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Could Payments for Environmental Services Improve Rangeland Management in Central Asia, West Asia and North Africa?

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ABSTRACT

Although several institutional and management approaches that address the degradation of the rangelands have been tested in the dry areas of Central and West Asia and North Africa (CWANA), impact has been limited. Nonetheless, the development of National Action Plans to combat desertification highlights the interest of governments to tackle this issue. Payment for Environmental Services (PES) may be a viable policy option, though, to date, most PES programs have focused on the management of different resources (forests, watersheds). The purpose of this paper is to examine whether PES could be a viable option to promote sustainable rangelands management in the dry rangelands of CWANA. Specifically, it focuses on the scientific gaps and knowledge related to the local and global environmental services produced by rangelands and addresses questions related to the beneficiaries of these services. Institutional conditions necessary for the implementation of such schemes are discussed.

Keywords: environmental services, rangelands, North Africa, West Asia, Central Asia.

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INTRODUCTION

As the awareness of policymakers, private sector, and civilians for environmental sustainability is increasing and the environmental services provided by various ecosystems of the planet are better recognized, new economic instruments are being developed to internalize these services into market transaction. Payments for environmental services (PES) schemes is one of them, operating under the principle that resource users in position to provide environmental services - through alternative land management and land use practices - should be compensated for the costs of their provision.

To date, most payment schemes for environmental services have been developed for forests protection (Landell-Mills and Porras 2002), biodiversity conservation (Pagiola et al. 2004), or watershed management (Kosoy et al. 2006), but they are not a common approach for rangeland management. Apart from a project[18] that focuses on silvopastoral systems to

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improve degraded pasture land in Latin America, the only case known to the authors is the Natural Resources Conservation Services (NRCS) Grassland Reserve Program in the USA, created in 2002. This voluntary program pays ranchers to restore or protect private rangelands. Other projects in the dry rangelands concern the valuation of environmental services. In south Texas, Lemberg et al. (2002) combined an ecological, hydrological, and economic model to assess the effects of brush control on improved downstream water supply in a large rangeland watershed. In Peru, Quezada (2003) conducted a complete economic valuation of the biodiversity and environmental services of the High Andean grasslands. In Central Asia, the carbon studies component of the Livestock Management and Rangeland Conservation Tools project is providing data on rangeland carbon flux (Wylie et al. 2004).

Fisher et al. (1994) presented evidence that shows that grassland soils can store as much as 70 t/ha of carbon, which is similar to forest soils and much more than previously thought. Farage et al. (2003) caution that semi-arid lands are particularly susceptible to soil degradation and carbon loss, and that management is extremely important in these regions. In addition, appropriate management of the rangelands could reduce wind erosion and frequency of dust-storms, limit the erosion of flora and fauna biodiversity, and improve water productivity.

While the first assessments of PES programs are being released (Sierra and Russman 2006; Alix-Garcia et al. 2005; Mayrand and Paquin 2004), this paper conducts a review of environmental services provided to rangelands in dry areas of Central Asia, West Asia, and North Africa (CWANA) in order to better understand whether Payment for Environmental Services could provide an incentive for sustainable management. Unlike many other PES schemes that are based on individuals undertaking investments or changing management techniques using their own asset base, most of the rangelands in the semi-arid and arid areas of the CWANA region are common-pool resources, meaning that local institutional development as well as the national political and legal framework will be instrumental in evaluating both the costs and benefits of rangeland PES schemes in the region. Determining just who bears those costs and receives the benefits can be quite a difficult task. Thus, given the common-pool nature of the resource, any evaluation must take into account the incentives and capacity to manage the resource base as well as to provide the investments needed to generate public goods in these areas.

ENVIRONMENTAL PROBLEMS AND SERVICES

Rangelands in the drylands of the CWANA region[9] can be defined as non-arable land, i.e. those areas not suitable for crop production due to low (less than 200mm) and highly variable rainfall, shallow soils, a high percentage of rocks, steep slopes, or a combination of these characteristics. The indigenous vegetation is mostly grass or grass-like plants, and shrubs not dominated by trees (Forage and Grazing Terminology Committee 1992). These rangelands contribute to the livelihoods of some of the poorest and most vulnerable communities in the world primarily by providing grazing for livestock.

Rangelands are estimated to cover 555 Mha of West Asia and North Africa, constituting 90 percent of the estimated degraded drylands (Lal 2002), with an additional 240 Mha in Central Asia and the Caucasus. In Algeria, studies of the steppe show a regression of plant cover of over 50 percent and the productivity of *alfa* steppes has been reduced by 4 for degraded grazing and by 50 percent for palatable grazing since the 1970's (Aidoud and

[9] Rangelands in CWANA can include non-arable areas in high rainfall (e.g. mountain) areas. In this paper, we focus on dry rangeland areas, i.e. the steppe.

Nedjraoui 1992). In Morocco, Boulanouar et al. (2000) estimated that 80 percent of the rangelands are moderately degraded, while about 12.5 percent are severely degraded.

