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PAYMENT FOR ECOSYSTEM SERVICES AND POVERTY REDUCTION IN RWANDA

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ABSTRACT

Two of the biggest challenges facing Rwanda today are reducing poverty, especially among rural households, and protecting the ecosystems, which provide essential services that support activities, such as subsistence agriculture, collection of safe drinking water, and the harvesting of forest products. Combining these two objectives is not easy and there are numerous pitfalls to effective policy design. This paper explores the possibilities of linking the growing interest in payments for ecosystem services (PES) mechanisms with alleviating poverty of smallholder farmers of Rwanda. Specifically, the potential of PES programs for carbon offsets, water quality enhancement, and biodiversity are analyzed to identify key challenges and opportunities for successful implementation. To have a positive impact on rural farmers, a main recommendation is the integration of PES programs with other rural development initiatives in order to avoid contradictory policies and actions in rural development and land use planning. PES programs also need to be tailored to the specific economic challenges faced by smallholder farmers.

Keywords: Environment, Rwanda, Poverty

INTRODUCTION

Two of the biggest challenges facing Rwanda today are reducing poverty, especially among rural households, and protecting the ecosystems, which provide essential services for a growing population whose survival is dependent on subsistence agriculture, collection of safe drinking water, and the harvesting of forest products. Connecting payment for ecosystem services (PES) with the rural poor could make a significant contribution to both of these challenges. Most of the population in Rwanda consists of smallholder subsistence farmers who produce most of their own food on one hectare or less. These farmers critically depend upon local ecosystems for survival and are directly affected by changes in availability of ecosystem goods and services, such water, medicinal plants, firewood, and raw materials for building. Thus, the loss of ecosystem services important for food, fiber, fuel, and water can be devastating for the rural poor in Rwanda. For example, deforestation has contributed to soil erosion, loss of agricultural productivity, and fuelwood scarcity. The loss of wetlands has threatened the availability of clean water. Subsistence farmers participate in the formal cash economy only in limited ways and, therefore, cannot readily substitute imported food, fuel, or water for declining local resources.

In addition, one of the most important needs for smallholder farmers in Rwanda, as elsewhere, is the need to generate cash income and participate more fully in local markets and, ideally, even regional or global markets. Opportunities for extra income, not only directly improve material standards of living, but also allow for important investments to increase the productivity of the major asset of the rural poor – land. Increased income can allow farmers to invest more in fertilizers, improved seeds, small-scale irrigation projects, and be a cushion during more meager times, such as droughts (Polak, 2008). Payments for ecosystem services could provide such income. By using their land, smallholder farmers can provide valuable services, such as carbon sequestration, water flow, or biodiversity protection. Buyers of such services can include international actors, such as countries or utilities seeking to offset carbon emissions, local entities, such as hydropower facilities dependent on reliable water flows, tourist operators dependent on biodiversity, and nongovernmental organizations. Thus, PES policies can be used as tools to help protect ecosystems and alleviate rural poverty by allowing smallholder farmers to generate income through providing valuable public goods.

THE IMPORTANCE OF ECOSYSTEM SERVICES

The Millennium Ecosystem Assessment (2003) defines ecosystem services as “the benefits people obtain from ecosystems”. The word ‘services’ in ecosystem services refer to both what economists would call goods (i.e. food and fiber) and services (i.e. waste assimilation and climate regulation). The Millennium Ecosystem Assessment categorizes ecosystem services into four different categories – provisioning, regulating, supporting, and cultural. Provisioning services are those physical entities provided by ecosystems. Examples include food, fiber, fuel, water, and some pharmaceutical products. Regulating services include climate control, prevention of erosion, and water purification. Supporting services include ecosystem functions that are necessary for other ecosystem services and include soil formation and nutrient cycling. Finally, cultural services include recreation, the spiritual significance of some ecosystems, and aesthetic values (Millennium Ecosystem Assessment, 2003). There are other ways of classifying ecosystem services, but it is indisputable that ecosystems provide valuable services that are necessary for human wellbeing and would be either very expensive or impossible to replace. For example, in a seminal paper Costanza, d'Arge, de Groot, Farber, Grasso, Hannon, Limburg, Naeem, O'Neill, Paruelo, Raskin, Sutton, & van den Belt (1997) estimated the value of the entire world’s ecosystems to conservatively be around $33 trillion.

