If services aren't delivered, people won't pay: the role of measurement problems and monitoring in Payments for Environmental Services

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Abstract

The idea of Payments for environmental services (PES) has an appealing simplicity, which may explain the success of the concept. However, successful projects are far limited though and two constraints have been identified in literature. The first is limited demand: too few service users are so confident about the mechanism that they are willing to pay. The second obstacle is poor knowledge on the institutional requirements entailing incentive and livelihood mechanisms which so far have received comparatively less attention. This paper focuses on both constraints by arguing that monitoring effectiveness and conditionality of PES schemes are crucial and that institutional arrangements for monitoring should be in place. By analysing in a systematic way what types of measurement problems there are, the paper shows that the type of monitoring that is required within a PES has consequences for the institutional arrangement needed for a successful PES. We find that the institutional arrangements for monitoring vary according to (i) the type of environmental service and its underlying production process, (ii) the extent to which the environmental service can be freely observed or measured, (iii) the extent to which activities of the resource managers who provide the environmental service can be freely observed, and finally (iv) the deterministic or stochastic nature of production processes.

Keywords: PES, monitoring, measurement, institutional arrangement

Introduction

There is an increasing interest in Markets for Environmental Services (MES) as an approach to integrate economic growth, ecological integrity and poverty reduction goals (Hope et al. 2005; Landell-Mills and Porras 2002). Most come down to payments for environmental services (PES) where the ‘demand side’ is often the government (Kumar 2005). Because environmental services have a public good nature, governments have usually taken up the responsibility of maintaining them. Many PES schemes are funded by development agencies or rural development programs, reflecting a combined goal of poverty alleviation and conservation of environmental services. However, recent research has shown that the poverty impact of PES is often mixed at best and may benefit the wealthier who have more natural assets (e.g. large landowners) (Landell-Mills 2002; Hope et al. 2005; Zilberman et al. 2006; Pagiola 2005; Zbinden 2005; Grieg-Gran et al. 2005).

The idea of PES has an appealing simplicity, which may also account for its success in recent years. Proposals to apply PES for various goals abound. Successful implemented PES schemes are far fewer though. Wunder (2005) identifies two key obstacles. The first obstacle is limited demand: too few service users are so confident about the mechanism that they are willing to pay — in some cases, because the link between land use and environmental services (ES) provision is insufficiently understood or ambiguous. The second obstacle is poor knowledge on the institutional requirements entailing incentive and livelihood mechanisms which so far have received comparatively less attention.

Wunder (2005:3) defines a PES as: “*a voluntary transaction where a well-defined ES (or a land-use likely to secure that service) is being ‘bought’ by a (minimum one) ES buyer from a (minimum one) ES provider if and only if the ES provider secures ES provision (conditionality)*”. The last requirement on conditionality is the focus of our paper. It is an extremely important one because it ties in with the first obstacle mentioned by Wunder. As Pagiola and Platais (2005) state: “*If services aren’t delivered, people won’t pay*”. Demonstrating that ES are provided entails establishing a biophysical link between land uses and ES outcomes and developing suitable methods for measuring and monitoring provision of the service. The lack of information to link changes in practices to increased provision of environmental services remains the “Achilles heel” for most PES programs (Pagiola et al. 2002).

It seems that poverty considerations may lead to disregarding this conditionality: *“(…) most implementers seem to shy away from the business-like feature of only paying the providers if they actually deliver the agreed-upon service. In general, they are too concerned about disrupting their relationship with poor rural farmers to withhold payment.”* (Wunder 2006), see also (Scherr et al. 2006; Wunder et al. 2005; Hartmann 2004). Ironically, the concern of the implementers (mostly governments or donor agencies) with poor rural farmers and ignoring the effectiveness of PES programs may compromise the long-term success of PES, jeopardizing the potential benefits of PES for these farmers.