Beside these figures from North Africa, information on rangeland degradation is scattered and incomplete, representing a formidable constraint to the development of environmental services markets in the region. Therefore, a first important task is to develop land degradation monitoring and prediction tools, which, together with the development of mitigation options, are three key elements in the current national action plan to combat desertification (UNCCD 2001). However, there are many challenges:

- Many dryland ecosystems are inherently non-equilibrial, meaning that changes do not progress in a gradual and orderly manner from pioneer to climax vegetation assemblages, and evidence of global climate change makes the task of assessment more difficult.
- Monitoring desertification requires aggregating a number of indicators, but there is still disagreement about which set of indicators to use (Squires 2001).
- Even where rangeland specialists agree that a rangeland can be characterized as degraded, specialists, as well as herders themselves, can disagree on the causal factors. Given such uncertainty, identifying concrete management options that both service providers and purchasers agree would lead to greater services is likely to be very difficult.

Nevertheless, in general, scientists agree that rangelands are degrading and that improved management is extremely important in this region. Four main public services could be provided by well-managed rangelands. They include: 1) carbon sequestration, 2) conservation of biodiversity *in situ* and in adjacent agro-ecological zones, 3) wind-erosion reduction, and, finally, 4) improved water productivity and flood erosion control. Below, we review the potential for rangelands in CWANA to generate these services.

Carbon sequestration

According to the 1995 IPCC estimates, rangelands may play an important role in sequestering atmospheric carbon (Allen-Diaz et al. 1996), especially through the large size of these rangelands. World grasslands store anywhere between 200 to 420 Pg C yr^{-1} in the total ecosystem, a large part of this being below the surface (Robert 2001). If the carbon sequestration on optimally grazed lands is greater than on unmanaged lands (un-grazed or over-grazed lands), the effects are inconsistent given the diversity of ecological conditions (Smith et al. 2006).

Data on carbon sequestration potential of rangelands are rare in the CWANA region. Lal (2002a) estimated that the soils of WANA have a potential annual C sequestration rate of 200-400 Tg C yr,$^{-1}$ accounting for 20 percent of the potential of global dryland ecosystems. Among several technical strategies proposed by the author, desertification control offers a potential C sequestration rate of 40-100 Tg C yr^{-1}. In Northen Kazakhstan, Wylie et al. (2004) estimated that rangelands in this ecoregion had an average of 1.27 Mg C/ha sequestration of CO2 during the 2000 growing season. More data are being analyzed to close the annual carbon budget for the Kazakh steppe.

Enhanced biodiversity

Biodiversity provides an agro-ecosystem with the ability to adapt to changes in the environment. A healthy rangeland maintains a high biodiversity not only of the plant species but also of the whole food chain.

Plant biodiversity

Three factors are considered to be the major causes of lost plant biodiversity on rangelands: overgrazing, collection of woody species for fuel, and conversion to cropland.

With overgrazing, the more palatable plant species disappear, and the less palatable or unpalatable species remain filling in the gaps and empty niches (West 1993). Uprooting or cutting of woody species for fuel destroys the microenvironment in which other species flourish. Invader plants dominate overgrazed rangelands and fill in the voids left by the suppressed palatable plants, replacing the diverse biotic-rich native plant communities. Resulting monocultures create their own self-sustaining environment.

As farming becomes more mechanized and population pressure increases, rangeland is ploughed and converted to crop land, destroying the protecting vegetative cover. In these harsh environments, the soil becomes prone to erosion, and within a few years the land is abandoned, reverting back to rangeland. However, once destroyed by cultivation, native species are slow to return, and the vegetation often consists of only a few native weedy annuals. It is nearly impossible to replace the once rich biodiversity by re-seeding or restoration with currently available technology; the rich native biodiversity is permanently lost once rangeland is cultivated. Syria is the only country in the region that attempted to address this issue in 1995 by banning the cultivation of lands below the 200 mm precipitation isohyet (a line drawn on a map connecting points having equal rainfall at a certain time or for a stated period). Yet, most of the land remains devoid of protective native vegetation.

The cost of rangeland degradation and desertification can also be measured in terms of the loss of valuable biodiversity in adjacent agro-ecological zones. This impact is particularly worrying in the Central Asia and Caucasus region, the location of two Centers of Plant Diversity. Although many crops do not originate in the rangelands *per se*, their diversity is affected by the status and use of the rangelands within the context of the broader agro-ecosystems within the region. Over-grazing and mismanagement leads to a decline in plant biomass production and, thus, in the ability of rangelands to provide feed for animal production. As this occurs, demands for cultivated supplementary feed on adjacent agro-ecological zones, which contain valuable agro-biodiversity, are increased. This leads to genetic erosion as the grazing pressure increases in these areas. Evidence of genetic erosion in a heavily grazed range transition zone was observed in 2001 in southeast Azerbaijan by an ICARDA-led plant collection mission (N.I. Dzyubenko, *pers. comm*.). The frequency of pasture and medic species within eight genera had decreased from 72 in the 1920s to 35 in 2001 (Table 1).

