an overview of case studies

Payments for soil and water conservation practices have primarily been the focus of national programs of public payments to farmers in the United States and in Europe – the Conservation Reserve Program in the US, and the CAP in Europe. In addition there are a few well-known site specific cases – the much discussed New York City Watershed Agreement, and an agreement between Nestle Waters, owner of the company that produces Vittel mineral water, and farmers in the watershed above the source springs.

In developing countries, PES initiatives have primarily been directed at forest conservation. Exceptions, which are primarily in Latin America, include three sets of small scale efforts in Central America and in the Andes, which are part of three programs:

PASOLAC (Programme for Sustainable Agriculture on the Hillsides of Central America) – which supports pilot initiatives in ten communities in Nicaragua, El Salvador and Honduras with support from the Swiss Agency for Development and Cooperation;

Cuencas Andinas (Sustainable Land Use in Andean Watersheds) involving 15 sites in Colombia Peru and Ecuador, among which the more developed initiatives are Lake Fuquene, Ambato, and Alto Mayo; and

Silvopastoral – the Regional Integrated Silvopastoral Ecosystem Management Project (RISEMP) – a GEF/World Bank regional project that supports pilot initiatives in Costa Rica, Nicaragua and Colombia.

Another longstanding initiative that is now addressing soil and water conservation is Cuenca, Ecuador.

In summaries of new and updated case studies recently released by IIED (Porras and Neves 2006), several other cases were identified that include at least a mention of a soil and water conservation component. These include the ICE Watershed Management Units - a private initiative of the Costa Rican Electricity Institute, developed to support restoration in watersheds upstream from hydropower facilities throughout Costa Rica. There is also a national initiative in El Salvador, EcoServicios, that is just getting started, with support from the World Bank and the Global Environment Facility. Although there is less information available as to whether and how SWC components have been implemented, other Latin American initiatives include: FONAG and Pimampiro in Ecuador, Valle del Cauca in Colombia, and protection of the Cerro San Gil Protected

Area, and Sierra de las Minas Biosphere Reserve in Guatemala. However the main goal in most of these is protection of reserve areas and forest.

There are also several initiatives in India, Indonesia, the Philippines and China, a new effort in Kenya, and also a transboundary initiative in the Drakensberg and Maloti Mountains in Lesotho, the major source of water for South Africa. Many of these are in exploratory or initial phases but serve to illustrate the broad interest generated by this approach, and considerations specific to the region.

Sources of funding and demand for services are primarily from international development agencies – particularly for initial start-up costs, as well as from hydropower companies and other businesses that rely on water. In some cases, modest user fees are charged to municipal water users.

This section discusses selected case studies in which SWC practices are the primary component, primarily from developing country experiences. Selected case studies from developed countries are also presented for illustrative purposes.

PASOLAC

PASOLAC provides up to $12,000 to municipalities for start-up transaction costs to develop PES schemes, providing that they make an equivalent contribution. Part of this is used as seed capital for a trust fund to support upstream soil and water conservation practices that is then administered by municipalities or their water boards. PASOLAC also conducts technical studies and surveys of willingness to pay for watershed services. User payments may be made in cash or in kind, by providing labor for conservation projects. Providers may receive technical assistance and cash (Pérez No date).

Key concerns throughout the project areas are soil compaction which reduces infiltration and therefore, contributes to drying up of springs, low groundwater levels, low dry season flows, and stronger floods. So far, among the ten sites, two that appear to be showing the most significant results are in San Pedro del Norte and in Jesus de Otoro (Pérez No date.) (Porras and Neves 2006).

In San Pedro del Norte, five farmers who occupy 13 ha, or 18% of the critical recharge area for the Los Cuevones spring, receive $26.3/ha/year which is paid by the 5000 residents of San Pedro through a portion of their water charges (USD $ .30 of 2.00), which is combined with 5% of the municipal budget. After two years of implementation, there are claims of an increase of 1.25 m2/day of water flow during the dry season, although it is not clear how this is monitored. In 2005-2006, the number of permanent springs was also observed to increase from 8 to 13. Among the conservation practices followed were to build rows of stone barriers at critical water infiltration points, construction of stone ditches in creeks prone to erosion, incorporating stubble into soil instead of burning it, and reduced use of chemicals, along with some regeneration of forests. Regardless, water remains insufficient to meet local needs (Pérez No date) (Porras and Neves 2006).

In Jesus de Otoro, the key issue that motivated the establishment of a PES scheme was the need to resolve conflict between downstream and upstream stakeholders because of pollution from coffee processing. The PASOLAC initiative has played an important role in resolving this conflict, and in fostering greater upstream/downstream collaboration. As a result, practices adopted included recycling of coffee pulp and management of processing waste, in addition to the construction of vegetative fences, irrigation ditches and terraces, organic agriculture, and also forest protection (Porras and Neves 2006; Pérez No date).

Although payments have only covered changes in practices on 22 ha in a watershed of over 3000 ha (since expanded to 74 ha), here too, there is a general belief that the flow of water has improved. Households pay $.06/mo in additional water charges, while payments to upstream land users range from $5.52 to 15.47/ha which amounts to .4 to 1.2 of their gross income (Kosoy, Martinez-Tuna et al. 2007).

Payment levels in both cases raise the question of motives for landowner participation. As summarized in Table 1 and Table 2, in San Pedro del Norte, payments appear to cover less than 10% of the opportunity costs of forest conservation, based on the price at which providers are willing-to-rent the land. For potential providers in both locations, the payment is approximately one quarter of the income that would be obtained if the land were rented,.. In Jesus de Otoro, opportunity costs are lower than in San Pedro del Norte when compared to what landowners consider to be a fair payment (Kosoy, Martinez-Tuna et al. 2007). Worth noting is that the payments in Jesus de Otoro are made both for forest conservation as well as for environmental practices, while in San Pedro del Norte, the payment is only for forest conservation (Kosoy, Martinez-Tuna et al. 2007). Although Kosoy et al (2007) were unable to provide an estimate that distinguishes the opportunity costs for adoption of better environmental practices from opportunity costs for forest conservation, it appears that these could be more fully compensated through PES.

Table 1: Farm income

	Gross income		Net on farm profits	
	Providers	Potential providers	Providers	Potential providers
	US$/ha/yr	US$/ha/yr	US$/ha/yr	US$/ha/yr
Jesus de Otoro	8,353	2,155		308
San Pedro del Norte	2.024	1,333	126	142.5

Source: Adapted from (Kosoy, Martinez-Tuna et al. 2007)

Table 2: PES Opportunity Costs

	Average payment	"Fair" PES		Average Willingness-to-Rent			
		Providers		Providers		Potential providers	
	US$/ha/yr	US$/ha/yr	PES % op cost	US$/ha/yr	PES % op cost	US$/ha/yr	PES % op cost
Jesus de Otoro	12	30.2	40%			47.4	25%
San Pedro del Norte	26.3	147	18%	334	8%	111	24%

Source: Adapted from (Kosoy, Martinez-Tuna et al. 2007)

Interviews by Corbera et al (2006), and responses to a survey by Kosoy et al, (2007) both suggest that participation might also be motivated by other benefits, as has also been found by other authors (Dalton, Lilja et al. Forthcoming). In this case, they include training and technical assistance for SWC practices that improve production, other benefits from forests - e.g., timber, firewood, non-timber forest products, scenery and legacy, social pressure, and the threat or fear of regulation or expropriation if landowners do not change their practices. Landowners may also have an incentive to overstate their costs as a bargaining tactic for higher payments, may gain by maintaining forests in areas not suitable for agricultural production, and may regard payments simply as a token of support for activities that are of mutual interest (Kosoy, Martinez-Tuna et al. 2007) (Corbera, Kosoy et al. 2006).

The payment amount, decided through political negotiation, also has little relationship to the estimates of willingness to pay. In Jesus de Otoro, the payment was only 3.6% of the estimated WTP. However, it is regarded as fair, and the service is perceived as good. In San Pedro del Norte, the opposite is true. Kosoy et al (2007) conclude that “social relations, perception, bargaining power, property rights and institutional aspects are probably more useful inputs to PES design than economic valuations” and that more research is warranted on the social embeddedness of markets for environmental services.