Another important reason why many PES schemes have poor monitoring schemes is that it is often difficult to measure environmental services and to establish a cause-effect relationship between land use and the services (FAO 2004). Relationships among management practices on specific farmers, effects on environmental services, and benefits derived from these services are often complex and not completely understood (Claassen and Horan 2000; Kleijn 2006). Clear and measurable indicators for the environmental services are often assumed. However, these are often lacking as well as a clear link between the agricultural practices and their effect: “*most of Europe's agri-environment schemes have very vague goals, such as to "prevent damage to the environment" or "provide wildlife habitats". Specific targets are not set; progress is rarely monitored; the baselines from which they start are not defined. The good that they do is thus hard to measure, which in some eyes makes the schemes hard to justify*” (Whitfield 2006:908). When a study evaluated these agri-environmental schemes and found them to be less effective than assumed (Kleijn et al. 2001), this led to a storm of discussion and possibly to reduced funding for such schemes (Whitfield 2006). In a follow-up project on evaluation of agri-environmental schemes, one of the conclusions was that “*insights into cause and effect are important for the design/re-design process, for which monitoring and clarity of objectives are key.*” (EASY-project 2006). Finally, Rousseau (2007) concludes that it is pointless to develop conservation policies if they are not complemented with a monitoring and enforcement strategy and that incomplete enforcement has great significance in the government's choice of instrument with which the conservation goal is to be achieved.

This paper analyses the question that if monitoring is indeed necessary for an effective PES scheme but at the same time involves (high) transaction costs, how should monitoring be organised to minimize these transaction costs? It does so by systematically analysing the types of measurement problems that exist, making use of the literature that has appeared in the relevant fields. The paper concludes with a summary of the findings and some hypotheses for future empirical work on monitoring issues.

The role of monitoring in PES

In general, a PES scheme includes certain economic agents (resource managers or farmers) who manage resources that provide a positive environmental externality, or environmental service. This environmental service benefits another group of people, which can be a specific group of people or society as a whole. These beneficiaries can be labelled the 'service demand side' or 'buyers'. For simplicity and following principal-agent theory, we will hereafter call the service providers 'agents' and the service demand side the 'principal', except in cases where we want to describe the type of agent or principal. In many cases the government, representing the interests of the beneficiaries, acts as the principal. We therefore assume there is only one principal and refrain from cases where there are multiple principals entering into contract with one or more agents. We also assume that agents face the same opportunity costs and are symmetric in their influence over the production of the environmental service, although we will relax that restriction at the end[1]. The agents and principal agree on a contract which specifies the actions that the agents should undertake and the payments terms. The principal expects the actions of the agent to lead to certain environmental services, for which she is prepared to pay. The payments cover at least the opportunity costs of the actions implemented by the agent, satisfying the participation constraint. Transaction costs play an important role in PES schemes. Transaction costs are

[1] I therefore do not investigate adverse selection, although this is an important issue in PES (Ferraro, 2005). More attention has been given to adverse selection problems in agri-environmental schemes, compared to moral hazard problems (Ozanne et al., 2001). Adverse selection with fixed and variable costs in PES is taken up in Arguedas, Meijerink, and van Soest (2007).

often under-estimated and may undermine the viability of a PES scheme (Landell-Mills and Porras 2002). Therefore the set-up of any PES scheme must aim to reduce transaction costs. This can be achieved by choosing the most appropriate institutional set-up (Eggertsson 2005).

Payments are conditional on services provided. In some PES schemes, payments are made to communities in the form of community social support, such as building a road, giving access rights or any other royalties, or building a new school or health centre (Noordwijk et al., 2004, Rosa et al., 2003). However, this undermines the conditionality of payments, as these cannot be taken away when environmental services are not supplied. We will therefore assume that payments are made contingent and that non-compliance leads to reduction or discontinuance of payments. Finally, information gathered from monitoring serves as the basis for enforcement.

Although there is a wide range of economic literature on enforcement (see Polinsky and Shavell 2000 for an overview), monitoring and enforcement have often been ignored by both academics and policy-makers when discussing environmental policy alternatives (Cohen 1999). In the economic literature on enforcement, the principal's problem is to choose enforcement expenditures (or equivalently probability of detection through monitoring), the level of fine, the standard for imposing liability and, if relevant, the imprisonment term. Because there is a trade-off between the level of fine and enforcement expenditures, the principal can reduce monitoring costs by imposing high fines (Becker 1968). In PES schemes, the voluntary nature limits the range of punishment mechanisms. Either they do not exist at all (see Wunder et al. 2005), or they are limited either to decreasing payments or to ending the contract completely. In agri-environmental schemes in Europe and the US, the possibility of a fine is often included (Ozanne et al. 2001), but because many PES schemes in developing countries aim to enhance rural development and reduce poverty, imposing a fine on poor resource managers in addition to withholding payments might be considered inappropriate. Thus, in most PES schemes there is no additional fine and the "punishment" consists of reducing payments, which is of a limited range. This can be modelled as limited liability. Given that there is a trade-off between the level of fine and level of enforcement or required monitoring this implies that monitoring and enforcement expenditures cannot be decreased much.

