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New Tools for Old Problems: Can Payments for Watershed Services Support Sustainable Agricultural Development in Africa?

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Abstract

Agriculture affects both the quantity and quality of water available for other uses, and under current production systems the impact is often negative. Adopting sustainable land management (SLM) practices can foster a more efficient water use and increase agricultural productivity, while reducing environmental risk from water pollution and regulating flows serving downstream communities. One of the key barriers to adoption of such practices is the high upfront cost associated with SLM implementation, which are a disincentive to their practice by poor landowners. This paper discusses how an emerging policy tool- Payments for Environmental Services (PES)- can bridge this gap by financing initial SLM investment costs, thereby lowering the cost barriers to SLM implementation. Drawing on ongoing experience in Tanzania, we discuss the main constraints to be addressed in order to realize this potential.

Key Words: Environmental services, water pollution, sustainable land management, rural development, economic incentives, natural resources.

JEL: O13, Q15, Q25, Q53, Q57.

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1. Introduction

World population is around 6.4 billion and growing at some 70 million per year, mostly in low-income countries. This population growth, coupled with economic development, industrialisation and urbanisation, will result in increasing demand for clean water. Alarmingly, while the world's population tripled in the 20th century, the use of renewable water resources has grown seven-fold (UNEP, 2007). Water withdrawals are predicted to increase by 50% by 2025 in developing countries, and 18% in developed countries (WWAP, 2006).

Agriculture is by far the principal user of all water resources taken together – rainfall and water in rivers, lakes and aquifers – accounting for more than 80% of all withdrawals. Further, FAO expects that overall water withdrawals for irrigation in all developing countries will increase by 14% in the period 2000-2030, as irrigated areas may increase by 20% (FAO, 2003b; Faures et al., 2002). Agriculture is therefore a logical target to look for water savings and demand management efforts. At the same time, the agricultural sector is key in meeting the challenges of food security and poverty reduction. In so doing, it will have to compete with urban and industrial uses for increasingly scarce water resources, possibly causing tensions between rural and urban areas, threatening regional or national food security (WWAP, 2006) and leading to growing inequity (IWMI, 2007).

Some agricultural production systems generate negative environmental externalities in the form of reduced water quality and quantity, thus exacerbating this competition. Unsustainable agricultural practices are a source of water pollution and water depletion in irrigated lands, declining groundwater levels, leading to insecure access to water. On the other hand, poor water management also contributes to the degradation of prime agricultural land (soil erosion, nutrient runoff, pesticide leaching, salinization, water logging) with resulting declining productivity, desertification and loss of ecosystem services (IWMI, 2007; World Bank, 2007). Degradation of natural capital and insecure access to water, for consumption and productive uses, are major barriers to increasing the productivity and resilience of agricultural production systems and improving rural livelihoods in sub-Saharan Africa (SSA).

Moving out of the vicious cycle of degradation and poverty will require better forms of production, such as Sustainable Land Management (SLM) techniques, that can foster a more efficient water use and reduce pollution problems, contributing to an increase in the quantity and quality of water available. Nevertheless, one of the key barriers for wider adoption of SLM is designing the proper incentives and technical support systems to stimulate the

adoption of such practices. Payment for Environmental Services (PES) schemes are one policy option for bridging this gap by providing incentives to upstream farmers that are consistent with the benefits they provide to downstream counterparts.

This work is aimed at identifying opportunities for this new economic tool to address longstanding problems of poor water management and land degradation in the agricultural sector. We outline the key challenges to widespread adoption of SLM practices in SSA, and discuss the constraints to be addressed in order to realize the potential of PES to control environmental risk for watershed services consequent to agriculture activities and to improve the livelihood of poor rural communities in developing countries.

The paper is structured as follows: the next section highlights the crucial role of water for agricultural production in SSA and the environmental effects of unsuitable agricultural practices on land and water resources. Section 3 looks into SLM as a cost-effective mechanism to manage environmental risk from non-point source agricultural pollution and the main obstacles to widespread adoption of such practices in SSA. Section 4 examines the potential of PES to act as incentives for adopting SLM and improving livelihoods. Finally, section 5 reports an illustrative example from the Uluguru Mountains of Tanzania.