We have always been dependent on the services that ecosystems provide. However, for most of human history, the impact of human activity on the provision of these ecosystem benefits was relatively small and localized. Recently, however, as the scale of human activity has increased and the human population has grown, we are altering ecosystems in ways that have never been done before. These changes have begun to threaten many of the crucial services that ecosystems provide. For example, forests are important, among other things, for filtering and retaining terrestrial freshwater supplies. Approximately 4.6 billion people depend on forests for at least part of their water supply, yet over the last 300 years, the world's forest cover has been reduced by 50% through human activity (Millennium Ecosystem Assessment, 2005). Somewhere between 10 and 30 percent of mammal, bird, and amphibian species are threatened with extinction (Millennium Ecosystem Assessment, 2005). This reduction can impair ecosystem function and, therefore, other ecosystem services and reduce the genetic diversity of the world's biota, which is an important resource for pharmaceutical development. Through burning of fossil fuels and land-use change the atmospheric concentration of CO_2 and other greenhouse gases have significantly increased - CO_2 by approximately 34% (Intergovernmental Panel on Climate Change, 2007). This change in atmospheric composition has and will increase global temperatures causing negative impacts on agricultural production in the tropics, flooding of coastal areas, and potentially much more devastating and frequent extreme weather events, such as hurricanes. Overall, over 60% of the ecosystem services examined by the Millennium Ecosystem Assessment were found to have been degraded or are currently managed unsustainably (Millennium Ecosystem Assessment, 2005).

Rwanda specifically has experienced a decline in multiple ecosystem services that impact human well-being. For example, deforestation in mountainous areas and the destruction of wetlands in low-lying areas have reduced the capacity of these ecosystems to filter, regulate, and clean water. Over the past 40 years, Rwanda has suffered very serious losses to its natural areas. Since Independence in 1962, the total area within protected areas (PAs) has been halved: from 4,115 km^2 to 2,073 km^2. The Volcanoes National Park (NP) has lost nearly half of its habitat since the end of the colonial period (310 km^2 to 160 km^2), while Nyungwe NP has lost more than 13% (from 1,175 km^2 to 1,013 km^2). Troubling as this situation is for Rwanda's parks, the losses are greater in the forest areas outside the PA network and wetlands. Of 280 km^2 of natural habitat within the Gishwati Forest Reserve in 1980, only 7 km^2 remain; of the 50 km^2 within the Mukura Forest Reserve, no more than 8 km^2 of degraded habitat remain (Weber, Masozera, & Masozera, 2005). And according to Kanyarukiga and Ngarambe (1998) at least 93,754 ha of the total 164,947 ha of wetland surface area have been cultivated. Degradation of wetlands and deforestation of natural forests has resulted in soil erosion, landslides, and flooding inducing the relocation of people and sedimentation of hydropower plants leading to power shortages and water scarcity in much of the country.

The cost of energy per kWh has increased from 7.5 cents USD in 1997 to 20 cents USD in 2005 (Nile Equatorial Lakes Subsidiary Action Program, 2006). The decrease in energy generation and water scarcity will likely become very significant in the near future as the demand for clean water and energy in Rwanda increases due to economic and population growth. Almost 50% of the agricultural land in Rwanda shows signs of soil erosion indicating a reduction in the capacity of the land to produce food and fiber. A study by Stoorvogel and Smaling (1990) revealed that Rwanda has one of the most severe nutrient depletion rates in Africa, with on average -54 kg N, -20 kg P^2O^5, and -56 kg K^2O per ha per year. As a result, the documented yields of legumes and beans have been declining over recent years (International Institute for Sustainable Development, 2005). The majority of Rwandans use wood or charcoal as their main energy source. Yet deforestation threatens this important ecosystem service. In addition, rapid deforestation and loss of some protected areas threatens biodiversity, which is important to tourism and potential pharmaceutical developments. Finally, climate change is projected to impact all the ecosystem services mentioned above by changing local climatic conditions, such as increasing the frequency and severity of droughts (Working Group on Climate Change and Development, 2006). Impairment of these and other ecosystem services in Rwanda can significantly reduce human well-being and threaten the development prospects for Rwanda in the future. Natural resource management for the protection of ecosystem services must be a high priority for the Rwandan government, civil society, and private industry.

However, resource management decisions are generally made on the margin. What is the cost and benefit for doing a little more or a little less of a particular activity? For ecosystem services to be incorporated in such decisions the incentives facing resource management, including those by smallholder farmers, need to include the marginal impact management decisions have on ecosystem services. PES programs are designed to provide such incentives. For example, the Clean Development Mechanism under the Kyoto Protocol allows developed countries to meet some of their reduction requirements by sponsoring afforestation and reforestation projects that sequester carbon in developing countries. Other PES programs are aimed at inducing resource users to protect biodiversity, provide clean water, and enhance other valuable ecosystem services.