Three main environmental services can be distinguished (Landell-Mills and Porras 2002)[2], these categories are also used by Rohjan and Engel (2005):

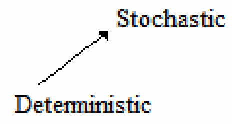
- Biodiversity conservation
- Carbon offset
- Watershed protection

Rohjan and Engel (ibid) categorise these according to production technology. We will do the same but in a slightly different manner. Our criteria are two-fold and linked to monitoring of input (activities implemented by the agents) and outcome (the environmental service). The first criterion is thus at the level of the activities where we make a distinction between those services whereby the individual activities can be measured independently and those whereby the activities influence each other, i.e. the activities of one agent affects the activities or outcome of another agent. The second criterion is at the level of the outcome where a distinction is made between those services that can be attributed to an individual agent and can thus be monitored per agent, and those services that are pooled or joint. This classification is illustrated in figure 1. Following Rohjan and Engel (2005), we characterise environmental services that can be supplied through an independent, an additive or a joint multiplicative production function. One square (bottom left) is left empty because it is technically not possible that a production function is characterised by interdependence but its outcome is not.

[2] Landell-Mills and Porras (ibid) also identify landscape beauty, but we will disregard this service for simplicity, as it is often combined with biodiversity protection.

Figure 1: classification of environmental services according to measurement of input or outcome

		Outcome: environmental service	
		Individual	**Joint**
Input	**Individual**	Production function: *Independent* Example: Carbon offset through tree planting	Production function: *Additive* Example: Groundwater management, watershed protection, decrease of run-off
	Group		Production function: *Joint multiplicative* Example: biodiversity conservation through joint forest management or through agri-environmental management practices



A third dimension is added in the figure and that is whether the link between input and outcome is deterministic, which means that the outcome is completely determined by the activities implemented by the agent, or whether it is stochastic, and that the outcome is influenced by natural processes, such as climate. Most environmental services are more or less influenced by natural processes, and thus the agent has no complete control over the outcome. Generally, in a market, buyers of a good or service pay for the good or service itself, and do not care how much effort was put into the production[3]. When you buy bread from the baker you are not interested in how much effort the baker put into it, you care about the bread you buy. Similarly, buyers of environmental services presumably therefore care only about the outcome of the production process, and not about the activities the resource managers have put into this. Thus, buyers on the environmental services markets would pay a certain price for each tonne of carbon offset, cubic metre of water supplied downstream, tonne of sedimentation reduced, number of rare species protected. This would suggest that monitoring would only need to be done at the outcome level. But this is only possible when the production process of environmental services is almost completely deterministic and the cause-effect relation between input and outcome is clear. Because it is not, monitoring is necessary of the activities implemented by the agents.

[3] Although increasingly, consumers care about the production process: whether it was environmentally friendly, or socially acceptable for instance.

The stochastic nature of the provision of environmental services thus includes a certain amount of risk. It is possible that certain activities have been implemented (at a certain cost), but that natural processes reduce the outcome. For instance, resource owners are paid to conserve a forest, but this forest is burnt by natural forest fires. In some cases, climatic conditions render the activities implemented by the agents ineffective. To illustrate this case, farmers are paid to implement soil and water conservation to reduce soil erosion but in a year with little rainfall there is little erosion anyway and the effectiveness of these structures is negligible. These effects are to some extent measurable – it is easy to verify whether there has been a fire, or the amount of rainfall. But in other cases the exact link between activities implemented by the agents and the resulting environmental service is not clear because the natural processes are not well understood.

