



The governance of ecosystem services from tropical upland watersheds

Louis Lebel and Rajesh Daniel

Upland watersheds in the tropics provide a range of crucial ecosystem goods and services. How they are governed can be crucial to human well-being and environmental sustainability. Communities, governments and firms have taken many different approaches to sharing these benefits, negotiating trade-offs between them, and allocating the risks and burdens if services are degraded or lost. This review of policies and projects draws four initial conclusions: (1) multi-stakeholder planning improves the assessment of underappreciated services and users, but does not eliminate importance of power relations; (2) regulations invariably create winners and losers with outcomes that often depend on pre-existing institutions; (3) information and incentives can change behaviours and are therefore important complement to plans and regulations; (4) monitoring is the least well developed area of governance. Many challenges in integrating ecological and social understanding remain.

Address

Unit for Social and Environmental Research, Faculty of Social Sciences, Chiang Mai University, Chiang Mai 50200, Thailand

Corresponding author: Lebel, Louis (louis@sea-user.org)

Current Opinion in Environmental Sustainability 2009, 1:61–68

This review comes from the inaugural issue
Edited by Rik Leemans and Anand Patwardhan

Available online 20th August 2009

1877-3435/\$ – see front matter
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DOI 10.1016/j.cosust.2009.07.008

Introduction

Ecosystem services are the benefits people obtain from ecosystems [1]. The notion was introduced and promoted as an alternative way of thinking about conserving biodiversity threatened by habitat destruction—one in which human well-being is considered more explicitly [2]. At the global level the distribution of valued ecosystem services overlaps substantially with locations important for biodiversity conservation in the tropics [3]. At the watershed level correspondence is more complex, dynamic and context-sensitive [4,5].

Upland watersheds in the tropics provide a range of crucial ecosystem goods and services to people living in them as well as further downstream and elsewhere [5]. These include being sources of food and water,

pollination and pest control for crops, sites for cultural activities as well as providing regulatory services like flood protection, buffering river base flows, carbon sequestration and water filtration. These services are used and valued by different groups at multiple spatial levels [6]. Intermediate services and underlying ecosystem functions, are vulnerable to climate change, invasive species, infrastructure development, habitat conversion, over-use and other human activities [1]. Societies have approached the governance challenges of fair and effective integration among multiple uses and balancing competing management objectives in diverse ways but with only modest success [7].

In this paper we review experiences with governing ecosystem services from upland watersheds of the tropics. We organize our review around a modified production–consumption system's [8] framework that acknowledges providers as just one part of the production process along with ecosystems (Figure 1).