Given that financial resources were not sufficient to increase transparency and fully engage stakeholders, participation and awareness of the program were both low. The tasks of identifying priority conservation areas and determining fees were largely undertaken by PASOLAC with limited participation. However, those who participated directly in the program were able to participate in other activities aimed at the improvement of agricultural production. The establishment of a local water committee also led to increased transparency and local participation in management and allocation of water (Corbera, Kosoy et al. 2006) (Kosoy, Martinez-Tuna et al. 2007).

Cuencas Andinas – Lake Fuquene

Among the projects associated with the CONDESAN-GTZ Cuencas Andinas project is a pilot initiative in the Lake Fuquene watershed, 90% of which has been converted to agricultural crops and pasture. This has raised the level of sedimentation, increased nitrogen and phosphorus inputs to the lake, and reduced levels of dissolved oxygen - thereby threatening the lake with eutrophication. The lake in turn supplies several aqueducts that serve downstream municipalities. The main agricultural actors in the upstream areas are traditional potato growers, who are responsible for high amounts of sediment, nutrients from fertilizer use, and other pollutants, as well as cattle ranchers in the lower and mid-range, who have recently shifted from extensive to intensive grazing (Rubiano, Quintero et al. Forthcoming). Lack of water treatment facilities for rural communities also contributes to water quality problems in the lake.

This initiative targeted areas of the watershed where the most sediment is generated, and valued the opportunity costs of alternatives. The opportunity cost of reducing sedimentation by taking land out of production was estimated at US$ 1578/ha for farmers in the upper catchment, and US$ 1255/ha for middle catchment farmers, or US$18 and US$11 per ton of sediment. However, research showed that this expense could be avoided through adoption of SWC practices that are estimated to improve income by approximately 20%, and also reduce the downstream costs of externalities (Rubiano, Quintero et al. 2006).

Although direct payments are not yet being made between these stakeholders, conservation practices have been adopted by small farmers across a 100 ha area through access to low interest loans available for environmentally sustainable production, backed by collateral provided by GTZ. Loans made in the first year have already been repaid, which is indicative of upstream benefits. Currently, negotiations are underway with banks, to increase loans for conservation farming. This will allow researchers to monitor actual impacts on soil and water so that they can demonstrate the provision of downstream benefits (including improved water quality). It will also allow stakeholders to learn whether the program is working, as well as recognize in adequacies in existing strategies, which is expected to lead to a change in values as well as practices. Recognition of the upstream value of conservation, by financial institutions, is helping to establish credibility and is paving the way to a payment program. (Porras and Neves 2006) (Tognetti 2006). In the implementation phase, a special effort was also made to insure inclusion of small poor farmers who were in danger of being left out because they did not belong to the farmer organizations that administered the funds.

Recognizing that availability of information alone won't resolve conflicts associated with environmental externalities, other research and development activities were also carried out in Fuquene and in another Andean watershed called Coello to better understand upstream-downstream relationships and strengthen capacity for collaborative resource management. Experimental economics methods, also known as "economic games," were used to explore different options for internalizing externalities including collective action, payment for environmental service schemes, and regulation. The games are based on real life scenarios of resource use in the watersheds, where the pay offs players earn—which are in real money—depend not only on their own decisions but also on those of the other players.

The results of the games confirmed expectations that cattle ranchers would not be willing to explore ways to improve their management practices given the high income losses associated with change. From the buyer side, the willingness of downstream residents to pay upstream farmers to change practices was higher in scenarios where there was direct communication between stakeholder groups and where payments were made directly to the farmers rather than through an intermediary, indicating a low confidence in existing institutions. Voluntary payments schemes led to better outcomes than compulsory ones, which is consistent with other studies that show that people prefer consensual solutions to regulation (Vélez, Brieva et al. 2004; Rodriquez and Cardenas 2008). Games designed to address willingness of cooperate also found that communication among players improved cooperation and led to better outcomes, however games designed to measure trust among individuals found that downstream residents have a distrust of upstream residents. (Rodriquez and Cardenas 2008). These results have implications for the design of PES schemes, especially in the early stages.

Cuenca City, Ecuador

Watershed management tends to become more comprehensive over time, as new problems become evident, and as capacity is developed. An example is the city of Cuenca in Ecuador, where, according to a case study by Echavarria et al (2004) a growing awareness of threats to the water supply led to the development of a master plan in the early 1980s and to implementation through a program of land acquisition beginning in the 1990s. These eventually led to a program of Integrated Water Resource Management (IWRM) designed to address multiple threats which included: over-allocation of the available water supply, sedimentation of hydropower plants, water treatment facilities and irrigation canals, and wastewater pollution control. This program was carried out through a variety of activities that included scientific assessment needed to identify response options, improvement of monitoring capacity, and training and technical assistance with the development and implementation of management plans.

The Machangara Watershed Council was created to provide a legal framework for participation of diverse stakeholder groups. Under a nationwide decentralization initiative, the municipality was also given a concession to manage the Cajas National Park, which contains 230 lakes and is a key source of water to the city. As part of a plan for expansion of the water supply, there has been interest in developing a payment program to address threats from cattle ranching and agriculture, for which the opportunity costs of changing management practices are high (Echavarria, Vogel et al. 2004).

Activities implemented by Machangara council include pasture improvement and soil conservation programs. Rather than direct payments, farmers in the mid-watershed are provided with training, technical assistance and loans to improve water use efficiency by switching to drip irrigation. As they are paid back, loans are made available to other farmers (Porras and Neves 2006).

Silvopastoral

The Silvopastoral project is aimed primarily at rehabilitation of pastoral areas, but is a well documented case in which PES is used to support upfront costs of conservation practices that would have otherwise been prohibitive. It has also shown tangible results in terms of higher productivity and had greater participation from the less well off households. The project is a joint effort of the World Bank, the Global Environment Facility and the UN FAO, who have funded payments along with training, technical assistance and transaction costs aimed at providing incentives for farmers to adopt forest grazing practices in three pilot initiatives in Costa Rica, Nicaragua and Colombia. These practices are expected to rehabilitate degraded pastures, protect soil, store carbon and promote biodiversity. Also, to improve water quantity and quality through increased infiltration – which reduces runoff and erosion, and through management of waste with biodigestors that convert manure to fertilizer and biogas. Although these practices are also expected to boost productivity sufficient to raise farmer profits by 50% after 5 years (see figure 1), upfront costs such as live fencing and tree planting had prevented their adoption (World Bank 2004).

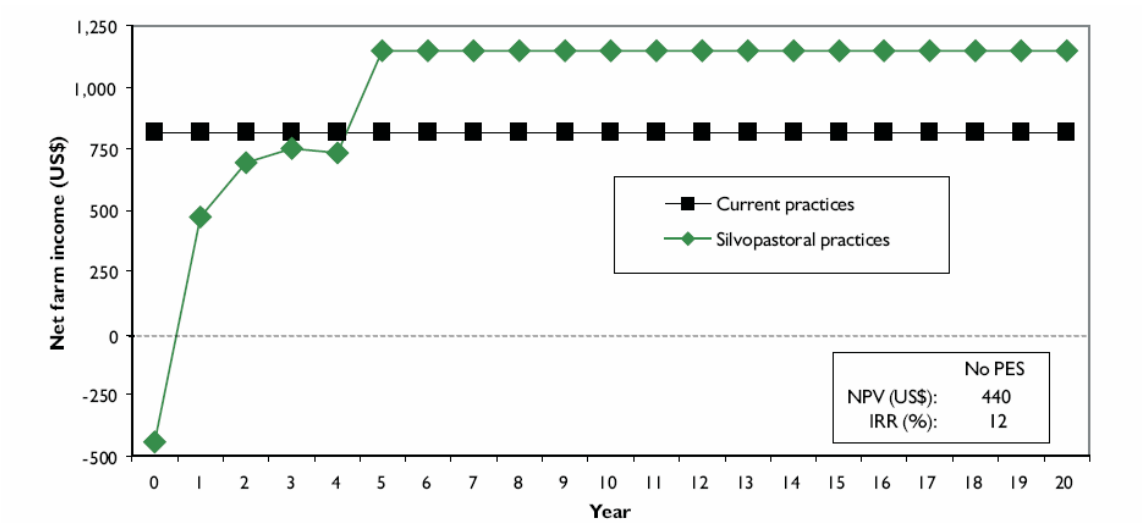

Figure 2: Typical time profile of benefits of silvopastoral systems. Source: World Bank 2004

Payments were only intended to cover biodiversity and carbon sequestration benefits, consistent with the GEF mission to cover global benefits, although it envisioned that payments for watershed services could be added at a later time, as downstream benefits are quantified and beneficiaries become aware of them. To avoid creating an incentive for farmers to clear additional forest prior to entering the program in order to qualify for bigger payments, an additional one time payment was provided up front to cover the benefits of existing services. This also helps to support the higher initial costs of changing practices (World Bank 2004).