The stochastic nature of the production of environmental services means that there is a production risk. Who should bear this risk, the agents or the principal depends on the contract. Especially when the agents are poor and are vulnerable to financial insecurity, the balance should be carefully considered. Rojahn and Engel (2005) discuss the role of risk through environmental processes in optimal incentive contracts (see also Ozanne et al. 2001; Fraser 2002). They observe that the general structure of PES contracts should be a two-part linear payment. The two parts of the payment scheme are a fixed compensation and a variable payment based on the produced amount of the environmental service. They serve to balance risk and reward. In general, risk and risk aversion on the part of the agent increase the risk premium of the agent and in that way their cost of supplying the environmental service. We will not discuss the role of risk further, although we acknowledge that risk and risk aversion are important aspects in designing PES contracts.

Independent production function

An example of an independent production function is tree planting to provide the service carbon offsetting. The activities of the resource managers planting the trees can be easily observed. The outcome, reduced carbon in the air, cannot be observed easily, but the link between the number of trees and the amount of carbon offset is clear and can be measured easily, thus we can safely interpret this as the outcome being easy to measure.

In the most simple case, three criteria are satisfied: (i) the production function is independent, (i) the link between input and outcome is clear and (iii) input and outcome are measurable, and a simple institutional arrangement will probably do. A contract or agreement will specify certain (measurable) targets that need to be met, which can then be verified by the principal with negligible transaction costs. PES schemes are often portrayed in these terms, but this simple case is rare in reality. Even in situations such as tree planting, the principal must make some costs to verify input or outcome. Especially in a PES scheme in which many agents participate, the sum of all monitoring costs can be substantial, let alone the enforcement costs. Monitoring costs can be reduced by using techniques such as remote sensing, which will cover many agents. The number of trees planted and amount of carbon sequestration can be monitored by for instance remote sensing techniques (Vincent and Saatchi 1999), which will reduce monitoring costs per tree planted. Another approach can be to work with groups of agents, where the agents monitor each other and the principal monitors the group, and holds the group accountable for the input and outcome. Ghate and Nagendra (2005) for instance examine the impact of the institutional structure on monitoring and on the effectiveness of forest management in India. They find that local enforcement (i.e. by the agents themselves) has been most effective in the case where forest management was initiated by the communities. However, this approach brings about potential problems of free-riding within a group, and specific solutions must be found for this problem. We will discuss group monitoring below under additive production function.

When outcome can be observed easily, but input cannot, there is a moral hazard situation. In general, in principal-agent models with moral hazard, if the principal observes the outcome but not the action, she can design a payment rule for the agent, based on the outcome, that provides the latter with appropriate incentives to act (Singh 1985; Macho-Stadler and Pérez-Castrillo 2001; Laffont and Martimort 2002). Monitoring is therefore often excluded from principal-agent models. However, Grossman and Hart (1983) in their seminal paper on moral hazard, acknowledge that the assumption that the principal cannot monitor the agent's actions at all may in some cases be rather extreme. In such cases, imperfect monitoring of the activities or effort of agents plays a role.

In the case of independent production, it is not often the case that the input activities of agents can be observed but outcome cannot. Due to the character of independent production, the outcome arises at the same locality as where the input measures are implemented and is therefore usually observable.

Additive production function

An additive production function resembles the independent production function in that each agent contributes to the environmental function independently. But with additive production, the combined effort of several agents produces a joint outcome. For instance, if several farmers reduce pumping of groundwater, the overall water level will rise, which can be measured. We assume here that the contribution of each agent is symmetric and additive. Thus if the outcome is lower than expected or specified in a contract, the principal knows that one or more agents have not contributed. The principal can only find out who by inspecting each agent. If the group of farmers is large, then the costs of inspecting each agent will rise accordingly.

This seems to be another moral hazard problem for which the solution is a contract that entails the right incentives to overcome this problem. But the common assumption in moral hazard is that outcome is freely observable and sufficiently informative about the agent's effort to warrant using it for contracting, which in the case of additive production is not tenable. In the above case, for instance, the outcome (overall water level) is not sufficiently informative about the individual agent's effort. In this case, some form of monitoring becomes necessary (Singh 1985; Baiman and Rajan 1994). The question now is how the principal should monitor the contribution of the agents. In an additive production function, it is possible to monitor the individual activities of the agents and the joint outcome, be it at a cost. There are two alternatives. The first is that the principal inspects all agents to determine who is shirking, and the second is that the principal contracts a group of agents and leaves it to the group of agents to monitor each other. We assume here that the activities of the agents can be observed, be it with (varying) cost.