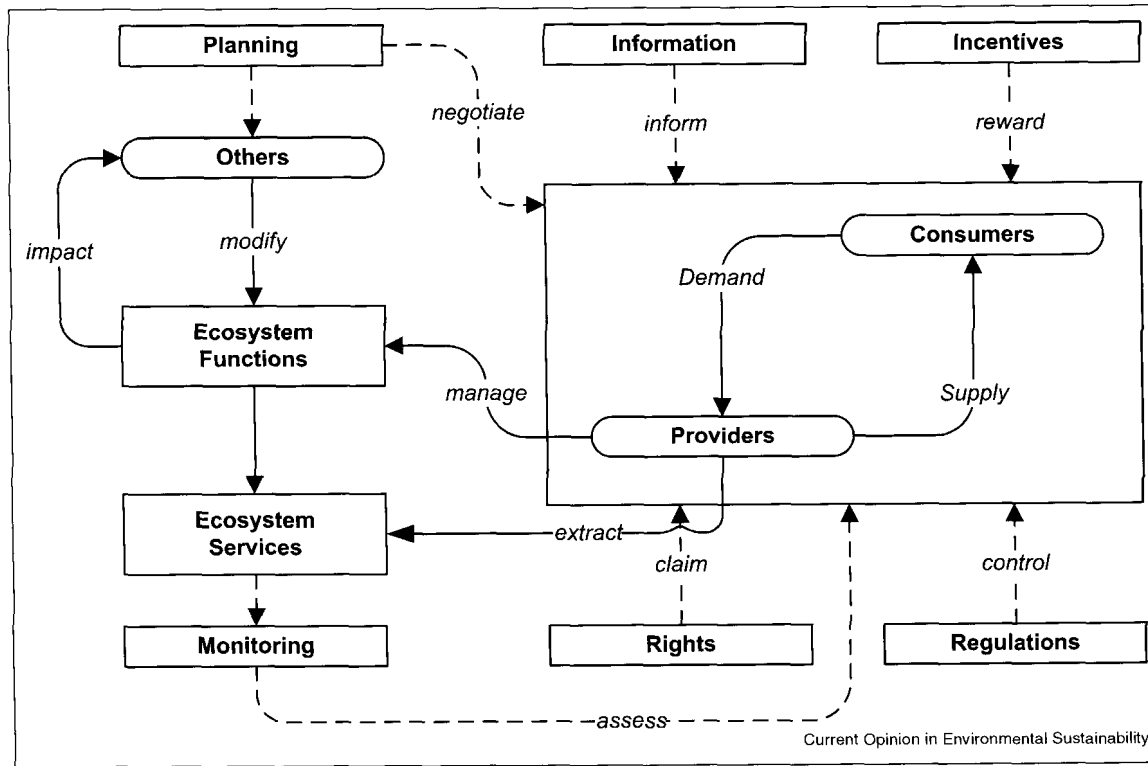
Planning

Spatial land-use planning

A common approach to managing the complex set of services from upland watersheds is through spatial land-use planning by experts. Most conservation policies and strategies of governments are still founded on the basic idea of separating people from their environments [7]. Vast areas of the tropics were declared as protected areas for conserving biodiversity and ecosystem services between 1980 and 2005, but often without corresponding increases in resources or capacity building for management [9]. Although many protected areas are effective at reducing deforestation within their boundaries impacts on poverty alleviation, apart from some local benefits related to tourism, have usually been small [9]. In some areas conflicts over land-use and access to forest resources persist, partly, because protected areas were declared over and adjacent to existing farms and settlements [10].

Governments have also exerted authority over forests outside protected areas to control logging concessions and rents as well as crucial watersheds through land classification and zoning schemes. In this approach regulations prohibit local access or use depending on how a parcel of land is classified, for example, as 'forest' or 'upland'. In Thailand, both forest and watershed classifications were used as instruments to strengthen state control of upland resources, restrict expansion of farmlands in upland catchments and threaten highland farmers with resettlement [11,12]. In practice the schemes are

Figure 1



Framework for the governance of ecosystem service. Three types of actors are explicitly shown: consumers, providers and others who modify or are impacted by the ecosystem providing the services of interest. Providers and consumers may be the same individual or household in self-organized and managed resource systems or might be widely separated in space and scale. Demand–supply relationships may or may not be coordinated by markets. The provider–consumer system is subject to different kinds of compulsory and voluntary initiatives that aim to change actor behavior, ecological sustainability and allocation of benefits, including: planning, information and incentives, rights and regulations, and monitoring.

left incomplete as the Thai state does not have the capacity, political support or available land to resettle the huge number of highland settlements to lowland areas [13].

Moreover, state land classifications do not correspond closely with provision of ecosystem services in many tropical landscapes; swidden, multi-species orchards, and agroforestry may yield more services than mono-crop plantations labelled as forests and assumed to be service-rich [14,15]. In such dynamic and complex landscapes ecosystem services are not coincident and provision varies spatially and over time. Thus, in seasonally dry tropics hydrological services like base stream flows at the end of dry season and flood protection services during wet may both be valued even when how to secure them is not fully understood [16*,17]. In Southwestern China, for example, some analyses suggest that indigenous land-use practices are more beneficial to long-term conservation objectives than protected areas [18,19]. In Mesoamerica others have suggested that densely settled agricultural landscapes should be managed simultaneously for biodiversity conservation and production [20]. Attention to ecosystem services appear to be a particularly promising strategy in

acknowledging and promoting conservation in such working landscapes [2*,21].