LINKING PES AND RURAL POVERTY ALLEVIATION IN RWANDA

Payments for ecosystem services (PES) are increasingly identified as potential avenues to the synergetic development-conservation objective, particularly for landowners in the low-income tropics (Tschakert, 2007). Most of the experience with PES has been in Latin America with some limited cases studies in Africa. Pagiola, Arcenas, & Platais (2005) reviewed a range of experiences with Latin American PES programs, and highlighted key factors that contributed to local participation, including the profitability of PES practices, secure land tenure, investment costs, level of technical capacity required to adopt PES-promoted practices, and transaction costs. In addition, these experiences have suggested that wealthier farmers with larger asset bases, more diversified incomes, non-farm income, and better access to information and social networks tend to gain disproportionately from signing up for ecosystem service provision, while poorer, less flexible, and less connected households can be left out (Brown & Corbera, 2003; Grieg-Gran, Porras, & Wunder, 2005). These insights illustrate the challenge of creating a synergy between ecosystem services and poverty alleviation in Rwanda. Despite these challenges, however, there is potential to produce ecosystem services on smallholder land in Rwanda. Much of the land in Rwanda is mountainous, so soil erosion and the resulting loss of soil fertility is a significant problem. Planting suitable land in forests or agroforestry systems can be an effective way to mitigate this problem while also providing a source of income for the farmer. Forests and agroforestry can also improve water quality, sequester carbon, and enhance biodiversity. Planting bamboo can sequester carbon and provide building and craft material. To understand how such practices can be applied to smallholder farmers in Rwanda, in light of the challenges in doing so, it is necessary to understand the specific challenges faced by smallholder farmers in this part of Africa.

In Rwanda, most farmers employ manual labor with very few inputs, such as fertilizer, pesticides, and improved seeds. According to Drechsel and Reck (1997) the use of fertilizers is very low (0.4-0.5 kg/ha) due to their high price. Many areas in sub-Saharan Africa, including Rwanda, are prone to regular droughts with soil less fertile than other parts of the world. In addition, Sub-Saharan Africa has less irrigated agriculture than other parts of the world. For example, over 35% of Asia's farmland is irrigated whereas only 4% of sub-Saharan Africa's farmland is irrigated (Sachs, 2005). In 2000, cereal yields in Sub-Saharan Africa were a little over one metric ton per hectare. By comparison, in Asia, cereal yields were over 3.6 metric tons per hectare, in Latin America about 2.8, and in North Africa and the Middle East a little over 2.6 (Sachs, McArthur, Schmidt-Traub, Kruk, Bahadur, Faye, & McCord, 2004). In addition, Rwanda is landlocked with no easy road or railway linkages to the coast. This geography can play an important role in economic growth by depriving a country of access to international markets.

With low yields, susceptibility to droughts, and limited access to markets, smallholder farmers in Rwanda often do not invest in agricultural technologies even if credit markets are available. Farmers in such a situation need two things to climb out of their poverty. First, they need low risk strategies to generate surplus income from cash crops. Growing such crops must require relatively few inputs, besides labor, in order to avoid the loss of significant financial investments during periodic climatic events, such as droughts or floods. These cash crops also need to be able to be integrated into the subsistence farming that is a necessity for smallholder farmers in Africa. Second, markets need to be made available for these cash crops.

Providing ecosystem services could meet such requirements under certain conditions. Agroforestry, for example, could provide a means to diversify food and fiber production and allow smallholder farmers to generate income through selling carbon credits or water quality benefits. The income generated from ecosystem services could allow these farmers to invest in improved seeds or small scale irrigation. In addition, selling ecosystem services, such as carbon sequestration, has the advantage that the output does not need to be transported. Hence, it can benefit smallholder farmers in remote areas. Carbon sequestration is also a service without scope for quality differences, so the relatively high production costs often faced by smallholders in meeting national or international standards do not arise in this arena (Cacho, Marshall, & Milne, 2003). This situation makes it critically important in Rwanda that agricultural policies, including those involving the production of ecosystem services focus on smallholder farmers, particularly those with one hectare or less.