In the first case, inspection games can be applied to analyse the strategies of the players and establish optimal monitoring (Fudenberg and Tirole 1991). Inspection games have been applied to various problems, including environmental regulation (Avenhaus et al. 2002) and various institutional arrangements, such as including an auditor can be modelled (Rasmusen

2007; Dittmann 1999). Inspection games often lead to mixed strategies, which are not as intuitive as pure strategies because people do not take random actions. But a mixed strategy here can be interpreted as a principal and a number of agents, where the principal selects at random an agent to monitor, with a certain probability. Vice versa, each of the agents chooses to shirk some x percent of the time, and cooperate 100 – x percent of the time.

In the second case of group contracting, the principal can reduce monitoring costs and transfer these costs to the agents. This is appropriate when monitoring costs are high for the principal but lower for agents. One could think of agents who are neighbours and who can easily observe each other's activities. The principal can then choose to inspect the group, which brings us back to the above situation, where the group can be considered as one agent. Establishing a contract with a group of agents has a fundamental difference with the principal-agent relationship and that is that group relationships entail the problem of free-riding since the effect of a reduction on effort (e.g. the principal punishes the whole group) is shared by all agents (Macho-Stadler and Pérez-Castrillo 2001). This problem can be modelled as a non-cooperative game, whereby the players choose between the strategy "cooperate" and put in the required effort levels, or "shirk" and free-ride on the other agents. There are two conditions that enable an agent to free-ride: first, the principal cannot detect who is free-riding and second, the principal pays the group of agents according to outcome and this is shared equally between group members[4].

Enforcement mechanisms do not need to take the form of punishment in the form of imposing a fine. There are various reasons why people will cooperate. This can be morality (people do what is morally right regardless of what other do), altruism (people are willing selflessly to contribute to a public goal), or inequality aversion (people feel guilty when they disadvantage others). However, Barron and Gjerde (1997) find that what they call 'peer pressure' does not always have a positive outcome when agents engaged in group production can detect and punish shirking (see also Kandel and Lazear 1992; Huck et al. 2002 on peer pressure). They describe for instance that there may be a conflict between the principal and

[4] It is interesting that in social psychology literature, various other motivational reasons for shirking ('social loafing') have been found, such as the lack of identification of individual contributions in a group effort, difficulty to establish a relationship between input and output, and a minimum of evaluation potential (Vermeulen and Benders 2003). This suggests that measurement difficulties and the complexity of input-outcome relations in PES actually contribute to shirking in groups!

the agents as to the optimal norm or sanction. The potential punishment agent 1 imposes on agent 2 benefits 1 if it induces greater effort by 2. But agent 1, unlike the principal, may not take into account the cost of such punishment in terms of deterioration on the work environment or psychological cost (such as guilt) for agent 2.

Several authors have analysed the role that punishment, trust and reciprocity play within game theory (Carpenter et al. 2004; Cox 2004; Engle-Warnick and Slonim 2003; Brosig 2002; Gintis 2000) and in common pool resource settings (Castillo and Saysel 2005; Cárdenas and Ostrom 2004). Repeated cooperation leads to players acquiring a reputation of being cooperative. This leads to trust, other players expect a player with a reputation of being cooperative to be cooperative also in the future. They then feel confident to reciprocate and also cooperate. The more repeatedly cooperative behaviour is displayed, the higher levels of trust are attained. However, if players defect and obtain a reputation for being cheats, other players lose trust in them and will no longer be willing to cooperate. The more often a player cheats, the less cooperation will be achieved.

Joint multiplicative production function

A joint multiplicative production function is characterised by the interdependence of production functions of different agents. Besides the fact that natural processes play a role, the activities of the agents influence each other. Their combined activities, no longer independent, lead to a joint outcome. For instance, the effect of the activities implemented in a certain field under an agri-environmental scheme that aims at improving biodiversity (plants, birds etc) depends very much on what happens in neighbouring fields. The implementation of agri-environmental schemes on a small number of interspersed fields, as compared to a scattered distribution of isolated fields, can improve the effectiveness of conservation measures by providing stepping stones for species dispersal (Kleijn 2006). Parkhurst et al. (2002) explored the possibility of achieving adjoining fields through an agglomeration bonus.