Table 1--Genetic erosion of pasture species in southeast Azerbaijan

Genra	Species observed in the early 20th century	Species observed in 2001
Trifolium	12	8
Onobrychis	12	3
Medicago	18	12
Hedysarum	8	2
Lotus	8	4
Melilotus	8	3
Coronilla	4	2
Galega	2	1
Total	72	35

Animal biodiversity

The degradation of the vegetation cover also affects the whole food chain of the ecosystem, from the herbivore insects to the insectivorous birds and the large-sized mammal species (gazelle, caprines). Destruction and degradation of habitats through human activities is the single most serious threat to fauna world-wide and is the cause of 85 percent of globally threatened bird species (BirdLife International 2004). The Northern Bald Ibis (*Geronticus eremita*), a bird considered to have disappeared from Syria more than 70 years ago and recently re-discovered in the country (Serra et al. 2003), could be considered an excellent ecological indicator for the rangelands of Syrian (*Al Badia*). This bird species is listed as globally critically endangered (IUCN 2003); only five adults presently survive in Syria – the last survivors of the whole eastern population once occurring in Southern Europe and the Middle East. The Northern Bald Ibis is an insectivorous colonial bird and was very common within the whole *Al Badia* until only 15-20 years ago. Although habitat degradation is not the only direct cause for the almost extinction of this species from al Badia (heavy human disturbance and uncontrolled hunting being among the key others), the time frame of its inexorable decline coincides with the beginning of the heavy degradation of vegetation cover of al Badia (Serra et al. 2003).

The erosion of flora and fauna diversity can be stopped and even the biodiversity can be improved through rangeland rehabilitation. The rangelands of al Talila reserve, 30 km south-east of Palmyra in Syria, offers an interesting example. After the land had been protected from sheep grazing for about a decade, the difference in vegetation cover and in occurrence and density of fauna species inside *versus* outside the reserve is stunning. For instance, during a three-year bird survey, five species were found only inside the reserve, while four others were detected at significantly higher rates inside the reserve *versus* outside of it (Serra et al. 2005). For ground-dweller animals the comparison is more significant: several mammal and reptile species are found only inside al Talila (G. Serra, *pers comm.*).

Wind erosion reduction

According to the Global Assessment of Human Induced Soil Degradation (GLASOD), most of the wind erosion occurs in Africa and Asia, affecting an estimated 310 Mha. Wind erosion is the result of climatic variations and human activities such as the cultivation of marginal dry areas, fuel and fodder collection, overgrazing and trampling by animals, and off-road vehicle use (Middleton and Thomas 1997). Wind-blown dust can be transported over short to very long distances and affects local communities as well as distant countries and continents in several ways:

- *Soil nutrients transfers:* Wind erosion can remove the fertile topsoil and reduce soil depth, which can result in a shift to less desirable plants. On the other hand, deposits of wind-blown soil can contribute to soil fertility and furnish essential nutrients. Usually wind-blown sediments are more fertile than the surface of the parent soil (Reynolds et al. 2001).

- *Damage to agricultural production systems*: Heavier sediments, which move by saltation, can damage crops, and excessive deposits can bury plants. A coating of dust has been found to increase leaf temperatures and water loss, while decreasing intake of carbon dioxide by plants. In China, for example, millions of dollars are annually lost from the reduction of grain production, decline of quality of vegetables and fruit, and drop in number of silkworm cocoons (Northcut 2001), while in North Africa several oases are buried (Sivakumar et al. 1998).

- *Ecological impact:* By one estimate, anywhere from about 990 to 1,650 tons of soil dust enter the world's atmosphere each year. In fact, dust in the air has been identified as one possible suspect in atmospheric instability and climate change (Northcut 2001). Bacteria and fungi, which are transported in plumes of dust from the Sahara across the Atlantic, are suspected to cause sea fan disease in the Caribbean coral reefs (Shinn et al. 2000). On the other hand, in-cloud photochemical reduction of desert dust can be an important source of bio-available iron, which can result in phytoplankton blooms in oceans (Saydam and Senyuva 2002).

- *Health:* Dust storms increase the risk of human health-related problems. In Australia, it is estimated that 20 percent of asthma problems are linked with wind-borne dust (CSIRO 2000). Animal health can also be affected by dust.

- *Habitation, infrastructure and industry*: Poor visibility causes road accidents, diversion of flights, and closing of businesses and schools, while wind sedimentation can bury roads, fences, railways and other structures. Airborne dust can work its way inside mechanical and electrical components, adding to the costs of maintaining equipments. Another economic impact is the moving of North African real estate to Bermuda (Northcut 2001).

Research has shown that the frequency and severity of dust storms can be reduced to almost negligible proportions through proper management practices. However, to achieve sustainable impact, there is a need for a combination of political, social, biological, economic, educational and engineering approaches (UNCCD 2001).

Improved water productivity

The natural range vegetation in the dry environments of WANA, both annual and perennial, is well adapted to survive long periods of drought and to capture the limited but sometimes intensive rainfall.