2. Agricultural Activities and Environmental Degradation of Water Resources

2.1 Water Use in Sub-Saharan Africa

Sub-Saharan Africa occupies about 18% of the World's landmass and is home to about 690 million people, mostly rural and depending on subsistence agriculture. Despite the abundance of natural resources, about two-thirds of SSA countries are ranked among the lowest with respect to the Human Development Index and more than 40% of the total population fall below national poverty lines (UNDP, 2006). Agriculture is the main water user in SSA, accounting for 87% of total withdrawal, against 10% and 3% for domestic and industrial sectors, respectively (see table 1).

Table 1 - Water and Agriculture in SSA

	Km ³ /year	% of total
Agriculture use	104.70	86.6
Domestic use	12.60	10.4
Industrial use	3.60	3.0
Total water withdrawal	120.90	100.0

Source: adapted from FAO 2008b

Water is a crucial input for boosting agricultural production. Maintaining the high productivity of irrigated land is key to increasing food security: even though irrigated farming accounts for only about 18% of cultivated area in the developing world, it produces about 40% of the value of agricultural output. The future of agriculture in SSA will therefore depend much on water (FAO, 2008b). In order to support the estimated doubling of population by 2050, and threefold increase in daily food consumption, the region will require substantial increases in food production (FAO, 2006). Although in the past few decades efforts have been made to improve water supply infrastructure in rural areas, with slightly more than 3% of its cultivated land under irrigation, there is considerable scope for further development to increase agricultural yields: FAO projects that the irrigated areas in SSA need to increase by 44% by 2030, the largest increase among developing countries (FAO 2003b).

Agricultural withdrawals will therefore continue to occupy the largest part of water needs in SSA, but domestic and industrial uses are also expected to increase rapidly, due to expansion of water supply coverage, rapid population growth and because higher incomes lead to higher per capita water use. By 2025, demand from the public water supply sector is expected to increase four times in Central Africa and five times in East and West Africa. Research on the changing urban water systems in Africa, where insufficient infrastructure is a major problem, indicates that while in the early 1970s many major cities still used groundwater supplies as their primary water source, by the 1990s primary sources were more likely to be rivers (Showers, 2002). Industry – whose annual average percentage growth doubled since 1990 to 2004, from 1.9% to 4% (World Bank, 2006) – is expected to claim a three-fold increase in the same timeframe (WWAP, 2006). This will exacerbate the conflict with the agricultural sector, resulting in increasing stress on freshwater resources in SSA.

2.2 Negative Externalities of Unsustainable Agricultural Practices.

Being the main water user in SSA, agriculture is also a major polluter, thus representing an important cause of water stress in the region. The majority of pollution from agriculture is described as “nonpoint source” because emissions from agricultural land does not emanate from a single point, but leaves each field and enters into water bodies – surface or underground – in so many places that accurate monitoring would be prohibitively expensive if not impossible (Shortle and Horan 2001).

The relationship between agricultural production and water pollution damage is complex, involving many hydrological, physical, chemical and biological processes that affect the nature and level of chemical elements and compounds in water bodies.

Agricultural activities may also have negative impacts on the hydrologic regime: the mean annual runoff and seasonal distribution of water availability. This may occur due to changes in water quantity caused by excess water withdrawals, reduction in the infiltration capacity of the soil, changes in the composition of plant cover with effects on evapotranspiration, diversion of flow from rivers/freshwater (shrinking lakes and rivers, wetland habitat loss and degradation) and fragmentation and destruction of aquatic habitats (FAO, 2000b; Finlayson and D’Cruz, 2005).

Unsustainable farming activities may also adversely affect water quality through degradation of land cover, erosion, nutrient runoff and leaching, leading to chemical contamination of watercourses and aquifers with fertilizers, pesticides and animal waste (see table 2), and to an increase in physical pollutants, resulting in water turbidity and reduction in the storage capacity of the water courses. In addition, irrigation and drainage activities can lead to higher salinity content as a consequence of evaporation and the leaching of salts from soils (FAO, 2000b). The bacteriological quality of water may be affected by higher concentration of pathogenic bacteria in surface water as a consequence of riparian grazing activities or waste influx from livestock production.