Initiated in 2002 and scheduled to last through 2007, the project was implemented on 1950 ha in 6 watersheds in 3 countries. Productivity benefits of 5% were observed on participating farms in a 2004 project report which also noted a 46% reduction in degraded pastures, a 275% increase in pastures with trees, 570 km live hedges, and 15,600 tons of sequestered carbon. Other benefits included the increased knowledge of the 288 farmers who participated regarding integrated management systems and the development of methods to measure impacts (World Bank 2004). A recently published paper that examined data from the Nicaragua project site also found that it also enabled greater participation of the poor, and that in spite of difficulties, they participated to a greater extent than better-off households and undertook more substantial changes in land use (Pagiola, Rios et al. 2007).

US Conservation Reserve Program

The most longstanding program that provides public payments to farmers for conservation purposes is the US Conservation Reserve Program. The triggering event was the Dust Bowl of the 1930s, following which the Soil Conservation Service was formed to provide technical assistance. In the 1985 Farm Bill, it was renamed the US Conservation Reserve Program, and began to award environmental payments to take marginal lands out of production based on a competitive bidding process. For accepted bids, the program also provided 50% of the cost of permanent vegetative cover. This phase came in response to a period in the 1970s when marginal lands were brought into production, in response to a global food crisis as well as to high commodity prices (Ruhl, Kraft et al. 2007).

The main objective at the time was to reduce soil erosion that was disproportionately concentrated on 11% of farmland, but it also resulted in water quality benefits estimated in 1989 at between $3.5 and $3 billion (Ribaudo 1989). Water quality began to be included as a formal criterion for payments in the 1996, when an Environmental Benefit Index began to be used to identify lands eligible for inclusion in the program. In addition to soil erosion and water quality, other key criteria now include: wildlife enhancement, enduring benefits – expected to last beyond the contract period, air quality from reduced erosion, and cost of installing practices for which costs are shared. Also at that time, areas such as riparian buffers and filter strips that provide a high level of diverse kinds of services automatically began to be accepted into the program at a higher payment level.

From 1986 through 2005, the program reports having invested a total of US $ 32.2 billion in the protection of over 36 million acres now enrolled in the program. Yearly costs for 2005 were US $ 1.83 billion. Reported benefits include: reduction of erosion by 450 million tons per year, sequestration of 50 million metric tons of carbon a year, and various kinds of benefits for wildlife, wetlands and water quality (USDA 2007). Specific water quality benefits are not reported by the program itself and are harder to quantify but according to one estimate, the program reduced nitrogen inputs by 681,000 tons/year, reduction of phosphorus inputs by 104,000 tons/year. Hunting and recreational benefits were estimated to be $1.4 billion a year in estimates conducted prior to 2003 (Johnson 2005)cited in: (Ruhl, Kraft et al. 2007).

On working lands, also as of 1985, farmers who receive crop subsidies were required to develop and implement Highly Erodible Land Conservation (HELC) compliance plans by 1995, which resulted in additional reduction of soil erosion of 295 million tons. Together with the CRP and reduction of erosion on other lands either taken out of production or where conservation measures were adopted voluntarily, soil erosion was reduced by 40% or 1.17 billion tons (Claassen 2004). However a 2003 survey found that erosion rates continue at a rate of 1.76 billion tons/year. According to a review by Perez (2007), there have also been difficulties in enforcement of this program. In addition, half of the lands on which there is high erosion have not been classified as highly erodible lands and are therefore not subject to compliance. Subsidies are also provided to farmers in areas of the highest nutrient runoff, which is not addressed at all in the compliance provisions.

As of 1997, more modest funds also began to be provided to share costs for management practices on working lands, in the Environmental Quality Incentives Program (US$ 596,611,480 through 2006). Practices supported include nutrient management, Integrated Pest Management, irrigation water management, and wildlife habitat management. Additional funds were made available in the 2002 Conservation Security Program, to reward those farmers meeting high conservation standards, and to create incentives for doing so through performance standards.

Implementation of performance standards remains a challenge. According to Heimlich (2006), this is not for lack of science, but rather lack of resources necessary to use it. Also, a low tolerance for approximation that is inherent in the measurement of ecosystem processes, and measurement at the farm level, which is meaningless for determining impacts on water and wildlife. The program also has a 15% cap on spending for technical assistance because it is considered a transaction cost.

Given that these programs are supported by public funds and are subject to renewal every five years, they are vulnerable to budget cuts (Ruhl, Kraft et al. 2007). Currently, rising commodity prices also appear to be putting pressure on lands retired under the CRP (USDA 2007), and funding for these agricultural conservation programs is dwarfed by that provided for subsidies. In the 2002 Farm Bill, conservation funding totaled US$ 14 billion, compared with US$ 64 billion for subsidies, while applications for conservation funds remain 75% unfunded (Perez 2007).

European Common Agricultural Policy

Driven by eutrophication of the Baltic and North Sea in the late 1970s and 80s, the European Common Agricultural Policy, or CAP, began to address environmental concerns in a limited way in 1980, when some member states and the European Commission began to contract with farmers for environmental services. However, specific agri-environment measures were not adopted until the “MacSherry reforms” in the 1992 CAP that formally recognized the multi-functionality of agriculture. These reforms obligated states to offer payments to farmers for foregone income and costs of going beyond good practice to deliver environmental services. The payments were decoupled from production and became conditional on cross-compliance with environmental and food safety standards, and maintenance of land in good agricultural and environmental condition. CAP Reforms in 2003 also decoupled most subsidies from production of crops, increased agri-environmental payments, and began to emphasize rural development over large farms, supporting practices consistent with the European rural landscape aesthetic, e.g., hedges, ditches, walls, and maintenance of permanent pasture. (Ruhl, Kraft et al. 2007)

Farmers sign multi-year contracts on lands targeted for their environmental characteristics. Payment rates are established locally, based on consideration of competing land uses. Costs of the program were up to € 2 billion/yr in 2000-2004, shared between the EU and the member states through which the program is implemented. Much of the emphasis has been on support for organic agriculture, which expanded from adoption of 100,000 ha in 1985 to 5.8 million ha in 2005, or 3.5% of EU farmland, driven also by the emergence of a higher-priced organic food market. Organic agriculture has also served to increase rural employment as a result of higher labor requirements, and to reduce agricultural surpluses. Other goals the program has helped to achieve include the reduction of agrochemical inputs, livestock extensification, conversion of arable land to grassland, soil conservation measures, biodiversity protection, rural landscape improvement, and water conservation. (Ruhl, Kraft et al. 2007)

Vittel mineral water

This agreement, between Nestle Waters, owner of the company that produces Vittel mineral water, and farmers in the watershed above the source springs, illustrates the complexity of developing and implementing even a seemingly straightforward payment scheme. It also demonstrates that the process goes well beyond science. Although it is a special case and involved a high value product for which there were no substitute locations, the process it illustrates is one that, with support, could be replicated in other kinds of circumstances. The following is based on a review by Perrot-Maître (2006).

Realizing that intensive farming could threaten the quality of their mineral water, the Vittel company took a proactive approach, by investing US$24.5 million over a seven year period to support the transition from intensive to extensive farming practices that required more capital, land and labor. Before launching the scheme, a four year research program was undertaken by a Vittel subsidiary company in partnership with the French National Agronomic Institute. The purpose of the research was threefold:

To establish relationships between farming practices and water quality.