POTENTIAL PES PROGRAMS FOR RWANDAN SMALLHOLDER FARMERS

In the following section, we discuss three ecosystem services; carbon sequestration, biodiversity and water enhancement, that Rwandan smallholder farmers can potentially supply. We highlight the challenges in designing PES programs aimed at smallholder farmers for each ecosystem service. It is hoped that designing policy and institutional arrangements around such challenges will produce more effective PES programs. The ecosystem services discussed here are not exhaustive of the potential services provided by Rwandan smallholder farmers. However, there is some experience in developing PES programs around these ecosystem services in developing countries and they each pose their own obstacles and opportunities to implementation. It is important to note that different ecosystem services are not exclusive. Often specific management techniques can yield multiple ecosystem services. For example, protecting riparian habitat by leaving a vegetative buffer strip along water courses can provide a multitude of ecosystem services. The vegetation can sequester carbon helping to mitigate climate change. The buffer strip can also protect biodiversity, both terrestrial and aquatic, and improve water quality downstream. Thus, it is conceivable that a particular farmer can be compensated for several ecosystem services further diversifying his or her income stream.

Carbon sequestration

Anthropogenic climate change resulting from the build-up of carbon dioxide and other greenhouse gases is causing increasing global concern. Terrestrial vegetation plays a significant role in the global carbon cycle by sequestering carbon dioxide from the atmosphere during photosynthesis and storing it in biomass. Land-use change can either increase or decrease atmospheric carbon dioxide levels by increasing or decreasing the amount of biomass. Currently, agriculture and forestry account for approximately 30% of anthropogenic greenhouse gas emissions (Intergovernmental Panel on Climate Change, 2007). As a result, various incentives, including PES programs, have been set up for the sequestration of carbon dioxide or the prevention of carbon dioxide emissions from land management.

Adopting agroforestry and planting bamboo are two promising means of sequestering carbon on smallholder land in Rwanda. Agroforestry involves planting trees along with traditional agricultural crops. The trees increase the biomass on a plot of land through the sequestration and storage of carbon from the atmosphere. It is estimated that for smallholder agroforestry systems in the tropics, the potential C sequestration rates range between 1.5 to 3.5 Mg C/ha/year and also have an indirect effect on C sequestration by helping decrease pressure to convert natural forests, which are large sinks of terrestrial C (Montagnini & Nair, 2004). Agroforestry is a traditional practice in Rwanda that could be expanded fairly easily. Currently, smallholder farmers in Rwanda sometimes plant fruit trees or trees to use as firewood, building material, or other wood products. In addition to sequestering carbon, agroforestry can provide many other benefits for the environment and smallholder farmers. For example, agroforestry provides a means for farmers to provide firewood, which is a critical need in Rwanda, to prevent soil erosion on sensitive hilly land and, in some cases, replenish soil minerals, such as nitrogen, phosphorus, calcium, and magnesium and protect water quality (Roose & Ndayizigiye, 1997). Bamboo is a fast growing species that can rapidly sequester carbon, prevent soil erosion, help restore degraded land, serve as a source of energy, and can be the raw material for various marketable products. Embaye, Weih, Ledin, & Christersson (2005) reported an aboveground and belowground biomass content of 66 Mg carbon per ha per year in a mature stand in Ethiopian highlands. Due to its very fast growth rate, it can be selectively harvested on a yearly basis making it very suitable for poor farmers.

While there are documented social, economic, and environmental benefits of agroforestry and bamboo, it is important to understand the challenges for carbon sequestration in leading to poverty alleviation for smallholder farmers in Rwanda. Programs that promote the alleviation of poverty through the adoption of land use change are not new and have formed a major aspect of rural development efforts over the past four decades (Lipper & Cavatassi, 2004). However, despite the positive effects of these programs, the adoption of low-cost technology, such as agroforestry, has remained low. The agricultural and economic development literature has frequently stressed that disparities in access to labor, land, asset, and money as well as farmer's knowledge, institutional linkages, and social networks define how vulnerable resource users are to uncertainties and risks intrinsic in technology adoption and market participation (Desgupta, 1993; Lipper & Cavatassi, 2004; Perez, Roncoli, Neely, & Steiner, 2007; Shiferaw, Okello, & Reddy, 2009).

Further, as elsewhere, there is social differentiation and spatial variation in resource availability among smallholder farmers in Rwanda, meaning that practices that seem feasible and eligible for carbon payments in one location or social group may not necessarily be so in another location. For instance a study by Bidogeza, Berentsen, Graaff, & Lansink (2009) found that female-headed households in Rwanda were adopting relatively cheap inputs, such as compost and green manure, because they are constrained by a low level of education and small farm size, which prevents them from adopting other more costly technologies. To successfully engage smallholder farmers in a carbon sequestration program, it will be important to understand these social and spatial variations in order to design a carbon credit scheme that contributes to poverty reduction. For instance, an appraisal of the profitability of carbon enhancing technologies (relative to existing practices) across different agro-ecological zones of Rwanda can determine the spatial variability in smallholder farmer willingness to adopt and to commit to implementing them overtime and can assess whether carbon sequestration revenues can increase rural farmer's incomes. Agricultural extension services can also tailor assistance to the specific needs in a region.