Local participation

A recurrent challenge for planning is getting adequate information about ecosystem services at the various scales relevant to decision-making [22*]. Local knowledge is often crucial and usually only available if agencies allow space for meaningful local participation in land-use planning [23]. Participatory land-use mapping and monitoring facilitated by non-government organizations and researchers in the Mae Chaem watershed in northern Thailand is a good example of bringing together both state agencies and communities into negotiations to meet multiple ecosystem service provision objectives [24].

Involvement of multiple stakeholders, including scientific and local experts, can help lead to a better understanding of underappreciated services. In Flores, Indonesia, researchers correlated forest cover in sub-watersheds of a protected area with incidence of diarrhoea in villages of indigenous residents, demonstrating the importance of another, but locally less well known service from forests—purification of drinking water [25].

In an insightful study of watershed management in mixed grazing-cropping landscapes in Ethiopia and Tanzania [26^{*}] negotiations were often crucial to solving collective action problems. Negotiation topics included pest control, soil conservation, spring management, and controls on free grazing. Agendas were set by residents. The community was able to agree on shared patrols of outer fields to protect them from free grazing. But even in this example divergent interests among stakeholders sometimes prevented easy solutions as in the case of private Eucalyptus plantations grown near a spring that the owner did not want to move and was legally protected from having to do so [26^{*}].

Planning with multiple stakeholders can be institutionalised through formation of watershed management committees, organizations or networks. These may be mandated by government or emerge independently to solve local resource allocation problems. Typically such organizations have little formal decision-making authority or budget but take on basic planning, conflict resolution and negotiation functions [27]. In the Upper Ping river basin several river subbasin committees were started with government support and each adopted slightly different committee structures and activity plans to deal with the range of stakeholders and issues important in their subbasin [27]. A challenge in each site was introducing new organizations with recognized cross-sectoral planning mandates against a background where individual agencies and water user groups already had well-organized networks and coalitions [27,28^{*}]. Overall, however, direct involvement of stakeholders in analysis of ecosystem services as a basis for informed negotiations and decision-making is rare [29^{*}].

Rights and regulations

Clarifying property rights

Whether an ecosystem service is a private, public, club or common good may make a substantial difference to practices [30^{*},31^{*}]. Individual property rights are particularly useful to farmers as they encourage investment in land, for example, to growing trees that may not provide returns for many years and formal title deeds are useful as collateral in obtaining loans [32]. Where land ownership is private and unambiguous some non-governmental organizations, like The Nature Conservancy or World Wide Fund, have directly purchased land to protect biodiversity and related ecosystem services [2^{*}]. At the same time pre-existing private property rights may hinder efforts to manage for services at scales larger than individual holdings and require other coordination mechanisms [30^{*}].

Some hydrological services like drinking water supplies from springs or streams are frequently managed as club goods [31^{*}]. Others are effectively managed with common property systems. Many such institutions are highly

local being restricted to a village or even a group of neighbouring households. Rules for community forests, for example, typically specify amounts or seasons during which valued but scarce forest resources can be collected [14,33]. Rules for common pool resources are flexibly bundled, so that allocation of scarce bamboo clumps or trees with resin or others needed for spiritual ceremonies might be allocated to individuals or households whereas access to regrowth might be open to all for grazing [34]. Dealing with hydrological services like flood protection or dry season water flows typically requires coordination at larger scale increasing the political complexity as set of users and uses expand [33].

In remote areas a lot can depend on local institutions and relations with the field officials rather than formal land certificates and regulations [13,35]. When more profitable opportunities emerge, for instance related to eco-tourism or logging concessions, ambiguities in land tenure become more problematic [36]. Clarifying property rights is often an important aspect of governance of upland watershed services.

Management of public lands for ecosystem service must also take into account multiple direct and indirect services. Research about values and ecosystem functions may help prioritise management efforts and deal with trade-offs [30^{*}]. Where services are used by stakeholders with diverse and non-compatible interests public awareness building, consultations and negotiations may be crucial to secure support for management strategies [37].

Responsibilities for management may include co-management arrangements with state agencies, firms and other actors [38^{*},39]. Learning-oriented co-management appears to be particularly well suited to upland watersheds with their dynamic and complex mix of valued ecosystem services [38^{*}].