To recommend changes for more stringent mineral water standards, and

To create adequate incentives for farmers to change their practices accordingly.

Following the study and a ten year period of negotiation, Vittel entered into long-term contracts with 26 out of 37 farmers in the watershed that were committed to the continuation of farming. These contracts provided farmers with subsidies and land use rights for up to 30 years on larger plot sizes (average 150 ha) in return for adhering to specified management practices.

Before joining the scheme, the farmers were all heavily in debt (and in many cases no longer owned their land) as a result of purchasing equipment for intensive farming promoted by the European Union Common Agricultural Policy (CAP). Furthermore, inheritance laws had often made it necessary for farmers to re-acquire fragmented farmland from siblings (among whom it had been evenly divided) in order to continue farming. The Vittel scheme overcame these problems by taking ownership of the land from the creditors and providing farmers with long-term use rights.

The subsidies included 200 Euros per hectare per year for a five year transition period, 150,000 Euros per farmer for new equipment, free labor to apply compost at optimal rates, technical assistance, and an introduction to new social and professional networks to support this extensive farming approach. Payments are based on compliance rather than performance, i.e., the level of service provision, since it is impossible to link change in water quality to practices on individual farms. However, there is extensive monitoring of nitrate levels in the water, as well as farming practices, so that these can be adjusted as lessons are learned.

A major point of contention was how to value the services provided by farmers, and whether to base payments on the opportunity costs of farmers or those of the company. Farmers were in a strong bargaining position since they had the combined ability to radically affect water quality, and since Vittel's strong brand connections to the 'Grande Source' (Great Spring) area (at the foot of the Vosges mountains in northeastern France). This compelled the company to search out a solution. However Vittel is also a major employer in the region, and farmers came to recognize that protection of the 'Grande Source' would in fact be a mutual benefit.

Under the agreement that was ultimately accepted, farmers were offered a way out of debt, which ensured that family farming in medium to large size farms could continue over the next generation without any loss of income. Among the key factors in the success of this initiative is that efforts were made right from the start to understand farmer's livelihood strategies, perspectives, future plans and constraints, as well as engaging them in the research program.

Scientific and economic research was preceded by research on the historical, geographical and sociological context of the watershed. This allowed the company to establish a dialogue and partnership based on mutual interest and trust with those farmers who wanted to continue farming. Other important factors in the success of the arrangement were the existence of strict legislation on mineral spring water, the formation of a locally based intermediary institution whose director became a champion of the cause, and last but not least, the acceptance of risk and uncertainty by everyone involved.

In contrast with annual payments made under the EU Common Agricultural Policy (CAP), the payments made by Vittel reflect a commitment to the long-term viability not only of farming, but also of farm families and communities, which is expected to become sustainable at the end of the transition period. The scheme was made possible by a special set of conditions that may or may not be found elsewhere. However, what is replicable, even outside of Europe, is the process through which the scheme was developed, which gave special attention to context rather than seeking out ideal conditions, and which transformed a situation of conflict into a successful private/public partnership. (Perrot-Maître 2006) as summarized in (Tognetti 2007)

Discussion of case studies

As is illustrated in the case studies, the development of an adequate base of scientific information to demonstrate that proposed land use practices have, or are expected to have measurable benefits, remains a key challenge. Lack of this information has not stopped the development of PES schemes that support SWC, nor is the availability of such information a sufficient condition. However, existing schemes have been based primarily on the adoption of practices rather than on performance with respect to the level of service delivery.

Even in the Vittel case, which was based on a four year research program conducted in partnership with the government, individual farmers are paid for practices rather then for performance, because this can only be measured cumulatively, at the watershed level. However, the package as a whole does provide an incentive for farmers to collaborate to achieve the desired results, as these watershed-scale results are critical to the viability of the payment scheme.

In the PASOLAC cases in Jesus de Otoro and San Pedro del Norte, the relationship between management practices and observed increases in water flow does not appear to have been scientifically confirmed. However the perceived benefits have been sufficient to motivate participation in the program even at a high apparent opportunity cost to providers. Co-benefits that include technical assistance, conflict resolution and environmental services with onsite benefits also appear to have played an important role.

In the Lake Fuquene case, an incremental approach is being taken, beginning at a small scale, with onsite benefits already evident from higher productivity. The goal is to progressively demonstrate offsite benefits, as these become measurable through ongoing research, and at the same time embed the PES in a broader process of sustainable rural development. This is also an objective of the Silvopastoral case, which aims to add watershed services onto an initial focus on carbon sequestration and biodiversity, for which the potential buyers are not geographically restricted to downstream areas.

In the United States CRP and related programs, benefits are demonstrated in the aggregate, through periodic surveys. With the recent addition of payments to create incentives for conservation on working lands, there is now more emphasis on payments for performance. As is discussed in the case study, the obstacle to implementing this approach is not the lack of technical information, but the low tolerance for scientific approximation and uncertainty, which is inevitable given the variability inherent in ecosystem processes. A second obstacle is the limit on technical assistance, which is regarded as a transaction cost rather than an essential component of a program intended to promote innovation, and which relies on learning to support complex adaptive management strategies.

Both the Vittel and the PASOLAC cases demonstrate that technical estimates of economic value, as well as links between management practices and ecosystem service delivery, may have little if any relationship to payment levels. In both cases, payment levels were ultimately decided through negotiation, in which the role of political power is unavoidable. Other important factors were the recognition of interdependencies at the community level and legislation that established stringent water quality standards as a condition for the product to be labeled as mineral water. There was also a lack of alternatives, given the association between the location and the brand name of the product.

Although scientific and technical information alone is not sufficient, by validating knowledge, and helping to clear up myths that can lead to inadequate or ineffective solutions, it can play an important role in informing negotiations and leveling the playing field. It is also likely to be necessary to justify PES in the long term, and to maintain political support for national level public payment schemes, which cannot rely exclusively on the local perception of benefits by downstream users.

The Lake Fuquene case demonstrated the important role of communication. In this case, games among stakeholders provided a platform for mutual learning, and for building trust and common understanding, which ultimately resulted in a higher willingness-to-pay for practices that are expected to improve the conditions of the lake.

As is illustrated in the Vittel case, a payment alone won’t help if the farming system is unviable. It is also important to understand farmer aspirations, to identify mutual interests, and what is needed to support a transition. In other words, to take a proactive, place-based approach by asking what it will take to make it work under given conditions. In this case, Vittel began by identifying those who intended to remain farmers and negotiated a package that included equipment, labor, technical assistance, and access to support networks, as well as a land tenure arrangement that enabled participating farmers to get out of debt. This lesson has important implications for developing countries where migration and off farm employment are playing an increasingly important role in rural livelihood strategies.

Tremendous opportunities for conservation can be seen in the decoupling of subsidies from production, and formal recognition of multifunctionality as the basis for agri-environmental payments in the EU CAP. In the U.S., it has been suggested that tremendous gains could be achieved without added cost by more broadly linking existing agricultural subsidies to environmental compliance.

Lessons learned from PES that can improve agricultural soil and water management

The most fundamental challenges in the development and implementation of PES schemes are to justify them by demonstrating that proposed land use practices will have measurable benefits, as well as to build stakeholder trust in the institutions through which they are implemented. Drawing on the case studies discussed above, and on previous reviews, a number of lessons learned can be identified that are particularly relevant to the use of PES to promote SWC, that illustrate some of the special challenges inherent in this approach, and that suggest a way forward. First and foremost is the need to clear up popular misconceptions, and to avoid creating expectations that markets provide a panacea. Also, ecosystem processes as well as collaborative endeavors are inherently variable. Although technical information can help to better understand trade-offs, and can better inform negotiation and learning, values and outcomes ultimately depend on what choices are available in a specific context. As a way forward, a place-based approach is suggested to better understand the context, and develop arrangements that complement livelihood strategies.