The adoption of appropriate institutional arrangements is also important. Economic incentives to sequester carbon may not necessarily translate into carbon sequestration programs without suitable institutional arrangements to facilitate the processes of aggregation, monitoring, and verification (Perez, et al., 2007). As Rwanda's landscape is a mosaic of small agriculture plots averaging less than a hectare, it would be difficult to develop carbon credits by reforesting individual fields or parts of fields, given the extremely small parcel size. One way to address this issue would be to aggregate small amounts of carbon sequestered in a large number of small plots to scales large enough to be tradable on carbon markets. For instance, a certain number of families could be aggregated and organized under carbon cooperatives in which local communities agree to reforest and protect a portion of their land that could be used collectively for sustainable wood harvesting and generation of carbon credits. The cooperative would be in charge, not only of selling carbon credits, but also providing support to farmers. As Eaton and Shepherd (2001) note, it is not enough to identify activities with high income generation potential for rural people, but rather it is critical to provide a reliable and cost-effective package of support and services ranging from extension advice, seeds, fertilizers, and credit to facilitate smallholder farmer participation. Institutional arrangements that can facilitate the provision of support for smallholder participation in carbon markets is thus essential.

In addition, facilitating cooperation among various administrative agencies that impact the management of smallholder land is crucial. The government of Rwanda has embraced decentralization as a form of local governance to enable people to participate more directly in the governance processes and empower marginalized communities. This policy has created a conducive environment for creating cooperatives and associations and opened opportunities for institutional capacity building at the local level. However, at the national level, given the current institutional arrangement, it is unclear which government agencies will, in practice, control forest-based carbon credits. For instance the National Forest Authority (NAFA) has the responsibility of managing and monitoring forest cover, deforestation, and overall land use changes and centralizes carbon credit transactions from forest-based projects. The Rwandan Environment Management Authority (REMA) has the overall responsibility of management of the bio-physical environment throughout the country and contains the Designated National Authority (DNA) for Clean Development Mechanisms (CDM) projects. The DNA has the responsibility of approving carbon projects proposed within the scope of the CDM. To encourage inter-institutional and intersectoral collaboration and ensure transparency in measuring and accounting procedures and equitable access to information by rural communities, a cross-administration forest-carbon group could be established. This group should have clear authority to evaluate and support forest-carbon projects, as well as to develop a set of guidelines on revenue-sharing, ecological values, and community benefits in which every potential project has to adhere.

Finally, credibility in a carbon market system will hinge on the existence of sufficient technical capacity within Rwanda to apply rigorous methodologies and standardized protocols for carbon measurement, monitoring, and verification; and for estimating costs and benefits of carbon sequestration. Experience in some other countries (i.e. Mexico) suggests that substantial funding can be lost in preparation of unsuccessful project proposals because of lack of necessary knowledge and capacity (Corbera, Soberanis, & Brown, 2009). In addition, often project developers do not explain, in plain language, the requirements to developing a successful carbon project in terms of design, implementation, monitoring, verification, certification, and interactions with intermediaries. Unfortunately, this has helped create an impression that PES programs are a foreign owned process creating skepticism in many countries, including Rwanda. Technical capacities are present in Rwanda (e.g. GIS analysis and remote sensing) but they are scattered in different government agencies, universities, and non-governmental organizations. It is critical that efforts be made to assess the capacity needs and design a capacity building program to adapt to the evolving opportunities in carbon sequestration.

Finally, in addition to carbon sequestration activities on smallholder land, there is an opportunity to generate the revenue for conservation of Rwanda's protected tropical mountain forests by valuing standing forests for the carbon they contain. For instance, a preliminary feasibility study on the opportunities for carbon asset development from forest conservation, avoided deforestation and reforestation in Nyungwe National Park (NFNP) demonstrated that assisted natural regeneration of burned forest areas could generate a total 30-year net revenue of $ 11.8 million (De Gryze, Durschinger, & Lambert, 2009). Potential markets for developing countries to store carbon in protected areas are being discussed as part of post-Kyoto climate change negotiations. Ways of ensuring that at least some of the revenue from such projects benefits smallholder farmers living around protected areas should be pursued. This would be critically important in Rwanda as some of the poorest communities in Rwanda are located near the borders of protected areas.