Table 2 - Water Quality Impacts of Agricultural Activity

Agriculture Practices and types of pollution		
Physical Pollutants (Sediment, Temperature, Turbidity)	Land clearing	Erosion of land- high levels of turbidity in rivers leading to higher water treatment costs
	Tillage/ploughing	Increasing siltation in reservoirs- higher maintenance costs
	Irrigation	Runoff of salts leading to salinization of surface waters and enrichment of groundwater with salt
Organic Pollutants (Nitrogen, Phosphorus, Microbes, Bacteria)	Fertilizing	Runoff of nutrients, especially phosphorus, leading to eutrophication causing taste and odour in public water supply
	Aquaculture	Release of pesticides and high levels of nutrients to surface water and groundwater through feed and faeces, leading to serious eutrophication
Toxic Pollutants (Pesticides, Herbicides, Heavy metals)	Weed and pest control	Potential human health impacts- water contamination and bioaccumulation of chemicals in edible fish species
	Livestock feed and disease control	Contamination of surface and ground water through metals contained in urine and faeces
		Excretion of animal undigested veterinary medicines or pathogens (bacteria, viruses) may contaminate surface water

Source: adapted from FAO 2007a

In SSA, the most important environmental problem is caused by physical and organic pollutants: eutrophication – the over-enrichment of water by nutrients such as nitrogen and phosphorus – is and may remain one of the main threats to water quality under the projected doubling of fertilizer consumption by 2020 (WRI, UNEP, UNDP and World Bank, 1998). In some regions, nitrate loads in suburban groundwater wells are 6-8 times the WHO acceptable levels (UNEP, 2000; 2002).

Biological pathogens are another significant concern in the African context. The use of animal manure in place of inorganic fertilizers, the lack of human sanitation in small farming communities, the widespread maintenance of livestock as part of the household livelihoods, and the probability that any confined animal feeding operation has unregulated discharges, all serve to accentuate the risk of microbial contamination with bacteria from livestock– such as *E.coli*, *protists* and *amoebae* (Kraemer et al., 2001; Masamba and Mazvimavia, 2008; FAO, 2007a).

Water scarcity forces people to rely more on poor quality water, leaves less available for basic hygiene and facilitates the spread of disease. The prevalence of suspended sediments and biological pathogens are of primary concern in the African context: water carrying large amounts of sediment provides a suitable environment for microbial activity and survival (40% of global morbidity and mortality from diarrhoea occurs in SSA). Elevated levels of nitrates in groundwater, from localized large-scale use of organic and inorganic fertilizers, also presents considerable health risks (e.g. methemoglobin anaemia in infants caused by excess nitrate in drinking water). Chemicals from pesticide residue may interfere with human hormonal functions, undermining disease resistance and reproductive health. Changes in flow regimes are also known to facilitate the spread of schistosomiasis (WHO and UNICEF, 2006, FAO, 2007a, INWMI, 2007).

Apart from negative impacts on water, unsustainable agricultural practices also have negative effects on soil structure, fertility and productivity. Land degradation is an increasingly serious problem in SSA- about two thirds of arable land in SSA could be lost by 2025 due to land degradation- with major implications for the region's economy, health and natural environment. The most severe land degradation problems affect two thirds of SSA and are linked to water-related soil erosion, predominantly in sloping lands where a combination of high rainfall, light soils, unsustainable farming activities and low ground cover renders the soil vulnerable to being washed away into the rivers (FAO, 2008c).

3. The Control of Downstream Environmental Risk from Upstream Agricultural Pollution: Contributions from Sustainable Land Management in SSA

The quality and quantity of water available to downstream users in a watershed depends on the particular type and distribution of vegetation, the underlying geology, soil type and the way that land is used and managed. By applying Sustainable Land Management (SLM) practices, upstream farmers and communities may enhance watershed services and improve water security for downstream water users. These practices can improve water quality (e.g. reducing chemical pollution and sediments) and help manage water quantity (e.g. improving rainwater retention and recharge of the water table, regulating flows and wetland function and reducing risk of flooding and landslides), thus improving the water supply available for other uses (Smith, et al. 2006; WOCAT, 2007).