Dispelling myths

Before benefits can be demonstrated, it may be necessary to dispel various kinds of myths and inappropriate generalizations related to land and water which may lead not only to ineffective or partial solutions, and to an inefficient allocation of resources, but also to placing an inappropriate share of the blame for watershed degradation and water scarcity on marginal groups in remote upland areas - all of which can exacerbate rather than solve problems, or create entirely new ones (Kaimowitz 2004). According to Lambin (2001), these kinds of myths are essentially simplifications of cause-effect relationships based on very generalized models of change, that have a popular appeal because they suggest simple and technical solutions and fit easily into prevalent worldviews. Myths regarding land and water relationships fall into 4 general categories:

Inappropriate generalizations from one site to another, and in particular, application of knowledge from wet temperate to arid and tropical zones.

Forests and water myths – e.g., that forests significantly reduce or prevent flooding and increase dry season flows. As identified in a review by Calder (1999), whether or not either of these occurs depends on numerous site-specific factors that determine the levels of evapotranspiration and infiltration, and therefore, the quantity of water that is available to stream flow, and the scale at which increased or decreased flows of water are significant. For example, forests do improve the permeability of soil and increase the amount of water that can be stored, and may significantly reduce flooding in a localized area. However this tends to have an insignificant impact or to be averaged out at larger scales, where runoff is received at different rates from many different sources in the upper watershed. The types of vegetation that occur, the depth of roots relative to water tables, and whether there is ground cover, will also play a significant role in the amount of evapotranspiration that occurs, and levels of stream flow. Soil that has been compacted as a result of previous management activities, the presence of roads, and other construction associated with development, can also reduce infiltration and change drainage patterns, regardless of whether trees are planted (Calder 1999). Also, as discussed in the introduction of this paper, a key factor in the amount of water infiltration and storage is the amount of organic matter in the soil.

Erosion myths – that soil conservation practices in limited areas upstream can have a significant impact on downstream areas, particularly in arid areas in which rates of erosion are naturally high. For example, modifying land use practices in areas where erosion is naturally high will not prevent sedimentation of dams, though it may have onsite benefits for the farmers (UN FAO 2002). Another fallacy regarding erosion at a landscape level is that it can be determined from plot level measurements, which assumes that all eroded soil has a negative impact, regardless of where it is deposited, and that agriculture is the main culprit (Swallow, Garrity et al. 2001). There is considerable evidence that erosion rates are significantly higher on roads and foot paths and marginal areas such as forest margins and steep slopes (Bruijnzeel 2004). A recent study in an upper catchment in Northern Thailand found that unpaved roads produce as much sediment as agricultural land despite the fact that these roads occupy less than one tenth of the area occupied by agriculture (Ziegler, Giambelluca et al. 2004).

Water scarcity myths – in which upstream populations are unfairly blamed for increases in water scarcity brought about by increases in demand, both upstream and downstream, or by climatic factors. For example, a case study in Thailand suggests that dry season flows have diminished primarily because of a dramatic increase, both downstream and upstream in dry season cultivation and irrigation of soybeans, by those who own paddy fields. However, the focus of regulation intended to address the problem has been on the more vulnerable farmers, who are dependent on rain-fed slopes in areas where significant forest cover remains, who have the least significant impacts on hydrology, and who are regarded as guardians of resources rather than as legitimate users (Walker 2003).

In sum, land use and hydrology interact in complex ways, in which forests are one of several factors that, along with agricultural practices, should be considered in the context of the entire flow regime. Even in small sub-basins, there may be complex interactions between various biophysical aspects and between them and human management systems that may defy the prediction of management outcomes.

An additional underlying myth is that there is a *panacea* or single solution that will solve a complex problem, be it markets, regulations, public or private ownership, or that complex problems such as those associated with land use change are driven by any single factor. What is important is to ask the right questions, in a diagnostic approach that draws on diverse areas of knowledge, so as to better understand the conditions, and determine how policy goals can be most effectively achieved (Ostrom, Janssen et al. 2007).

Ultimately what is needed is a more nuanced and adaptive learning approach to policy. For example, as is illustrated in a review of trends in water policy by Meinzen-Dick

(2007), various kinds of panaceas have been promoted over the past 50 years. These policies, which have alternated between strong control by the state, control by water user associations, and a market approach, have all had successes in some instances, and failures when applied more broadly to diverse conditions. Meinzen-Dick concludes that what is needed instead is an understanding of how these different institutional arrangements complement each other and interact, and the conditions in which various approaches are likely to be successful. For example, as is seen in PES cases, markets rely on government enforcement capacity and often on regulatory caps. Effectiveness of user groups, markets, and the role of government coordination are heavily dependent on scale.

Limits of quantification

External support for the upfront costs of conservation practices, and those that cannot be eventually recovered through higher productivity, will depend on the ability to demonstrate their offsite benefits, and the scale at which they can be detected. As discussed further below, it will also depend on the extent to which they are perceived and valued by downstream beneficiaries, as well as on the rights and responsibilities that underlie those values. To the extent these benefits can be quantified, the level of payment can be made contingent on levels of service provision. This has the added benefit of creating an incentive for upstream land users to demonstrate their ingenuity, and exercise whatever capacity they have for innovation.

Quantification presents as much an institutional problem as a scientific one, in part because most downstream impacts cannot be attributed to individual farms, and in part because it requires collaboration to gather site specific information across a watershed. With respect to carbon storage, agreement is also needed on policies for dealing with impermanence and risk. However, as methods become standardized and accepted, and if soil sequestration becomes eligible for carbon credits under international climate agreements, payments for this service may become a driving force for soil and water conservation practices, as there will be a larger pool of buyers beyond those in immediate downstream areas.

An estimate of the water balance indicates changes in water storage in the soil, provides a framework for quantifying variation in storage and flow, and can be linked to ecosystem processes that produce both onsite and offsite landscape benefits. Storage of water in soil also enables the retention of nutrients and organic matter, which contributes directly to carbon sequestration. Where data is lacking, it can be supplemented with local knowledge that farmers typically have. The water balance can also provide a structure for initiating data collection on all of the relevant factors, while the watershed itself provides a convenient geographical framework (Tognetti, Mendoza et al. 2004).

Water storage is essentially what remains once streamflow, actual evapotranspiration, and loss to deep water aquifers are subtracted from overall precipitation. The principal component of the water balance is Actual Evapotranspiration (AET), which is also the principal source of variability and uncertainty because it is a function of numerous variables that include climatic factors, vegetation, and land use. Therefore, a major obstacle to the reliable estimation of AET is the difficulty of obtaining site-specific land cover and land use data that reflect all of the significant heterogeneities generally found in a landscape. However, as discussed above, the prospect of benefits may provide an incentive for land users to cooperate in monitoring activities.

While it is necessary to demonstrate links between management practices and outcomes to the extent possible, a key challenge in the development of CRES initiatives will be to manage expectations of complete information and scientific certainty. For example, in the US environmental quality incentives program for agriculture, a key constraint on the use of performance based measures appears to be a reluctance to move ahead with existing scientific tools because they are not believed to be 100% accurate (Heimlich 2006). This is a classic problem in the use of science for policy which reflects either a misuse or misunderstanding, not so much of scientific facts as of the scientific process and variability inherent in complex ecosystem processes.

By beginning with an assessment of assets that support livelihood, and with the more tangible and direct onsite benefits, as well as a reasonable working hypothesis regarding links between practices and larger scale changes, the latter can be addressed incrementally, as scientific capacity is developed, and as longer term data becomes available. As in any other market, uncertainty needs to be accepted as a factor to be considered in negotiation and in policy. The IPCC experience, culminating in their being awarded in Nobel peace prize in 2007, went a long way towards making the public aware of the challenges to using science to make policy.

Synergies and/or trade-offs between services

Even when land and water links can be demonstrated and quantified, a recent literature review on the subject raises questions about whether the magnitude of damages or benefits is likely to be economically significant, when considering only the relationship between land use and hydrology. This will largely depend on downstream economic interests that rely on water, and the scale at which impacts are significant (Aylward 2004). Furthermore, maximizing a single service usually comes at the expense of others. For example, forests may come at the expense of livelihoods unless they are managed for multiple benefits rather than only for carbon or timber, just as the maximization of production in agriculture has come at the expense of supporting and regulatory services.

However, there can also be synergies among many of the values associated with land use practices, which may have economic significance when combined, e.g., biodiversity protection, carbon storage, aesthetic and recreational values as well as on-site productivity. The challenge will be to develop institutional arrangements that allow payments to be pooled, and insure they reach service providers.