Water

The ability of healthy watersheds to moderate water flows and purify drinking water supplies is one of their most tangible and valuable (social and economic) services (Postel & Thompson, 2005). Land management can have a significant impact on both water quantity and quality. Forested areas and intact wetlands filter water before it enters streams, rivers, and lakes and retain water thus regulating the amount and timing of water delivery in watersheds. Watersheds without adequate protection deliver less clean, less reliable water to downstream users. Deforestation, clear cutting, and poor farming practices can send large influxes of eroded sediments into rivers and streams, degrading the quality of water (Calder, 2000). As suspended sediment levels change, so may the time and effort required in treating water, leading to increasing expenditures on treatment, maintenance, and operations as well as additional equipment capital costs.

Unlike carbon sequestration and biodiversity, most of the ecosystem services related to water accrue to local or regional beneficiaries. Rwanda's cities depend on small forested watersheds and wetlands for their water supplies and electricity generation. Of the total installed electric power generation capacity of 41.25 MW, hydropower accounts for 65%, while thermal power accounts for 35% (Safari, 2010). Many of the existing hydroelectric power plants are run-of-the river schemes, with minimal storage which make them very dependent on stream-flow for their operation, a constraint that becomes particularly significant during the dry season. In addition, they are more vulnerable to sedimentation because of their limited storage capacity and damage to their tubing and turbines from sediments. High peak-flows are also harmful because much of the water cannot be used for power generation and transported debris can clog intakes and damage turbines.

Failure to formally recognize, protect, and manage the water purification and sediment control services provided by the watersheds has led to the incremental deterioration in these services over the last two decades due to agricultural land pressure. As a result, Rwanda has experienced energy and water shortages, especially in cities. For example, due to reduced water flows, the generation of electricity from two hydropower stations, Ntaruka and Mukungwa, has declined from 11.25 MW to 2.5 MW and from 12.45 to 5 MW, respectively, in the last two decades (Safari, 2010). In addition, increased sedimentation resulting from high rates of hillside erosion due to the cultivation of the Gishwati forest has led to rising treatment costs of drinking water and higher maintenance costs of water and hydropower plants. For instance, the average amount of aluminum sulfate needed to remove sediments from water plants located in an intact watershed, such as Nyungwe forest, varies between 0 and 40 g/m^3, while for a plant located in the Gishwati watershed it is around 143 g/m^3 (Masozera, 2008).

The government's strategy to deal with the problem of water scarcity and its consequences has mainly focused on law enforcement and expanding the physical infrastructure through engineering projects. Environmental management instruments are almost completely absent from the government's strategy. The growing cost of infrastructure services has induced the government to subsidize production and consumption of water and electricity, as many households have difficulties affording the services. Due to the increasing costs associated with supply-side measures and the failure of past policies to inspire appropriate and sustainable management of natural resources, it is important to create economic incentives for improved environmental management to ensure regular flow of water resources.

A rich variety of institutional mechanisms exists to encourage higher levels of protection of hydrological functions, including payment for watershed services. The rationale of such PES schemes is to provide economic incentives to avoid environmental degradation in areas where severe water problems are linked to environmental degradation, such as deforestation. However, despite the global experimentation with payment for watershed services (PWS) schemes, for almost a decade, only a few programs exist in Africa. Two of them that are operational are located in South Africa and six others are being initiated or in planning phases in Kenya, South Africa, and Tanzania (Ferraro, 2007). Payment for watershed services proponents frequently cite a common list of obstacles to the development of payment schemes: lack of technical and market information, limited institutional experience, inadequate legal frameworks, limited successful business models, suspicion of markets for public goods, and equity concerns. While these characteristics are likely barriers to Africa PWS, Ferraro (2007) notes two fundamental barriers to establishing PWS in Africa, including the financial health of institutions benefiting from watershed services and consumers with the ability to pay. These two barriers are relevant to the Rwanda context as well. Two potential consumers of water ecosystem services in Rwanda are the Rwanda Electricity Company and the various tea factories around the country.

Despite the fact the Rwanda's current energy pricing policy does not take into account the real economic costs of environmental damage, the average supply cost estimated at 22 US cents per Kwh remains above the current price level of 20 US cents (Nile Equatorial Lakes Subsidiary Action Program, 2006). This situation has made the Rwanda Electricity Company inefficient in operating and undermined its capacity to improve and expand services. One of the potential solutions to improve efficiency of Rwanda utility companies would be to charge consumers the full economic costs of water and electricity by reviewing the pricing policy and subsidize connection to facilitate access to low income groups. The current consumption subsidies for electricity in Rwanda are regressive in large part due to access factors that prevent the poor from using the services (Angel-Urdinola &

Wodon, 2007). As poor households tend to live in areas without electricity service, or far from electric lines where service exists, it is difficult for them to benefit from electricity subsidies simply because they are not connected to the network. Angel-Urdinola and Wodon (2007) suggest shifting from a single rate for all consumers to a Volume Differentiated Tariff (VDT) structure whereby only those consuming a total volume of water or electricity below a certain threshold would benefit from lower prices. VDTs are composed of two or more different tariffs, the first highly subsidized and the second much less or not at all, to which consumers are assigned based on their total volume of consumption. This system could lower the price and improve access to services for low income groups, while increasing the price to more affluent households. Under this regime, the money collected by electric and water utilities could pay smallholder farmers located in critical/sentitive watersheds to implement conservation practices, such as planting vegetation buffer strips or utilizing agroforestry, on their land that would improve water quality.