Another way of achieving this is by offering group contracts. If it is not just a matter of joining fields but if specific activities of adjoining agents influence each other, it makes sense to contract a group[5] so that agents can coordinate activities. However, this type of group will be slightly different than we discussed in the previous sections and has been labelled team production. Alchian and Demzetz (1972 p. 779) were the first ones to describe team production: "*With team production it is difficult, solely by observing total output, to either define or determine each individual's contribution to this output of the cooperating inputs. The output is yielded by a team, by definition, and it is not a sum of separable outputs of each of its members*." Alchian and Demsetz thus make a distinct separation between additive and joint multiplicative production functions. After the seminal paper of Alchian and Demsetz, team production has been analysed by several authors (specifically Holmström 1982; McAfee and McMillan 1991) and has been applied to many different settings.

If we take the strict definition of team production and assume that it is not possible to observe the cooperation (i.e. marginal productivity) of team members, neither the principal nor the agents can enforce cooperation based on monitoring individual input. This again runs the risk of becoming a prisoners' dilemma in which the Nash equilibrium is shirking by all players. Holmström (1982) has shown that under certainty[6], team incentives alone can remove the free-rider problem. Such incentives require penalties that waste output or bonuses that exceed output. The principal either enforces penalties or offers bonuses. This role is what Holmström calls the 'breaking the budget-balancing constraint'. The free-rider problem is not only the consequence of the inability to observe actions, but equally the consequence of imposing budget-balancing. Breaking the budget constraint will permit team penalties that are sufficient to police all agents' behaviour.

Although the role of the principal as a budget-breaker is certainly a solution to the free-rider problem in the case where agents' activities cannot be monitored, Rojahn and Engel (2005) point out that this type of collective punishment has several disadvantages. Most importantly, it might be perceived as unfair because it may lead to a situation where complying agents are forced to make up for their free-riding agents to avoid punishment. Bowles (2004) adds to this that when there are significant stochastic influences on the level of performance of the

[5] In the Netherlands, farmers have organised themselves into such groups. The European Union has recently allowed that farmers can participate in groups in agri-environmental schemes (IPO, 2006. *Nederlandse Catalogus Groenblauwe diensten 2007*.)

[6] Although group incentives can also work under uncertainty, their effectiveness will be limited if there are many resource managers and if the resource managers are risk-averse. In this case, the need for monitoring arises.

team, which is very possible in PES schemes, Holmström's solution becomes unfeasible. However, it is difficult to find an alternative solution to the case where shirking cannot be detected and this is why Holmström's contribution is so important.

A more fundamental point of criticism is that Holmström's model assumes that the principal and the agents have conflicting interests. However, one could assume that agents will not enter into a voluntary PES contract under a team production scheme when they do not agree with the goals the principal has set. This will be true for some PES settings, especially when PES contracts only pay the opportunity costs such as in many agri-environmental schemes in Europe. Changing the conflicting goals assumption changes the uncooperative situation to a cooperative model. More recent literature analysed moral hazard with several agents under a cooperative model (see Che and Yoo 2001 for an overview; Macho-Stadler and Perez-Castrillo 1993). Cooperation between agents depends on amongst others, whether there exists a group culture or cohesion within a team. This can be achieved by the incentive scheme. According to Harkins et al. (1980; cited in Vermeulen and Benders 2003) rewarding and punishing agents should be based on group outcomes because the individual efforts are not visible. Group rewards are seen as an important determinant for cohesion, as collective rewards increase the 'group feeling'. Case studies in the area of the provision of water-related services by farmers in The Netherlands have demonstrated that interactive learning processes among area-based stakeholders can function as an effective governance mechanism in the water sector (SLIM 2004a; 2004b).

The last case we will shortly discuss here is when joint output is costly to observe and input may also be costly to observe. We have not found many models that incorporate these restrictions. Gautier (1999) developed a model in which the agents and principal invest together to develop a product (in our case a certain environmental service). Agents are responsible for the production of the service, and the principal invests in monitoring. The level of effort by the agents is private information to each agent. The efforts determine, together with a random shock, the output's value. This value remains unknown until the product is brought on the market. There is thus a time lag between input and outcome. For PES this may be a relevant model, as the outcome of activities implemented by resource managers often only appear after a certain period (in the case of watershed services appearing downstream, or number of birds after the breeding season) and are influenced by natural processes (which may take the form of a random shock). In the model, the principal can observe a signal about the output's quality. The accuracy of the signal is affected by the principal's monitoring decision. Without monitoring, the signals are noisy. By investing in monitoring, the principal can observe perfectly informative signals. For PES this may be interpreted as follows. The principal may observe some signal about the environmental service delivered without making too many costs. However, in order to measure the environmental service precisely, the principal must invest in a costly measurement exercise: an extensive survey of agro-biodiversity in an area, or quantity of water downstream.