Globally, carbon sequestration could become an important driver of markets for bundles of ecosystem services and of changes in land use practices, providing that credits for forest and soil sequestration are available in the next climate agreement. At present, only minor payments for no till practices are available on the voluntary market, through the Chicago Climate Exchange.

The role of negotiation

Although technical information can be critical for clearing up myths and for informing negotiations, it is not sufficient to support a PES scheme. As can be seen in the case studies, values of ecosystem services ultimately depend on bargaining power and on what choices are available. Equity, co-benefits and social factors are also important factors in motivating collaboration.

Areas of negotiation may include:

Reaching agreement on desirable outcomes and policy objectives,

Rights to ecosystem services and responsibilities for their provision, and

Resolving conflict between new and existing uses in achieving an equitable distribution of costs and benefits.

How these issues are resolved has implications for whether or not there are incentives to adopt SWC practices. Forums for negotiation also support social learning, and thereby provide a foundation for placing value on ecosystem services, which would otherwise not be produced.

To create incentives for soil and water conservation, or to achieve any other socially desired outcome, it will first be necessary for all of the relevant stakeholders to agree on what those outcomes are, with inputs from science as well as from local knowledge as to whether they are technically and economically feasible. This provides a foundation for developing comprehensive land and water policies that are consistent with them as well as for considering what economic and regulatory instruments will be necessary to cover the cost of adopting new soil and water conservation practices, that are also deemed fair and acceptable.

For example, the Millennium Ecosystem Assessment developed scenarios to explore the expected outcomes of different kinds of policy choices (MA 2005). Although global in scale, this approach was subsequently used as a tool for community planning in watershed scale projects that generated a guide to the approach (Evans, Velarde et al. 2006) and a series of case studies.

One of these, conducted in the Mae Chaem watershed in Thailand, illustrates this approach in a situation of land degradation and upstream/downstream water use conflict. Scenario workshops conducted with stakeholders in the Mae Kong Kha subwatershed of the Mae Chaem watershed first gave the communities an opportunity to learn and develop a common understanding of the problem of watershed degradation, and to identify the direct and indirect drivers of change, which include underlying policies and lack of rights. By exploring implications for the future of different choices and policies, the communities were able to agree on a preferred scenario in which the land would be managed for multiple functions with an emphasis on agroforestry, and on steps that they could take to achieve this. Among these was to convert to higher value lower input farming methods consistent with this scenario, to develop farmer organizations through which to conduct planning to support production and marketing, and to obtain knowledge and other outside support necessary to make this transition. The workshops were also a source of validation for expert scenarios of change in the region (Thongbai, Pipattwattanakul et al. 2006).

The process can also be expected to generate conflict between new and existing uses that are no longer adequate to support human well-being, and for which a change in practices would bring high opportunity costs. Therefore it may also involve negotiation among stakeholders regarding rights to ecosystem services and responsibilities for their provision, as well as the authority to manage them and participate in policy decisions.

Whether there is an actual incentive to manage soil and water for the production of multiple benefits, and whether stakeholders have access to them, will depend also on the form of property rights or other forms of entitlement, without which, upstream land users will be unable to enter into contractual agreements or be assured of future benefits from conservation practices. They may also risk eviction as values rise for services to which they lack recognized rights (Landell-Mills and Porras, 2002).

However, clear property rights by themselves will not insure conservation. A frequent result of creating individual private property rights and loss of communal rights is illustrated in a case study of the Nyando basin which drains into Lake Victoria in Kenya where, as parcels are passed on to succeeding generations, they become further subdivided and subject to greater farming intensification (Biamah, Stroosnijder et al. undated). Areas of private property can also become de facto open access when investments in conservation practices would not benefit owners. For example, in degradation hot spots, or areas such as roads, footpaths, and steep slopes that contribute disproportionately to degradation, the benefits of soil conservation are entirely downstream because they do not increase onsite production (Swallow, Garrity et al. 2001).

Therefore, it is also important to be aware of the different forms of property rights, the kinds of incentives they create, who they include or exclude from benefits, and the various overlapping and conflicting claims for them, all of which will reflect customary social norms as well as more formal laws. The legitimacy of various claims will depend on the outcome of negotiation and conflict resolution, in which political power is an unavoidable factor (Meinzen-Dick and Pradhan 2002).

By providing land users with greater bargaining power, establishment of rights and responsibilities enables them not only to have a voice in defining desirable outcomes, but also to more effectively participate in the development of management plans as well as other decisions that affect them. Participation may occur through user associations or watershed councils, which can facilitate collaboration and technical assistance in the preparation of management plans, help to overcome language and educational barriers to participation, and provide access to information. Participation can also be expected to improve the quality of decision-making because of the knowledge stakeholders bring regarding the site-specific variability of local conditions, and can make a difference in whether or not goals are achieved, as was found in a review of ten case studies of participatory river-basin management by Mostert et al (2007). When there are many stakeholders with diverse interests over large areas, rights enable more effective participation in larger scale basin-wide regional and national organizations, and also provide a basis for holding them accountable to local livelihood interests.

Payment arrangements for freshwater and other ecosystem services therefore constitute a long term process of institutional development that needs to be considered in the context of broader issues of fairness, democratic governance and also current trends towards decentralization of authority. For markets to work, democratic institutions are essential because there needs to be trust that people will obey rules and abide by agreements made, which is unlikely to occur unless arrangements are regarded as fair (Lipton, 1985). Several case studies show that willingness to pay or to participate in conservation activities, depends not only on expected returns and the ability to pay, but also on whether the payment is considered fair, whether it will be put to effective uses, whether those who pay are able to effectively participate in decisions as to how the revenue is spent, and whether all of the actors participate who are necessary for conservation practices to be effective (O'Connor 2000) (Koundouri, P. et al. 2003) (Porto, Porto et al. 1999) (Kerr and Sanghi 1992) .

The negotiation of fair agreements provides a platform for mutual learning and conflict resolution, as well as a foundation for selecting appropriate economic and regulatory instruments that can create incentives for achieving desired outcomes. Appropriateness will depend on policy decisions that determine how costs and benefits should be distributed. Ultimately these rights and responsibilities determine the distribution of costs and benefits associated with any change in practices and whether there is an incentive to make such changes. Costs for adopting soil and water conservation practices may include those of risk and uncertainty that would accompany any change in practices and adoption of more complex management practices.

Getting the questions right: start from a livelihood perspective

To ask the right questions about ecosystem services, and to get the right science, it is necessary to start from a livelihood perspective, by identifying environmental assets that support stakeholder livelihoods, and factors that influence their decision-making. These can then be traced back to changes in environmental and socio-economic conditions that are being responded to through resource management decisions. Agricultural systems themselves are a response to known ranges of variability in climate as well as to socioeconomic conditions, regarding which farmers can be expected to have important insights.

This provides a very different perspective of PES, in which community well-being and practices for self-provisioning provide the foundation upon which to build capacity for income generation and for provision of ecosystem services that have benefits offsite and at larger scales (Rosa 2006).Often overlooked in initiatives in which payments are provided only for conservation purposes, is that environmental services are directly linked to community production strategies, and are therefore critically important for the communities themselves (Rosa, Kandel et al. 2003).

From this livelihood perspective, a key consideration is the range of variability in environmental conditions, and extreme events rather than average and aggregate conditions. Extreme events are major drivers of ecosystem as well as policy change and are sources of vulnerability and risk to livelihood – and particularly to food security, which is among the key factors in household decision-making. In addition to variations in yield, common changes linked to these extreme and randomly timed events are the transport of sediments and pollutants, most of which occurs in conjunction with storms. Therefore, water quality tends to go down in wet years. Although water quality may improve during droughts, these have other more insidious consequences, particularly since they tend to go unnoticed until they are well underway. Among the benefits of conservation agriculture is that it reduces variability of the yield because it is more resilient to extremes – i.e., droughts, storms, floods, landslides (FAO 2001).