Policies and regulations

In the tropics a lot of research and policy scrutiny has been directed at forestry and agriculture on sloping lands [16^{*}]. This has been driven by concerns about risks of landslides, soil erosion and sedimentation of waterways in upland areas where rainfall events can be particularly intense. At larger scales floods are blamed on deforestation [40]. Maintaining and restoring the services provided by vegetation has been focus of substantial research and development activities, with increasingly sophisticated attention given to influence of landscape structures on service provision [41] and social organization [23].

Several countries in South and East Asia for example invoked logging bans in native forests in response to serious flood events [42,43]. China also introduced several major policies combining enforcement and incentives to increase forest cover on sloping lands [44]. Although

national in scope successive policies have had major impacts on livelihoods and land-uses in the ethnically diverse subtropical watersheds of Yunnan Province [18,43] leading to, for example, the almost complete elimination of swidden cultivation by the Hani and its replacement by rubber [21].

A typical shortcoming of conventional regulations is that they are inflexible and thus inefficient [31^{*}]. Decentralization provides more scope for adjustments to local contexts. Institutional interplay among levels of governance can be important for capacities to manage resilience allowing greater flexibility to negotiate ecological and social uncertainties and surprises [45]. Allowing for constructive interplay with higher level institutions, especially in case of services valued at global scale such as carbon sequestration, for example, improves institutional designs and project outcomes [46^{*}].

Information and incentives

Building awareness

Understanding about ecosystem services, especially supporting services, is often underdeveloped. Building awareness of the services provided by ecosystems is important to garner public support for their conservation both at level of policies as well as in targeting improvements in management practices in particular watersheds [30^{*}].

Education programs should consider both production and consumption issues (Figure 1). Even donors may also need to be educated about alternative approaches to integrating conservation and development [36]. A range of accounting techniques have been developed to help people understand dependencies on ecosystem services from generalized ecological footprints through to valuation of specific services [30^{*},47]. Participatory and deliberative methods for accounting and evaluation are likely to grow in importance [48] especially where knowledge about hydrological services is strongly contested [16^{*}].

In northern Thailand, upstream, ethnic minority, communities are widely perceived by lowland communities and policy-makers as a threat to, rather than providers of, ecosystem services [35,49]. Nevertheless, a study in Mae Sa watershed found that downstream resources users were willing to pay for water resource improvements and upstream farmers would change practices given adequate compensation [49]. Education around ecosystem service projects may help reduce discrimination.

Information is also important to ensure that the full set of relevant policy options is considered. Forest management practices for carbon conservation and sequestration range from slowing down deforestation and assisting regeneration in the tropics to forestation schemes and agroforestry [50]. Fire and disease management is often crucial to maintaining carbon stocks and fluxes [51].

Accidental and deliberate spread of fires into forests can result in huge emissions of CO₂ destroying carbon stock projects as well as having major impacts on other watershed services [51]. The most significant opportunity in tropical regions for reducing carbon emissions is to avoid deforestation and degradation in the first place [50].

Payments for ecosystem services

Payments for environmental, or ecosystem, services (PES) have emerged as an alternative or complement to spatial planning and regulatory approaches to conservation [31^{*},52]. PES schemes are voluntary transactions in which an environmental service is bought by a buyer from a provider if and only if the provider secures service provision [53^{**}]. Such schemes share similarities to eco-certification of products and other incentive-based mechanisms, like environmental taxes or subsidies [31^{*},54^{*}]. Common challenges include clarifying property rights, getting prices right and linking actions to compensation [29^{*}]. PES appear to be most relevant when an ecosystem service is under threat in marginal lands where opportunity costs are modest and land claims clear [52].