Degradation of the vegetative cover of the rangelands, leaves a large percentage of the soil bare. The unprotected soils are affected by sealing and crusting, properties that are found in many soils in the dry areas (Levy et al. 1986). Rain falling during small and low intensity events will evaporate from the hard, bare soil surface or puddles without any productive use, whereas high-intensity and long-duration events will cause surface runoff and flash floods. These surface flows collect in wadis, inland salt sinks or surface depressions, from which the water evaporates back to the atmosphere or infiltrates to recharge the groundwater such as the Nubian Sandstone aquifer below the deserts of Egypt, Libya, Sudan, and Chad (FAO et al. 2003).

The surface runoff also detaches and transports soil particles and valuable nutrients from surface soils, with the fine particles (silt and clay) being carried along with the water to finally settle in depressions. These silts and clay will seal the surface of these ponds, thus, reducing groundwater recharge and increasing the loss of local water resources to evaporation.

The main effects of micro-catchment water-harvesting systems and vegetation restoration would be the reduction of flooding and erosion, and improved local rainfall water productivity. Groundwater recharge is likely to be a minor component. To truly improve groundwater recharge, macro-catchment water-harvesting techniques such as check dams, infiltration basins, and recharge wells are needed (Bouwer 2002). Whatever interventions are made to improve the local water use, any potential effects on downstream water users need to be considered.

BENEFICIARIES AND MARKET DEVELOPMENT

Better rangeland management will have impacts at a range of levels, from a global impact by generating environmental services, which we have seen could be quite substantial, to a local impact. We first consider the beneficiaries, then examine issues of market development as evaluating the services produced and identify the likely purchasers of environmental services. We finally focus on the impacts PES development could have on the providers and the rangeland population.

Multi-scale beneficiaries

Some environmental services will benefit the global population (global good), whereas others will benefit specific groups at regional and local scales (Table 2).

Table 2. Principal benefits and beneficiaries of sustainable rangeland management at various spatial scale.

Scale	Environmental services supplied	Benefits	Beneficiaries / demanders	Monitoring
	Increased carbon sequestration	Mitigation of global climate change	International community / countries, private companies	Soil sampling, eddy flux towers, static chambers, vegetation cover by remote sensing
Global scale	Enhanced plant and animal biodiversity	Enhanced resource base for future generation	Conservation groups, tourism industry, private companies	Survey of key eco-indicators
	Dust storms reduction	Improved health, decreased maintenance costs in infrastructure and industry, decreased damages in agricultural production systems.	Tourism industry, urban populations, government	Remote sensing
National scale	Increased aquifer recharge	Increased water availability	Water users	Groundwater levels, groundwater use
	Flood reduction	Decreased damage of infrastructure (roads, reservoirs), crops and houses.	State (public insfrastructure), utility companies, downstream population	Stage heights at hydraulic structures, reservoir siltation, infrastructure damages
Local scale	Increased water productivity			
	Decrease of soil degradation	Conserve livestock productivity	Local herders	Biomass survey, soil sampling, stocking rate monitoring
	Increase of plant biomass			

The primary beneficiary of carbon sequestration and biodiversity conservation would clearly be the "world" population (including future generations).

Other environmental services such as reduction of wind erosion and sedimentation are beneficial at both the local and regional scales. Reducing wind erosion will benefit the population living in and from rangelands; in addition, small population numbers and less infrastructure susceptible to damage implies that the off-site impacts, particularly dust, may far exceed the on-site impacts (Piper 1989).

Water related services are probably those that offer more balance between on-site and off-site benefits, though it still depends on the individual case in question. Improved vegetative rangeland cover will increase *in situ* rainfall water-use efficiency by turning the rain into biomass, while the reduction of floods will decrease infrastructure and cropland damage downstream. Groundwater recharge interventions could provide water for local communities, or the water could be pumped and piped to more remote villages and towns.

Environmental valuation

Once the beneficiaries are identified, ecosystem services will have to be valuated to facilitate the development of markets. However, because of the inherent spatial and temporal variability of the natural processes involved, and the interdependent and the intangible nature of such services, putting a value on them is difficult (Turner et al. 2003). Today, two conflicting methods are mainly used (Farber et al. 2002): i) the ecological valuation methods that take into account the internal structure of ecosystems and derive value by a cost-of-production approach, but neglect the consumer preferences, and ii) the economic valuation methods, which are based on consumer preferences and combine a set of cost-benefit, hedonic pricing, and contingent valuation methods (Costanza et al. 1997; Bienabe and Hearne 2005) to approach the different environmental values. These systems neglect the ecological interdependencies.

Furthermore, both evaluation systems do not capture the normative and ethical aspects of the ecosystem valuation. In addition, merging the three aspects of nature, economy, and society is the current challenge of valuing ecosystem services (Winkler 2006).