Known ranges of variability can be used to put lower bounds on unknown thresholds of resilience – which refers to the range of variability within which changes can be adjusted to (Holling 1973). Variability in data is also key to understanding the underlying hydrological processes of a catchment (Yew, Dlamini et al. 1997). A dry year worth of data followed by a wet year is generally more insightful than monitoring consecutive years of similar climate regime (Tognetti, Mendoza et al. 2004). Periodic high flows of water, also associated with storms, create disturbances that serve to maintain river channels, riparian areas, wetlands, and mangroves where ecosystem productivity and diversity are concentrated (Poff, Allan et al. 1997) (Whiting 2002).

Soil types and soil moisture are an important source of variability that, combined with topography and climatic conditions contributes to the environmental heterogeneity found across landscapes and that define suitable land use choices. Interactions among these factors are particularly complex in the uplands, which occupy 70-80% of watershed areas (Gomi, Sidle et al. 2002), and are important for identifying landscape "filters" (van Noordwijk, Poulsen et al. 2004), or areas that have disproportionate effects on runoff and sedimentation.

Given the implications of this complexity for management practices and outcomes, stakeholders themselves will often have important knowledge and insights regarding variability in soil and flows of water that can be integrated with current understanding of general hydrologic principles. This "soft knowledge" can be particularly important in the absence of long-term data collection and also for responding to even greater variability that is occurring with global climate change. As reported in a review by (Tognetti, Mendoza et al. 2004) "soft data" are available from local knowledge and professional experience in a region, and have been shown to improve conceptual understanding of hydrology when "hard data" is limited (Seibert and McDonnell 2002) (Oba 2001) (Sinclair and Walker 1999). Archaeological evidence of hydraulic structures is often used to attest to the successful application of local knowledge. More recently, Aboites (Aboites 1998) describes interviews of the Yaqui people in the design of one the largest irrigation schemes in Northern Mexico during the early 20th century, whereby magnitude and frequency of flood peak events were documented by engineers.

By also engaging communities in actual monitoring efforts, in collaboration with researchers who work with them to develop appropriate science based tools, they also gain more direct understanding of watershed processes. In the Mae Chaem watershed in Thailand, this approach, which has been adopted by ASB and partner organizations, has enabled upstream communities to better defend their interests and, by documenting actual sources of pollution, has played a role in conflict resolution with downstream communities. In this case, changes in upstream land use are the result not only of a transition from slash and burn agriculture towards the adoption of more permanent fields with greater use of water, fertilizer and pesticide inputs, but also of logging, expansion of agricultural areas downstream, and establishment of protected areas (ASB 2004).

Technical knowledge is not the only knowledge than communities need to improve their ability to manage resources. In many rural communities, awareness of the policies, institutions and legal frameworks under which water and related resources are management is very low. This is even true where recent legislation has been passed increased the scope of community participation in resource management. Educating communities about their rights and responsibilities is a first step to bringing them into the negotiation process on an equal footing with politically powerful stakeholders. World Wildlife Fund (WWF) and partners are pioneering a approach called the conversatorio which is based on teaching communities their rights and building their capacity to exercise, them. (Candelo et al, 2008)

Starting from a livelihood perspective will also provide insight into important distinctions among stakeholders, such as small and large landowners, who will have different opportunity costs. Often, changes in ecosystem conditions may not appear economically significant in the aggregate, but may be significant to particular stakeholders at particular times and places, such as water during a dry season, when a small change in availability can make a big difference.

The implications of upper watershed complexity for management practices and onsite outcomes is well illustrated in a case study that evaluated the field coverage and effectiveness of implementation of soil and water conservation measures in the Nyando basin in Kenya. Here it was found that this varies from 10 to 95% depending not only on ecological conditions, but also on land use, land tenure, farm size, profitability, livelihood assets of household, contribution of agriculture to household income, and duration of settlement. On farms that did adopt conservation practices, yields were higher. The main constraint on broader adoption is the upfront cost of these measures, combined with low commodity prices that so far, have not shown any gains from trade liberalization (Biamah and Gichuki undated).

Scaling up

Given the large size of upper watersheds, before significant changes in service provision can be detected downstream, soil and water conservation practices generally need to be implemented over a large enough area to have a measurable cumulative impact. In addition to the development of SWC practices appropriate to the context, this will require an adaptive approach that can at least begin to address the conditions that limit the flexibility of individual farmers at different scales. As discussed in this paper, key factors range from availability of various kinds of inputs (land, labor, capital), knowledge to support complex management practices, issues of tenure security and access to markets, to policies that place rural areas at an economic disadvantage and also exclude upper watershed stakeholders from participation in decisions that affect them.

The various kinds of challenges involved in scaling up have been categorized (Menter, Kaaria et al. 2004) as:

Quantitative – which involves increasing the number of people served by or involved in the program through replication of existing activities;

Functional – which involves extending the program by adding new kinds of complementary activities such as marketing services;

Political – which may involve a building a political base necessary to change the rules; and

Organizational – involving changes in organizational structure necessary to increase efficiency and effectiveness.

. As these activities are typically beyond the scope of individual project efforts, the challenge will be to develop mutually reinforcing strategies.

Organizations formed by farmers, landowners, downstream water users, and other intermediary organizations play vital roles that make these initiatives possible and reduce the transaction costs, by negotiating contractual agreements on behalf of groups of buyers and sellers. They may also carry out other vital activities necessary to support innovation that are often considered as transaction costs to be minimized. However, many of these might be more appropriately classified as a permanent cost of landscape level management or the development of new markets, just as existing markets are supported by government agencies that provide law enforcement services and ensure product safety as well as availability of information. For example, preparation of joint management plans, monitoring and technical assistance will be necessary to support adaptive management in a changing landscape, as part of an ongoing process of integrated assessment and learning.

The Landcare movement appears to provide an important model for providing Technical Assistance, which is critical in the development of new practices. This is a voluntary organization originally developed by farmers in Australia to collaborate and share knowledge regarding common problems in land management. For 2006/2007, the Australian government committed $37 million in funding to support Landcare activities that include extension services and grants for natural resource innovation. In Australia, there are now 4000 Landcare groups that involve 40% of farmers who manage 60% of the land. It is an approach that has been followed in other countries particularly Southeast Asia (Australian Government 2007). In a case study of soil conservation in the Philippines, this farmer led approach to extension, with technical support from ICRAF led to broader adoption of natural vegetative filter strips in selected locations. Important factors included the extent to which conditions matched those of the original site, a stable political situation, and absence of competing economic interests found in urbanizing areas. The sub-village level, decentralized, non-hierarchical structure of the Landcare groups, informal networks, and practical hands-on training were also important for knowledge dissemination (Catacutan and Cramb 2004).

According to Al Appleton, the former Commissioner of the New York City Department of Environmental Protection, who negotiated the New York City Watershed agreement, given the difficulties and complexity of developing new institutions, the key is to find a good starting point that can support a unified strategy, aimed at creating sustainable rural landscapes. Even a modest initiative can become a "righteous cycle" in which the flow of ecosystem services produces economic and social benefits that can be reinvested back into the environment, leading to further economic and social benefits. (as reported in Flows #23, (Tognetti 2006))

One point of departure is to provide incentives for collaboration rather than or as a complement to incentives for individual farmers, which can bring benefits of joint efforts and cumulative effects. This could be done by funding various forms of intermediary organizations, e.g., watershed councils, conservation districts, and cooperative conservation projects (Cox 2006) or providing bonuses for cooperative activities or conservation on adjacent lands (Goldman, Thompson et al. in press).

In the New York City watershed agreement, a separate agreement was reached with farmers, that their participation in the development of farm management plans and adoption of their specified conservation practices would be voluntary, and that the program would be managed by the farmers themselves. All regulations were suspended except for one that restricts willful pollution. However, this agreement was conditional upon participation of 85% of farms within 5 years, and upon achieving goals for protection of the entire landscape rather than for individual farms. According to Appleton, reaching just this agreement with farmers took a year, but the requirement was met and non-point source pollution was reduced. (as reported in Flows #7, (Tognetti 2005))

Recognizing that watershed services come in bundles from a single dynamic landscape, an institutional arrangement that is often suggested is to create Ecosystem Service Districts (Goldman, Thompson et al. in press). A precedent for this is in Conservancy Districts, established in the Cuyahoga basin in Ohio, following a large flood in 1913 that exceeded the response capacity of local governments, and led them to support the creation of watershed entities entirely funded through local tax initiatives. These are watershed scale entities that have the authority to tax and control land use. A unique feature of these districts is that they are overseen by a Circuit Court that consists of judges from each of the existing local jurisdictions. The judges in each district appoint a three-member board of directors who are therefore downwardly accountable to these local jurisdictions . (Miami Conservancy District 2007). Water utilities are also an obvious candidate for the role of managing urban and rural exchanges (Appleton, personal communication).