Industrial water users, such as tea estates, are self-supplied industries - not connected to a distribution network. Tea production necessitates a considerable amount of water for growing and processing. For instance, the global average virtual water content of 1 kg of black tea is 10.4 m^3 (Chapagain & Hoekstra, 2008). This makes water a strategic commodity for tea estates as it is a main factor of production. But it is still considered as an open access resource or a free gift from nature as the economic cost of water is never included in the market price of the tea produced. Based on avoided costs estimates, tea estates, dependent on clean water from Nyungwe Forest National Park, could pay the Office of Tourism and National Parks for the conservation of the forest and smallholder farmers around the park to engage in best agricultural management practices. The extra income from such payments could increase the income of smallholder farmers in the region and reduce pressure to convert land in the park, or the buffer zone around the park, to agricultural uses

Biodiversity

Rwanda possesses an extraordinary level of biodiversity given its small geographical size. Most of this biodiversity is located in three protected areas within the country. Virunga National Park, in the northwest of the country, and Nyungwe National Park, in the southwest, consists of high montane tropical forests. Akagera National Park, in the east, consists of tropical savannah. Significant threats facing these protected areas and the biodiversity contained within them include land conversion to agriculture of buffer zones and even the parks themselves and illegal use of park resources (i.e. collecting plants, mining, etc.) by the local population surrounding the parks (Hatfield, 2005; Masozera & Alavalapati, 2004). If local smallholder farmers surrounding these protected areas could directly benefit from the biodiversity protected in these parks, then some of the pressure to convert these areas to agriculture and illegally poach their resources would be lessened. The value of the biodiversity in these areas is large and mostly accrues to the international community. Therefore, there is potential for payments to help protect these natural areas and increase the income of smallholder farmers surrounding them.

For example, one recent study clearly indicates that the forest in Virunga National Park provides significant positive value to the international community through tourism (i.e. gorilla tracking expeditions), existence values, and other ecosystem services. However, local communities, particularly smallholder farmers, receive little of the benefits produced by the Park and disproportionately bear the costs of the Park. Specifically, over 20 million USD of the benefits derived from the Park accrue to the national and international community. The local communities actually lose approximately 11.7 million USD, mainly in the form of the opportunity cost of land occupied by the Park (Hatfield, 2005). This creates a system where there is little incentive for local smallholder farmers around the Park to support its protection and refrain from land conversion around and in the Park.

Payments made to local farmers to refrain from converting more land to agriculture through intensification on existing agricultural land could help alleviate this situation. For example, Hatfield (2005), in the study mentioned above, found that as little as 68.10 USD could be paid to smallholder farmers around the Park to mitigate the desire to convert additional forestland to farmland. This payment could be used to invest in agricultural inputs to increase the productivity of these farmers or as credit to be invested in land use practices that could sequester carbon and increase soil fertility. This increased productivity could relieve poverty in the area, while at the same time increasing the ecosystem services that the global community receives from the Park by reducing the pressure to convert forestland.

Along these lines, the Rwanda National Parks Services (ORTPN) has initiated a revenue sharing scheme that aims at increasing the effectiveness of national parks in attaining conservation objectives and contributing to the improvement of communities' livelihoods around the parks. The revenue sharing policy earmarks 5% of the total gross revenue earned in each park to be combined into a national pool where at least some of the money is used for poverty alleviation. However this program is small relative to the population density of poor smallholder farmers around the Parks. Such programs should be substantially scaled up and linked to other rural development initiatives.