Market development

Carbon sequestration and biodiversity conservation are global public goods; their consumption cannot be attributed to well-identified beneficiaries. Nonetheless, growing public awareness of the benefits of these goods has meant that governments, international NGOs, and private companies are now paying for these services. All the CWANA states, except Iraq, have ratified the Convention to Combat Desertification (UNCCD), the convention on Biological Diversity (UNCBD), and the Convention on Climate Change (UNFCCC), which are necessary for governments in order to access international support for providing such services. The Kyoto protocol has first been ratified by the Central Asia and Caucasus, and lately by the WANA countries (7 countries of the region have not ratified it). The current Kyoto Protocol favors the emerging economies of the Central Asia region, while the WANA rangelands are not eligible under the Clean Development Mechanism.[10]

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[10] Markets for carbon sequestration have emerged since the Kyoto protocol signing in 1997. Rangelands in CWANA qualify under 'Grazing Land Management - Re-vegetation of semi-arid and arid lands with shrubs or grasses', which is not eligible under the Kyoto Clean Development Mechanism (CDM). The CDM for Land Use, Land Use Change, and Forestry (LULUCF) is limited to afforestation and reforestation activities in the first commitment period (2008-2012). However, some Central Asian countries are eligible, as "economies in transition" under Joint Implementation (JI). For the WANA countries, the second window of the BioCarbon Fund will explore options for Emission Reductions through the CDM through activities other than afforestation and reforestation. They are, therefore, not eligible for Kyoto credits in the first commitment period, but may be creditable under emerging carbon management programs.

Parallel to the Kyoto Protocol's CDM, a voluntary market for carbon offsets is emerging, where public or private organizations exchange carbon credits for reasons other than regulatory compliance (Taiyab 2005). Although this market is small, based on highly variable prices (from USD 5 to USD 35 per tCO2), and lacking transparency and standards, it is growing rapidly and could represent a good alternative for the WANA countries.

Unlike carbon sequestration and biodiversity conservation, there are tangible, negative externalities associated with wind and water erosion, where "upstream" users affect "downstream" benefits, which creates a likelihood of downstream beneficiaries having greater incentives to pay for services to reduce wind and water erosion. Additionally, downstream benefits can be both "private" (improved health, less costly expenditures on privately-owned mechanical equipment and crops, more valuable tourism industry) and public (less costly maintenance of infrastructure), meaning again that identifying "demanders" may be easier than the case with either carbon sequestration or biodiversity services.

Finally, different environmental services may not be complementary, i.e. increased investment in providing one service may have a negative impact on other environmental benefits. For example, rehabilitating rangelands through shrub plantations may increase carbon sequestration, but have negative side effects on biodiversity. However, it might also be possible to bundle environmental services (Landell-Mills et al. 2002); combining services for financing might help to avoid this problem. In addition, if single environmental benefits are relatively small on the national scale, merging them could increase the chance of funding in the global arena and increase the payment each provider will receive. Finally, merged bundles (environmental services sold together that cannot be divided among different purchasers) may induce a reduction in transaction costs.

Impact on local population

PES programs are not poverty reduction programs, but their implementation can have a positive impact on reducing poverty when the program is well planned (Pagiola et al. 2005). Potential benefits can be directed through three main channels: i) increase in local environmental benefits themselves, such as reduced wind erosion, groundwater recharge, and flood prevention, ii) local indirect benefits on livestock productivity generated by healthier and better managed rangelands, and iii) payments made to the environmental services providers.

Generally, provision of certain ecosystem services may generate both costs and benefits. For instance, creation of reserve grazing lands or enforcing seasonal stock limits may lead to greater forage productivity and greater diversity of forage species on restricted rangelands, which in turn will lead to improved animal productivity as well as reduced vulnerability to climate events. However, herders may also suffer losses due to reduced access to various range resources while the range is regenerating, and losses from increased grazing pressure on remaining rangelands can be quite high. The net impact will be a function of the options available to reduce rangeland degradation and, in many cases, trade-offs are likely (Section 5.2). Additionally, even net benefits are likely to differ widely among communities and household members.

PES Implementation: Some Institutional Issues

Before addressing issues related to the provision of environmental services, this section considers some institutional issues that will have to be addressed in the implementation of a PES scheme. First, property rights will have to be clarified in order to identify who will be the potential providers of environmental services and therefore the payment receivers. Then, transactions costs resulting from matching the supply and demand side will have to be managed.

Land tenure

Rangelands in these semi-arid and arid areas are generally under some form of state and, sometimes, tribal tenure. Very little is “private” in a conventional, freehold tenure sense. As many authors have noted, the capacity to spread climatic risk by having access to a wide range of pasture resources implies that non-private tenure arrangements are likely to be preferred by livestock owners – and, importantly, others who have secondary (or “weaker”) claims to various resources found on these rangelands (Goodhue and McCarthy 1999; Niamir-Fuller 1999). There may well be significant trade-offs in designing payment mechanisms that recognize and accommodate various rights holders.

We can draw insights, however, from several institutional approaches that have been applied in CWANA. These can be classified into three main approaches (Ngaido et al. 2002): i) state appropriation that implies the revoking of tribal control (with traditional institutions continuing to operate informally and manage range resources) (Rae 2000), ii) control by pastoral communities/organization that consists of giving pastoral communities different degrees of control over the access, use, and management of resources, and iii) formal titling of tribal collective land which provides the tribes with a legal basis for a wide range of property rights.

These different experiences have had limited impacts on halting rangeland degradation; either over-use or under-investment continue to plague these many areas. Taking land directly out of production by the state is usually very expensive since monitoring and enforcement costs tend to be very high. Promoting “group” ownership tends to reduce herd mobility and is made difficult by the fact that identifying who belongs in the “group” is often quite complex. Different clans or sub-clans may have different degrees of access rights to certain range resources; one sub-clan may have what could be considered primary rights, with others’ having secondary claims that are exercised, for instance, in time of drought (Ngaido and McCarthy 2002).