To date only a few such schemes have been operating for a significant period in developing countries; quite a few of these deal with watershed protection and related services. Wunder and Engel [53^{**}] reviewed a sample of programs invoking payments for environmental services that included several studies from tropical South America and found user-financed as opposed to government-financed programs were better in terms of fit to targeted beneficiaries, local conditions and needs, and *monitoring*. China, Mexico and Costa Rica each have large programs giving payments to landowners for changing land-uses [54^{*},55]. The program in Costa Rica established in 1995 pays for carbon sequestration, water regulation, biodiversity conservation and landscape aesthetic services with main proxy being having what would otherwise be agricultural land, forested [55]. Quito, the capital city of Ecuador, has successfully introduced a *Water Fund* that draws on contributions from water users and donors to fund projects that improve the watershed that provides its drinking water supplies [2^{*}]. The program initially struggled to build up adequate funds to implement projects [56], but was eventually successful, as appreciation of the role forests play in improving water quality grew.

In the complex resource management situations typically found in upland watersheds introducing new markets for ecosystem services needs to consider *carefully existing* access rights as well as who is excluded and who will benefit or be at a disadvantage [28^{*},57^{*}]. Poor, marginalized and otherwise vulnerable groups are often more dependent on ecosystem services and have relatively low opportunity costs than others [54^{*}] but their capacities to engage may also be limited. Poor farmers in Vietnam

uplands with small holdings were unlikely to join reforestation schemes unless compensation was adequate to cover loss of food production [58]. Moreover, when there are many poor small providers transaction costs can be high and thus not competitive [54^{*}]. Studies of two carbon sequestration projects in Mexico showed how women and poorest were excluded from designs and that outcomes reflected political affiliations with project managers [57^{*}]. Non-participants (others, Figure 1) in ecosystem services projects may also be impacted adversely, for instance, when landless farmers lose access to common pool resources [59]. Although evidence about welfare impacts remains modest the emerging findings suggest that PES programs, on balance have had relatively small positive effects, and are unlikely to become central to poverty alleviation efforts [59].

Ultimately, how rules are arrived at may matter as much as their final form. Thus, who runs a project is a crucial feature of PES schemes [53^{**},57^{*}]. Intermediaries may be created by service buyers or sometimes a third party. Non-governmental organization may be helpful where farmer's groups (as providers) are not formally recognized or buyers unfamiliar with negotiating directly with farmers [17]. Reliability of the organization and the ability to build trust in schemes are crucial [17,60^{*}]. An assessment of the management capacity of seven organizations that sell ecosystem services from tropical forest in Latin America, for example, found that marketing and client satisfaction were often neglected and that different market actors have very different criteria and preferences making it necessary for suppliers to target offers carefully [60^{*}]. The role of marketing in successful PES activities has not received adequate attention.

Payments must be based on what can be monitored, usually land-use, but in case of carbon sequestration projects more precise accounting is often possible [53^{**}]. Sometimes the evidence-base that links land-use to delivery of particular environmental services is weak [52]. The typical assumption that 'forests' provide the necessary ES is a good example. Another problem is permanence: how to ensure ecosystem services continue to be protected, especially after payments from a particular program or policy end [53^{**}]. Donors may be worried about financing long-term projects and how to handle non-compliance given traditional role as aid providers [36]. Finally rewards or compensation does not have to be direct cash payments to individuals; they could be payments to groups or in form of guarantees of privileged or secure access (such as land tenure) to services or other resources like training [17,61]. Non-financial incentives may be more important to poverty alleviation than direct payments [61]. Despite some important limitations, PES and related schemes are an important addition to the set of policy options and instruments to integrate conservation and development.

Monitoring

Monitoring of policies and projects is important to: detect incomplete or distorted implementation; assess compliance with agreements; evaluate actual impact; and, learn from past to improve future interventions. Monitoring may be undertaken by ecosystem service providers, users or third parties.

Actual management practices for timber, water and other ecosystem services from upland watersheds frequently do not match plans, follow rules or fit expectations on the basis of simple incentives. There are many reasons including uncertainties in how ecosystems and people will respond to interventions, as well as more insidious ones, like deception and corruption [62]. Transparency is crucial to building trust among parties [17,31^{*}].