CONCLUSIONS AND RECOMMENDATIONS

While PES programs are not designed to be a poverty alleviation strategy, they can result in more sustainable livelihoods through the provision of cash or in-kind benefits to participants, especially when targeted specifically at rural communities (Pagiola, et al., 2005). For over 30 years, research has focused on the development and promotion of low-cost technology, such as agroforestry, fast growing nitrogen-fixing legumes, and the inter-or relay-cropping of green manure (Drechsel & Reck, 1997; Roose & Ndayizigiye, 1997). However, despite the positive effects of these technologies on nutrient supply, reduction in soil loss, increased crop yields, and fodder and firewood production, their adoption has remained low (Drechsel & Reck, 1997). The adoption has failed because new technologies have not matched with the socioeconomic circumstances of farm households. The literature on adoption of natural resource management innovations/technology has frequently stressed the role of different factors, such as farm size, capital, and labor availability, education, risk perception, and risk attitude, and land ownership (Bidogeza, et al., 2009). It has also been demonstrated that improved market access that raises the return to land and labor, access to credit, and availability of pro-poor options for beneficial conservation are critical factors in stimulating livelihood and sustainability-enhancing investments (Lipper & Cavatassi, 2004; Shiferaw, Okello, & Reddy, 2009). These are barriers that can prevent smallholder farmers from participating in PES programs. There is also tendency to assume homogeneity within the faming population, particularly with respect to socioeconomic variables (Nkonya, Schroeder, & Norman, 1997). PES programs and extension activities aimed at smallholder farmers need to focus on the specific needs of smallholder farmers and adapt programs to the variability of smallholder farmers needs in different regions and social groups.

Ecosystem services cut across all economic sectors and are supplied at different institutional and geographic scales. As Brown and Corbera (2003) note, a critical challenge in the new carbon economy is establishing robust cross-scale institutional frameworks to enable an equitable interaction among stakeholders and, more importantly, to deliver sustainable development to local communities. To successfully design and implement a PES program, efforts should be made to ensure institutional coordination to avoid contradictory policies and actions in rural development and land use planning. Studies that explore the roles, interests, and perspectives of different actors involved will help decision makers to identify areas of synergies and conflicts across institutional arrangements. In addition, transaction costs are a major issue in determining the viability PES programs associated with smallholder farmers. Future research needs to focus on which type of institutional arrangements for smallholder farmers reduce transaction costs. For example, the effectiveness of different cooperative arrangements of smallholder farmers in facilitating the participation in PES programs should be explored. The role that indigenous institutions could possibly play, in this regard, should also be considered.

Finally PES programs are very information intense. Both suppliers and beneficiaries need information on the ecosystem services provided by various ecosystems and how they are impacted by management. For instance, downstream water users, such as a tea factory, need to know the quality of the water they are receiving from upstream and how it is influenced by specific land use practices. They also need information on the value, to them specifically, of improvements to water quality due to land management practices. Only then could they put a value on the management practices of upstream farmers and facilitate payments. One vehicle for gathering such information is through traditional research funded by the government and international donors. Thus, there is a need for the international environmental community and development agencies to collaborate in funding research to gather information on ecosystem services in Rwanda. In addition, however, Environmental Impact Statements (EIS) could be used to gather needed information. As elsewhere in the world, EIS's are already used in Rwanda to gather information on how various projects in the private sector influence the environment. Numerous consulting agencies offer their expertise to entities needing to conduct an EIS. Environmental Impact Statements could be required to include information on the ecosystem services impacted by the projects, the value of these impacts on specific impacted groups, and the level of dependency of a particular project or economic activity on ecosystem services. This type of information could range from rough qualitative estimates to detailed quantitative estimates, depending on the cost and availability of information. Over time this could help build a substantial base of information that can be used to develop PES programs.

PES programs, alone, cannot reduce poverty of rural farmers in Rwanda. Therefore, PES programs should be integrated with other rural development initiatives as a means to increase incomes with particular emphasis on restoring, or preserving, ecosystems and raising the awareness of the importance of ecosystem services. It is becoming increasingly clear, to both development advocates and conservationist/environmentalist, that the goals of economic development and conservation must be linked and that ultimately one depends on the other. Without protecting the flow of ecosystem services, development will ultimately be hindered. Without alleviating poverty and providing a means for social and economic development of the poor, the challenge of conservation will be substantially more difficult in developing countries, such as Rwanda. While not a panacea, PES programs provide a potential tool to address both economic development and ecological sustainability in Rwanda. In order for such an endeavor to make a significant contribution, it is essential that such efforts focus on smallholder farmers.

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Clarion University of Pennsylvania, Clarion, Pennsylvania. Payment for ecosystem services and poverty reduction in rwanda. G. Andrew and Michel Masozera ABSTRACT Two of the biggest challenges facing Rwanda today are reducing poverty, especially among rural households, and protecting the ecosystems, which provide essential services that support activities, such as subsistence agriculture, collection of safe drinking water, and the harvesting of forest products. Combining these two objectives is not easy and there are numerous pitfalls to effective policy design. This paper explores the possibil