Thus, PES programs and projects must consider the nature and extent of overlapping property rights in these areas, and different contracts can be structured to provide services depending on the underlying property rights. For instance, in certain highly degraded areas where large investments are required or where specific areas of land generate very high environmental services, PES contracts could be structured to pay current rights holders for restrictions or prohibitions on land use under a more traditional state managed arrangement (Ngaido et al. 2002). This strategy is not likely to be cost effective over large land areas that may be demarcated as local tribes managed land or even co-managed by state and local users. Instead, combinations of different tenure systems operating over the relevant spatial scale may enable both an equitable and efficient solution. There is a great deal of interest in many drylands regions to promote innovative property rights systems that enable flexibility in access and use while maintaining or increasing incentives to invest in this vital resources. PES contracts thus need to take into account the value of the current property rights systems in order to develop mechanisms and promote investments that give added-value to the rangelands where possible, and consider options for substituting land use and management practices only in strategically important areas.

Transaction costs

Considering the interaction between local communities and potential purchasers, there are three broad classes of transaction costs involved with implementing PES programs: search and negotiation, monitoring, and enforcement costs. As outlined in Scherr et al. (2004), transactions costs can be very high, and often lead to extremely reduced payments actually going to providers in the case of forest-based projects (Niles et al. 2003 cited in Scherr et al. 2004). Below we consider such transactions costs in the context of rangelands.

Search and negotiation costs

Search and negotiation costs are those arising from identifying a source willing to pay for environmental services and negotiating a contract with that source. Without some centralized clearing-house of information, search costs are likely to be very high, particularly for more isolated, poorer communities where members have limited education and experience dealing with outsiders. Negotiation costs will also be a function of the legal framework under which such contracts are made, plus the extent of bureaucratic procedures that need to be followed in order to secure PES contracts. Networks of local actors are likely to be very important in reducing search and negotiation costs.

Monitoring costs

Both the agent purchasing the environmental services as well as the local community will face monitoring costs; the distribution of such costs will likely be a negotiating point itself and its level will certainly depend on how difficult it is to verify compliance. Monitoring activities are of two types:

1. Assessing land change in order to verify that appropriate investments or management practices have been made. While increased reforestation/afforestation projects might be easy to verify, costs of verifying that changes in management actions have taken place are

likely to be very high for most programs. In the USA, government managers of PES schemes are particularly concerned about payments tied to change in management practices and/or change in use of variable inputs, as these are both extremely difficult to monitor. In addition, debates still rage about the causality between different management strategies (e.g. managing grazing pressure) and biomass, particularly in the semi-arid and arid regions (Vetter 2004).

2. Assessing the impact of land use change on the level of provision of ES in order to evaluate the economic benefits for the purchasers. The lack of information to link changes in practices to increased provision of environmental services remains as the "Achilles heel" for most PES programs (Pagiola et al. 2002).

Moreover, both monitoring activities will differ by environmental services provided (Table 3):

- Carbon sequestration: Several advances in measurements of soil carbon pool have been made so that it can be implemented in a cost-effective manner (Lal 2002b). In addition, carbon pool can be monitored at regional scale using remote sensing of the vegetation cover and land use change (given the limits presented above).
- Wind erosion: Assessing the economic impact of dust storms on crop, human and animal health, the economy and environment is very complex and difficult to quantify. According to Squires (2001), it will take several more years to prepare the necessary information to precisely asses the situation.
- Water: Siltation of reservoirs and damage to infrastructure can be used as indicators of changes in run-off and water erosion due to improved rangeland management. However, the extent of this damage is also affected by the highly variable rainfall. Changes in groundwater recharge can be assessed by measuring groundwater levels and water quality with a network of wells or piezometers, although, actual quantification of groundwater recharge is very difficult, because aquifer properties are often highly variable and are rarely isolated units (De Vries and Simmers 2002). Furthermore, process-based simulation models could assist with an evaluation of the effect of land management changes on potential change in the system.
- Biodiversity: The biodiversity of a certain natural environment can be assessed through the regular monitoring of key ecological indicators. These indicators can be flora or fauna species either strictly associated with particularly valuable habitats or playing a key ecological role in the functioning of the whole ecosystem. Monitoring flora and fauna eco-indicators can be carried out by members of local communities or technicians from government institutions or from NGOs, if suitably trained and equipped.

Table 3--Benefits, costs, and returns of management options for range improvement.