A key issue for all interventions, whether regulatory or incentive-based, is whether they actually lead to positive changes in ecological sustainability and human well-being that would otherwise not have occurred. A rigorous evaluation requires comparison with baseline or control areas but is rare [30^{*}]. An evaluation of the impacts of Costa Rica's payment for environmental services program using remote sensing, for example, found that deforestation rate in period 1997–2000 was not lower in areas that received payments; the study also noted, however, that deforestation rates were low overall as a result of past conservation policies [55]. An analysis of changes in poverty status of households in two Colombian watersheds suggests that improved watershed management had only very limited impacts on poverty [63^{*}]; the most important livelihood strategies were related to livelihood diversification, in particular, off-farm incomes. Attributing impact to specific policies or projects is not straightforward.

Projects and policies that hope to successfully improve the management of ecosystem services should seek to and expect to learn from past interventions and be flexible enough to update rules to fit new knowledge. A successful forestry program in Mexico that rewards carbon sequestration, for example, had to revise its rules in light of improved understanding of how carbon is traded and how carbon projects should be designed [46^{*}].

Finally on-going environmental changes make the need for adaptive responses imperative. Climate change will impact the services provided by upland watersheds [7]. The spread of invasive species and new emerging infectious diseases are important to both biodiversity and human well-being. Land-use planning and management to sustain ecosystem services will increasingly need to consider movements of animals and plants as climate changes and related disturbance regimes (like fires and floods) also shift [7]. Even in absence of changes in external drivers the consequences of local interventions

are often uncertain requiring monitoring, learning and adaptation [38*]. Monitoring and evaluation, however, are a neglected aspect of ecosystem service projects and policies.

Conclusions

Upland watersheds in the humid and seasonally dry tropics provide a range of ecosystem services. How they are governed has consequences for both ecological sustainability and human well-being. In this paper we divided projects, policies and other initiatives into planning, regulation, information and monitoring.

Planning has conventionally been led by government bureaucrats relying on neat physical and institutional separation into conservation and use. In the tropics there is substantial evidence that meaningful participation of local resource users, managers and ecosystem experts leads to more informed and appropriate plans. Watersheds are useful management units but not the only level for which governance is needed. Multi-stakeholder planning exercises do not eliminate the importance of interests or power relations, but the deliberative elements improve the quality of assessment of underappreciated services and users.

Regulations important for managing ecosystem services can be top-down, self-generated or more frequently a combination of local, informal, rules and national, formal, regulations. With multiple services and interests changes in management brought out by regulations invariably create winners and losers. Projects and policies are always undertaken in the context of pre-existing institutions and power relations that modify implementation and help shape outcomes.

Box 1 Research needs

Most initiatives aimed at improving the management of ecosystem services are based on limited knowledge about both key ecological and social processes. Several research questions stand out:

1. How does biodiversity relate to ecosystem functions and provide the foundations for valued ecosystem services? What are the effects of losses on biodiversity on social-ecological systems?
2. Who benefits and loses from interventions aimed at securing provision of particular sets of ecosystem services?
3. How does the process through which decisions are reached influence the perceived success of ecosystem service projects?
4. Are certain combinations of instruments, voluntary or compulsory, market-based or rights-based, more effective than others in ensuring efficient and fair allocation of the benefits derived from ecosystems?
5. What motivates consumers and intermediary firms to consider ecosystem services and modify their habits in response to concerns about their condition and opportunities to sell or otherwise be rewarded?
6. How can the practical knowledge and experience of ecosystem service managers be integrated more fully into scientific research to further improve the governance of ecosystem services?

Information and incentives can encourage provision of desired ecosystem services. Voluntary approaches are often more flexible than regulations and plans but only work if incentives are adequate or messages and social norms are persuasive enough. Issues of equitable access, and consequently whether or not they contribute to well-being of poorest groups, remain controversial [59,64].

Monitoring is the least well-developed area of governance. Independent and timely post-evaluations of projects and policies are rare [2*]. Most projects and policies have often been pursued in absence of detailed understanding of ecosystem functions and services [65** ,66]. Many challenges in integrating ecological and social understanding remain (Box 1).

Acknowledgements

This review was supported by grant ARCP2008-18NMY-Braimoh from the Asia Pacific Network for Global Change Research and grant PN50 from the Challenge Program on Water and Food with funds from Echel Eau and the International Fund for Agricultural Development.

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