3.1 Impact of SLM on Watershed Services

SLM is defined as ‘the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions (UNCED, 1992). SLM aims to maintain ecological integrity and long term sustainability of ecosystems (land, water, biodiversity), increasing productivity (quality, quantity and diversity) of goods and services (FAO, 2008c) and conserving natural capital. SLM encompasses a wide range of farming systems that aim to conserve natural resource, minimize negative environmental impacts, and better capture and maintain water in the rootzone, using a variety of strategies (see box 1).

Box 1 – Sustainable and Resource-Conserving Agriculture Strategies

- Organic farming, where artificial additions to the farming system (inorganic fertilizers and agrochemicals) are avoided, and the role of natural cycles is emphasized.
- Conservation agriculture, which combines minimum or zero tillage with mulching or cover cropping and crop rotation to improve soil quality and reduce erosion.
- Ecoagriculture, which emphasizes managing agricultural landscapes to enhance production while conserving or restoring ecosystem services and biodiversity.
- Agroforestry, which incorporates trees into agricultural systems and stresses the multifunctional value of trees within those systems.
- Integrated pest management, which seeks to use pesticides only when other options are ineffective.
- Integrated nutrient management, which seeks to make a judicious use of inorganic fertilizers and organic amendments, to strengthen nutrient recycling mechanisms and to reduce nutrient losses through erosion control.
- Integrated water management, which seeks to maximize the use of scarce rainfall and increase available water in the root zone in order to enhance biomass production. Drainage and irrigation constitute important aspects of water management.
- Integrated livestock management, which seeks to diversify production, use crop by-products, incorporate manure in soils and raise overall productivity.
- Improved grasslands management, which seeks to improve pasture and animal production through improvements in forage quality and quantity, resulting in higher animal yields.

Table 3 presents an organizing framework for SLM-related interventions that have been shown to enhance watershed functions and land productivity, and that can be envisaged for improved resource management at watershed level. Most of these practices can achieve

multiple objectives. Agroforestry-based soil fertility systems (rotational fallow or permanent intercropping with nitrogen-fixing trees) can double yields and increase net returns on land and labour, in many hillside and agropastoral areas in the southern Africa region, while helping to maintain water quality (World Bank, 2007).

Table 3 - Organizing Framework for Technical Aspects of Land and Natural Resource Management at the Watershed Level

Watershed objectives	Land use Management
Sustain or increase land productivity	<ul style="list-style-type: none"> • Intensify land management, replenish soil nutrients, and control soil acidity by liming and organic inputs. • Crop rotation, agro forestry and intercropping. • Select and use adapted crop, forage, and tree species. • Manage grazing and eliminate the use of fires for land clearing and pasture reclamation. • Maintain soil cover via cover crops and residue recycling. • Protect and stabilize slopes. • Use water harvesting and efficient irrigation where possible. • Maintain drainage to prevent water logging and salinity build-up.
Provide adequate quantity of water	<ul style="list-style-type: none"> • Use soil cover to enhance water infiltration and prevent soil crusting. • Use crop, forage, and tree species with high water-use efficiencies.
Maintain water quality	<ul style="list-style-type: none"> • Protect vegetative filter areas in riparian zones and wetlands to remove excess sediment and nutrients (nitrogen, phosphorus). • Manage household and livestock waste to prevent pollution of surface and ground water. • Contour plantings, vegetative strips, and terraces • Cover crops, perennial vegetation and green manure crops • Reduced or zero tillage • Integrated Pest Management
Reduce flooding and flood damage	<ul style="list-style-type: none"> • Protect and maintain wetlands and zone and regulate floodplains. • Plant deep-rooted vegetation to enhance infiltration and water consumption by plants.