	Controlled grazing	Controlled grazing + shrub plantation	Controlled grazing + shrub plantation + water harvesting	Protected natural range
Environmental benefits				
Increased carbon sequestration	X	XX	XX	XX
Plant biodiversity	XXX	XX	XX	XX
Animal biodiversity	XX	XXX	XXX	XX
Reduced wind erosion	XX	XXX	XXX	XX
Increased aquifer recharge	X	X	X	X
Flood reduction	X	X	XX	X
Increased water productivity	X	XX	XXX	XX
Decreased soil degradation	X	X	X	X
Increase of plant biomass	XX	XXX	XXX	XXX
Local returns (animal productivity)				
First returns (years)	1-3	2-3	2-3	3-5
Variability of returns	XXX	X	X	XXX
Costs				
Investment (capital)	X	XX	XXX	X
Monitoring	XXX	X	X	XX
Enforcement	XXX	XX	XX	XXX
Supplementary feeding	-	-	-	XXX

X: Slight benefit/cost; XX: significant benefit/cost; XXX: large benefit/cost; - : reduced cost

Enforcement costs

Enforcement costs arise in the case of non-compliance and are related to both local, traditional interpretations of property rights as well as the formal legal framework. Those engaging in the contract, and the legal framework under which the contract is signed, must address the very difficult questions of who has both the responsibility and authority for enforcing compliance, what are the punishments for non-compliance, and who has the authority to extract punishments.

Thus, whereas monitoring costs of implementing ES projects might be shared among providers and purchasers, enforcement costs are likely to fall almost entirely on the providers. In other words, groups will have to create legitimate enforcement mechanisms for ensuring compliance amongst group members and bear the full costs of actual enforcement. Costs of enforcement are thus likely to increase as the membership size and spatial distribution of members increases, since both are likely to be associated with weaker social links and greater likelihood of multiple, and, perhaps, overlapping authority structures. Similarly, the technical provision of environmental services often requires that those with rights to geographically-defined resources will need to agree and work together. The ability for different individuals to "self-select" into the group of providers will be far more limited than is the case, for instance, with micro-credit groups. This is true in most cases of management of common resources, but it is worth stressing since other authors have already suggested the success of certain "micro-credit" programs as offering a potential solution to structuring PES contracts in regions with communal property rights.

ENVIRONMENTAL SERVICES PROVISION

In this section we consider issues surrounding supply of environmental services. We consider several management approaches that have been implemented to address land degradation in the rangelands of CWANA, since many of these programs that aim to halt land degradation contain activities necessary to generate the PES identified above. Then, we look at the individual and collective incentives to provide environmental services under several management scenarios. Given that various forms of communal property rights continue to prevail at the local level and based on the nature of externalities involved in the provision, monitoring, and enforcement of environmental public goods, we expect that collective action will play a crucial role in organizing communities to manage the transaction costs associated with the implementation of PES. We conclude the section with a discussion on the implication of heterogeneity in individual incentives for the design of institutions to enable local people to provide environmental services.

Technical options

Until now, the principal intervention in the region has been the government-led establishment of shrub plantations and rangeland reserves. Extensive areas have been planted to fodder shrubs as *Atriplex* spp. (Gintzburger et al. 2000). After periods of resting, native vegetation between the shrubs becomes re-established and produces nearly as much annual biomass as the shrubs; the shrubs also serve as a stockpile of both fuel wood and forage, where forage is used during drought and dry seasons when no other green grazing is available.

Such government-led interventions have had limited success in controlling access to and use of such rangelands, simply because costs of demarcating and guarding the reserves have been relatively high. Without effective grazing management, the plantations revert to degraded rangeland. Such restoration is therefore ineffective without a change in the land use and management that caused the degradation in the first place.

To minimize high management, monitoring, and enforcement issues, several shrub-plantation projects have been implemented where specific social groups, such as extended families or pastoral cooperatives, play a key role. Groups are compensated during the shrub-growing period (2-3 years) based on the opportunity cost of grazing foregone, and thereafter the identified group members are guaranteed exclusive use of the areas. Though such approaches appear to be much more successful, often a legal framework that would enable wide-scale adoption of such approaches is lacking. However, such an approach is quite consistent with other PES programs being implemented for different services around the world; that is, acknowledgement of the foregone opportunities during initial stages is explicitly recognized and assurance of receiving benefits in the future is a key aspect of program development and the institutional framework.

Beside range rehabilitation programs, the use of water-harvesting structures, such as small earth or stone dikes, to capture rainfall run-off is a complementary approach to improving rangelands and to reduce floods. Construction of check dams, recharge ponds or wells, or diversions in *wadis* will slow down the runoff water and will generally improve the recharge of water to the aquifer (Yahyaoui et al. 2002).

The development of a PES program could induce the development of global management plans for community rangelands, with the appropriate mix of technologies and other management options such as rotational grazing that would guarantee the sustainability of the system. This is discussed in the next section.

Individual incentives and collective provision

Below, we consider individual incentives to invest and/or change management of the natural resource base and the group's ability to work together to provide these locally generated environmental services from local common pool resources

Individual incentives to undertake any rehabilitation/management of the rangelands will depend on the technical options chosen. A better economic analysis of the technologies presented above is therefore crucial in order to answer the following questions: Does the PES scheme require substantial investment (shrub plantations vs. native rangeland grazing management)? If so, are the benefits produced pure public goods, in the sense that all benefits accrue to everyone with access rights, e.g. shade bushes planted on common grazing lands? Or, are there mixed "private-public" benefits, e.g. flocks from individuals who planted shrubs can graze the shrubs? How long will it take for returns to be generated? Where the PES program is fully implemented, will such benefits from investment be easily verified, or will fluctuating climatic conditions make it difficult to assess the benefits in the short- to medium term? Similarly, are individuals' actions easily monitored, or do fluctuating climate conditions or a large spatial scale make it difficult to ascertain the extent to which outcomes are related to human activities? What is the scale and scope of the project, and, thus, how many people and/or institutions will need to coordinate, monitor, and enforce the PES program?