The Conservancy Districts established in Ohio were the critical enabling factor for a more recent conservation strategy developed by Keiser, (undated) that was designed to ease the pressure on land with high conservation value by reducing pollutant loads and storm water volume, increasing green space, public trails, groundwater recharge and base flow and restoring habitat. The strategy resulted in annual savings of $US 1.6 to 5.3 million (compared with the cost of achieving the same result through separate programs) over an area of 1200 acres. This approach may be gaining momentum. Also in the U.S., an Ecosystem Services Council was recently formed in the state of Oregon, by an alliance of business, government and environmental organizations, to support investment in whole ecosystems, and to unify global, state and local initiatives (Ecosystem Services Council 2007).

As in the formation of Conservancy Districts, and the original Soil and Water Conservation Districts formed after the Dust Bowl of the 1930s, collaboration is often triggered in response to events. For example, in Indonesia, the ability of stakeholders to negotiate and obtain tenure security in exchange for implementing agreed upon management plans, was made possible by the fall of Suharto, combined with the efforts of ICRAF and other organizations (Verbist, Van Noordwijk et al. 2006). In Pimampiro, users became willing to pay an increase in water charges after infrastructure improvements had improved the water supply (Porras and Neves 2006). In Fuquene, Colombia, massive floods in 2006 brought the problem of watershed and the lake to national attention and prompted action by the central government (DNP, 2007)

Although there is a global trend towards decentralization of authority that has opened opportunities for greater local control in natural resource management, globalization and economic integration have also resulted in an increase in the power of competing private interests, the loss of traditional land tenure arrangements, and in the diminished capacity of governments (WRI 2005). In parallel with these trends, as limits are reached on developing new supplies of water, there is also a shift in water policy, in which there is increasing emphasis on how existing supplies are allocated (Saleth and Dinar 1999). This also raises questions of rights and rules, and how to recover the costs of water delivery as well as conservation. These trends present opportunities for developing new approaches, but will also require a concerted effort to insure that desired outcomes are achieved.

Summary and conclusion

Efforts to protect watersheds through the establishment of payments for environmental services, have been driven by multiple objectives: to create economic incentives for conservation, and to contribute to poverty alleviation by covering opportunity costs of alternative land uses and added management costs. Also, to ensure the continuity of conservation efforts, by creating self-financing mechanisms that might replace the diminishing availability of public funds for conservation.

In practice, many PES arrangements, particularly in agriculture, are paid from public funds through contractual arrangements between governments and farmers. Apart from large public payment programs for farmers in the US and in Europe, payments have primarily been directed at conservation of forests and protected areas that are regarded as having regional and global benefits, under the assumption this would benefit the poor by providing compensation for the opportunity costs of alternative land uses. However this has not always been the case. In part this is because the poor rely more heavily on small plots for subsistence and face higher opportunity costs when land is set aside for conservation. In part it is for lack of tenure security and other barriers to their participation in contractual agreements.

Although driven by multiple objectives, payments have also been targeted at individual services that benefit particular groups of potential buyers. This creates a danger that, like some past efforts to manage river systems to meet multiple objectives, PES initiatives will ultimately be driven by the more dominant and tangible economic interests and will not benefit the poor unless explicitly designed to do so. This is, above all, a social and political rather than a technical challenge.

Although there are trade-offs between the objectives of payments, as well as between the various kinds of services provided, the goal of poverty alleviation and support for agriculture in remote upland areas is beginning to be a higher priority among international institutions. A newly updated set of case studies reviewed and summarized by IIED (Porras and Neves 2006) suggests that there is beginning to be a more concerted effort to also address the barriers that have prevented the poor from access to the benefits of PES. Also, for PES agreements to include support for improvement of soil and water management practices that may have greater impacts than forest clearing alone (Bruijnzeel 2004). In addition, there is a growing body of literature that is beginning to examine PES from an agricultural perspective, including the recent FAO (2007) report on the State of Food and Agriculture. In the World Bank's 2008 World Development Report, PES is regarded as an important element in a broader development strategy in which agriculture is now recognized as playing a key role. And at least one PES initiative - the Silvopastoral project in Central America, (Pagiola, Rios et al. 2007) - is beginning to provide evidence of higher participation by the poor than by those better off. This initiative exclusively targeted ecosystem services from working lands by providing incentives to make a transition to forest grazing practices.

The focus on upland forests is a partial approach that only targets what may be the more tractable aspects of the problem of land degradation and loss of ecosystem services. Globally, agriculture accounts for 70% of global water consumption – in some areas, heavily subsidized. Upland rainfed agricultural areas, of concern here, have generally been bypassed for being regarded as presenting a less tractable problem and providing a low return on investment. However, strengthening institutions in the upland areas and giving farmers access to benefits of higher productivity, may also give them an incentive to protect neighboring forests from further encroachment. In a case study of a PES initiative in Pimampiro, Ecuador, Wunder and Albán (in press) suggest exploring the potential for complementary ICDP projects that are conditional on forest protection.

As a source of multiple benefits, and as components of the ecosystem that can be managed, soil and water conservation provide a foundation for a more holistic, ecosystem approach, and for responding to multiple threats to human well-being. Their onsite, multiple benefits for livelihoods and health, can provide an entry point for participation in a landscape approach, establishing links to downstream benefits incrementally, as understanding is gained, and as there is an opportunity for stakeholders to learn about threats to services that may have been taken for granted, place more value on them, and build relationships with downstream, as well as regional and global stakeholders. Such processes also build trust in the use of PES as a mechanism for protecting these services. However, unless attention is given to the barriers that prevent access to onsite benefits that enhance productivity and livelihood, they will continue to be encountered.

PES is not a panacea but, as part of an integrated strategy, can play an important role in meeting upfront costs of changing land use and management practices. Among these costs are not only those incurred by individual farmers, but also the development of enabling institutions necessary to scale up, and to promote innovation beyond individual pilot projects. This may require support of national programs. The prospect of payments can also provide impetus needed to develop these institutions, and, with appropriate support, can reinforce efforts to achieve more effective public participation, which has been shown to make a difference in the outcomes achieved.

Carbon storage, which also increases onsite productivity benefits, is likely to become an important driver for changes in land use practices, providing that the next climate agreement allows credits for carbon stored in forests and soils. Unlike watershed services, the benefits of carbon storage are not limited to downstream users, and therefore, have a larger global pool of potential buyers in what is a rapidly emerging market.

The way forward – a place based approach

As a point of departure, a place-based process of assessment is necessary both to demonstrate the economic significance of links between ecosystems and human well-being, to understand what choices are available to land users as well as to beneficiaries of ecosystem services, and to develop initiatives that are appropriate to their context.

The conduct of place-based assessments presents an institutional challenge to the practice of science itself, in which traditionally, the goal has been to identify universal principles, and then determine the kinds of situations to which they can be applied. Although generalizations may be found, in place-based research, according to Lambin et al (2003) the goal is instead to identify the range of conditions and diverse pathways of change. This provides a qualitatively different kind of information that, when combined with comparative analysis and synthesis of case studies, has improved the understanding of land use change. By focusing instead on interactions among all of the factors relevant to a particular place, in their historical and geographical context at different scales, a place-based approach highlights and provides a better understanding of diversity, and of what makes places unique, as well as the choices available. It also helps to avoid the overgeneralizations that have plagued these kinds of payment arrangements, regarding relationships between forests and water, which depend heavily on these dynamic interactions.

By gathering information in context, within a frame of reference defined by stakeholders, rather than in a compartmentalized disciplinary framework, it is integrated to begin with. This perspective then makes it possible to ask the right questions and "get the right science", which is a prerequisite to "getting the science right."

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