Source: adapted from FAO 1995

3.2 Cost-Effectiveness of SLM for the Environmental Risk Management in Watersheds

Available policy options to control the environmental risk for water from agricultural activities range from economic incentives (subsidies, taxes and transferable property or use rights) to regulatory instruments¹. Selecting the most appropriate method for water pollution

¹ Also, educational and awareness-building measures, mechanisms to increase access of upstream farmers to downstream markets, the building of organizational structures providing a forum of exchange between upstream

control depends on the information available, the number of pollutants to be controlled, the feasibility of the monitoring needs and the transaction costs (O'Shea, 2002).

The diffuse nature of agricultural runoff and leaching makes it difficult to identify and monitor emissions and to control those emissions directly, which is a prerequisite for evaluating the performance of land-based water protection measures. The transmission path from source to receptor involves many unknown variables (rainfall, soil type, microbial activity, level of groundwater table) and the time lag between emission and its appearance in the receptor, are problematic when trying to relate the effluent to its source (O'Shea, 2002) and would render monitoring costs prohibitive.

Because factors generating agricultural pollution can be monitored at lower cost than emissions, traditional policy instruments based on emissions cannot be used in this context (Segerson, 1998). This is why policy has tended to focus on indirect instruments regulating inputs and management practices which can achieve the desired target at least cost (FAO, 2003b, 2007a; Griffin and Bromley, 1982; O'Shea, 2002). SLM techniques fall into this strategy: changing crop mixes and production practices or developing new technologies that alter the output/waste ratio, can reduce the amount of potential pollutants in the waste flows, modify the timing of the outflows, thus reducing the likelihood that the potential pollutants are delivered to a watercourse and mitigating the damage caused. Also, mandatory regulations generally have drawbacks: they are too rigid, have high transaction cost and information needs. This is particularly true for Africa, where technological and institutional inputs are less available (Eskeland and Jimenez, 1992).

In this way, agricultural water quality policy has focused on using instruments designed to provide incentives for farmers to use environmentally-friendly practices voluntarily (Segerson, 1998; Segerson and Miceli, 1998) and more commonly, on mitigating poor water quality and avoiding health impacts through water treatment. Treatment to remove contaminants and to raise water to a standard suitable for domestic use involves a number of different treatments: pre-treatments for the removal of sediment, material and biological pathogens, filtration, disinfection (Steel and McGhee, 1979; WHO, 2006). The extent to which each of these processes are deployed and the exact choice of technology varies with source water quality and the economic capability of the water provider (FAO, 2007a).

and downstream stakeholders, and participatory approaches (e.g. participatory watershed planning) could be used to encourage farmers to switch to less polluting farming practices.

Which of the two approaches, prevention or mitigation, is to be followed in order to protect water resources from agricultural non-point source pollution? To the extent that both approaches will improve water quality for domestic use, they will both serve to alleviate the economic impacts on human health. However, given the site-specific nature of land use, agricultural production and water pollution, there is no general answer to this question. The key question is therefore one of cost-effectiveness: how cost-effective² are *ex-ante* measures to reduce water pollution from agricultural landscapes versus *ex-post* water treatment at the point of withdrawal and abstraction?

In principle there is no sound justification for basing policy on a *presumption* that prevention is more cost effective than treatment, although this is often the case (Lichtenberg and Penn, 2003). Protecting good quality water may take less time (and effort) than improving already poor water quality and, therefore, might be prioritized. There is in fact little doubt that the more uncontaminated the source of water supplied to the public, the purer will be the water at the tap – or, at least, the lesser the treatment required at the water supply system intakes. Preventive measures may appear preferable also for precautionary reasons, that is, reducing the risk of environmental degradation that could prove irreversible (or excessively costly) to remedy (Lichtenberg and Penn, 2003). For example, cost-effectiveness and precaution are the main reasons the US Environmental Protection Agency cites for expanding groundwater protection programs: for groundwater contamination, the per acre costs of many leaching reduction measures appear to be low compared to water treatment costs. Given the importance of groundwater as a source of drinking water and the costs and difficulty of treatment, the best way to guarantee supplies of groundwater is to prevent contamination (U.S. Environmental Protection Agency, 1990).