Conclusions and discussion

Because the idea of PES is so appealing, many PES projects are being implemented around the world. The appeal of PES is enhanced by the fact it can provide poor resource managers an additional income source, thus combining environmental and poverty reduction goals. It seems that because the *concept* of PES is widely accepted, the need is felt less to actually show the effectiveness of PES projects and measure the environmental services provided, or monitor the activities implemented by the resource managers. However, showing the effectiveness of PES is crucial to its long-term success, especially when the private sector is going to buy into the concept and pay for the environmental services they benefit from.

The specific nature of environmental services makes monitoring a multifaceted issue. The institutional set-up of a PES scheme depends on (i) the type of environmental service and its underlying production process, (ii) the extent to which the environmental service can be freely observed or measured, (iii) the extent to which activities of the resource managers who provide the environmental service can be freely observed, and finally (iv) the deterministic or stochastic nature of production processes, or put differently, the extent that natural processes determine the environmental service. Transaction costs arise when costs must be made to measure the activities of resource managers and the environmental services. If these are high, implementing a PES scheme may become infeasible. The institutional arrangements must therefore be such that they reduce transaction costs and maximise pay-offs to resource managers and the principal. This may be achieved by providing different types of incentives, which include payment arrangements and punishments, and different monitoring systems.

We have distinguished three different types of environmental service production processes (following Rojahn and Engel 2005): independent, additive and joint multiplicative. We have shown that there are different monitoring issues for the three production processes. The role of monitoring has been paid relatively little attention, and to our knowledge, the different types of institutional arrangements for monitoring that fit different types of PES schemes and related transaction costs have been often ignored. This paper is a first attempt to shed some light on this issue, but more (empirical) work needs to be done to develop institutional arrangements that on the one hand reduce transaction costs of monitoring and on the other hand show the effectiveness of the PES scheme. This paper has put forward the hypothesis that in case of an independent production function, monitoring can be done on the basis of individual contracts. Depending on the ease with which environmental services can be monitored, different monitoring tools can be implemented (e.g. from remote sensing to individual visits). In the case of an additive production function, monitoring can be done on the basis of a group contract. Different arrangements for monitoring the group and avoiding free-riding behaviour, are possible depending on the type of group. But monitoring is based on joint output and individual activities (input). For a joint multiplicative production function, monitoring should be based on a group contract and based on joint output only.

Empirical work should test whether these options are (a) indeed the most effective (i.e. workable and acceptable to agents) and (b) the most efficient (i.e. minimise transaction costs). As a follow-up to this theoretical work, it is envisaged to test these options in the field. This will be done in the framework of the “Green Water Credits” project that will be implemented in Kenya in 2008. In this project, farmers will be monitored for ‘green water services’ they supply by implementing soil and water conservation practices in their fields. These ‘green water services’ entail increasing the soil moisture content, and by doing so increase groundwater levels and reduce soil run-off. The beneficiaries of these services are multiple, but the main group are the electricity companies that use hydro-electrical dams. These dams need a regular flow of (ground)water and a reduced soil run-off that siltates the dams and damages the turbines. This is an example of an additive production function. Three monitoring arrangements will be tested. The first will entail group contracts (e.g. per village) where the group will monitor each of the members. If certain farmers of the group are found to be skirting (by field visits), this will have consequences for the group as a whole (in terms of payment). The second will also entail group contracts, but monitoring will be done through remote sensing instead of field visits to reduce transaction costs. However, it might be more difficult to pinpoint individual farmers and again a group will be held accountable for any skirting detected. The third will be individual contracts and individual monitoring. This paper asserts that this last option is difficult to implement because output (i.e. increased groundwater flow and reduced run-off) is extremely difficult and costly to measure per farmer. But it is included to test this assertion.

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