Taking as a starting point the vast literature on managing common pool resources (Ostrom 1990; Baland and Platteau 1996), we assume that individual incentives are likely to favour collective action where the returns to ES investments or changes in management practices yield greater returns when more people participate, where such investments produce both public and private goods, where monitoring individuals' contributions is relatively easy, where returns to the investment begin to accrue immediately, and where such returns are less variable.

The actual costs and benefits to different investments and management options are likely to be context specific. Nonetheless, we propose a subjective classification of environmental benefits, implementation costs and returns characteristics for some management options based on the inter-disciplinary experience of the authors in countries of the WANA region (Table 3). For example, investing in shrubs on the common rangeland is easy to verify locally and perhaps even by purchasers; it provides a pure global public good in terms of carbon sequestration and a common good in terms of forage produce for animals. The group required for such investments may be quite small, but the investment may require large up-front outlays, and benefits do not accrue until some time in the future. Reducing grazing pressure through controlled grazing is likely to generate pure local and public goods in terms of increased bio-diversity, reduced soil erosion, and increased biomass. On the other hand, benefits to herders in terms of animal productivity depend on everyone else' abiding by the new limits; both monitoring and enforcement costs are likely to be very high in order to ensure compliance. The spatial scale of enforcement, plus accounting for all those who have periodic access to the rangeland, is likely to increase these costs still further (McCarthy 2004). Impacts on future animal productivity are likewise uncertain and variable. Nevertheless, these results are illustrative, and a proper economic evaluation will have to be implemented on a case basis.

A last point that will have to be taken into account while planning PES scheme is how heterogeneity amongst users is likely to affect individuals' incentives to comply with PES programs. Greater heterogeneity of users is likely to increase the costs of collective action for implementing any PES program. Users might differ in terms of what rangeland products they rely on (forage, fuelwood, medicinal herbs), in terms of exploitation levels (herd sizes), the degree of access, use, management, and exclusion rights (primary vs. secondary or tertiary rights holders), in terms of total wealth (those with and without access to outside income), in terms of social or cultural backgrounds, etc. Benefits to various PES programs are likely to differ across these different types of users, meaning that negotiating amongst users is likely to be quite high. Determining a schedule of who should receive benefits and how much may be quite contentious, though groups may agree that all PES payments be put toward investment in provision of other local public goods (wells, schools, health clinics, roads), functioning like local administrative revenue. Determining the distribution of costs where investments are concerned is also likely to be more difficult in more heterogeneous groups. In the end, however, the resulting distribution of costs and benefits to individuals will affect their likelihood of actively supporting various PES programs, and thus the costs of monitoring and enforcement that the group as a whole will have to bear.

CONCLUSION

Renewed attention is being given to rangelands and the people dependent on them; governments in the CWANA region in particular have shown increased political will to tackle the difficult issues of poverty and degradation of the rangelands. Nonetheless, because of the social, legal, and economic dimensions associated with non-private ownership of rangelands, purely technical options to combat desertification and maintain rangeland productivity are more limited than the options available for development in more favourable areas, meaning that identifying and evaluating alternative management and institutional options is crucial.

Here we have considered both the types of gains that can be expected from improved management of rangelands, as well as some of the institutional issues that need to be addressed if the people living in these environments are to take advantage of PES programs. There are indeed potentially very large benefits to be gained from well-managed rangelands in the dry areas to both rangeland users as well as society at large, particularly wind erosion reduction, conservation of biodiversity, soil carbon sequestration, and improved water productivity. Actually, if the per hectare contribution of rangelands to the global services is smaller that from forests, the contribution applies to vast expanses so that the total services are substantial.

Other than the important task of quantifying and improving scientific knowledge of these various benefits, institutional issues remain. One of the major concerns regarding contracts between providers and purchasers in these environments is the underlying property rights structure which influences just who the service providers are. To make sure that the poor and marginalized groups do not lose their pre-existing rights (be it partial, secondary, or fuzzy), effective mechanisms for identifying current rights holders need to be put into place, perhaps with community members and government officials, and/or local NGO's or civic groups.

Once the group is established, questions regarding the investment and payment schedule, and the monitoring and enforcement mechanisms must be addressed. The transaction costs of implementing such a program will be shaped not only by the individual's incentives, but also by the institutional design and the cooperative capacity of the group to make and enforce collective decisions. Therefore, local community members are far better placed to undertake monitoring and enforcement and to provide at least the first-line of conflict resolution mechanisms. To ensure legitimacy and fairness, such conflict resolution mechanisms should allow for appeal to non-local mediators and to the formal judicial system. Finally, heterogeneity in interests has to be dealt with directly and should be built into the distribution of costs and benefits.

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