If improving the input water quality to regulated water systems results in cost savings in the U.S., it will likely result in cost savings in SSA as well because in these countries the investments in water treatment facilities have in many cases not yet been made. Thus, costs of water treatment plants are unlikely to be lower in SSA than in developed countries and the alternative of avoiding the water quality problem through improved agricultural management would be a more appropriate solution in SSA.

² Environmental policies are cost-effective if they achieve some measurable objectives or goals at least cost.

3.3 Key Challenges to Widespread Adoption of SLM Practices in Sub-Saharan Africa

In Sub-Saharan Africa, a first set of barriers that prevent wide-scale farmer's adoption of BMPs such as SLM techniques is represented by knowledge gaps at local level (farmers, communities, local extension officers) to adopt new technologies and to follow strategies that would allow them to increase production and conserve their natural resource base. The lack of adequate training together with insufficient access to new technologies, are a consequence of the ineffectiveness of advisory services due to a lack of financial resources (TerrAfrica, 2007).

A second set of obstacles is represented by economic factors. The most convincing argument for land users to invest in SLM is an increase in land productivity in the long-run, due to improved biological and chemical components of the soils, and its associated economic returns (Wocat 2007). However, in the short-run, during the transition phase from conventional agricultural to more sustainable practices, farmers face establishment and maintenance costs, and incur in opportunity costs over land and labour resources invested. In this period, farmers will often have temporary negative economic returns if no adequate economic incentives are provided.

Establishment costs are defined as those specific one-off initial costs which are incurred during the setting up of a SLM technology (e.g. extra labour, hire of machinery, purchase of equipment). Maintenance costs relate to keeping the system functional: they are generally made up of labour, equipment and agricultural inputs (Wocat, 2007). For example, research in study sites in Africa, where SLM practices are adopted, has recorded decreasing fertilizer inputs needs over the long-run (ACTN, 2002), fertilizer use can increase in the transition period, depending on whether green manure crops are used in the rotation and how effective they are. These costs are country- and site- specific (see table 4).

Table 4 - Examples of Establishment and Maintenance Costs for Selected SLM Practices

	Technology	Country	Establishment costs	Maintenance costs
			\$US/ha	\$US/ha
Conservation agriculture	Small-scale conservation tillage	Kenya	n.a.	93
	No till technology	Morocco	600	400
Terraces	Traditional stone wall terraces	South Africa	1.270	160
	Fanya juu terraces	Kenya	320	38
	Small level bench terraces	Thailand	275	45
Agroforestry	Shade-grown coffee	Costa Rica	2.535	330
	Grevillea Agroforestry System	Kenya	160	90
Vegetative strips/cover	Natural vegetative strips	Philippines	84	36
	Vetiver grass lines	South Africa	140	25
Grazing land management	Improved grazing land management	Ethiopia	1.035	126
	Restoration of degraded rangelands	Kenya	230	32

Source: Wocat 2007

Short-term opportunity costs may also include foregone income for farmers as they change from their prior crop production or farming practices to the new. In fact, during the transition phase, farmers may not yet gain the yield increase expected from implementing the SLM practices, while the soil ecosystem adjusts from an equilibrium to another, with a consequent increase in yield volatility and output uncertainty.

Naturally, these costs can have a negative impact on the adoption behaviour of the poor, who generally have higher risk aversion and face higher discount rates. Risk-averse farmers are often reluctant to make a major change in their farming practices due to the potential risk to yields, income and food security that are involved, even if it is only for a limited period. Also, household size, education levels and farming experience may limit farmers' capacity for scaling-up SLM practices, exacerbating the implementation costs.

The implementation of SLM practices could therefore have an overall negative impact on the farming business in the short-run and financial support to foster farmers to the adoption of good practice could be necessary. This will bring us to the third set of barriers which could prevent low income agricultural producers from adopting SLM technologies: the implementation of SLM practices requires some capital investments which is hardly available for poor farmers. Credit facilities to support up-front investment by land-users are lacking and farmers – especially the poor ones – have difficulty in obtaining loans. Incentives like up-

front investment support for returns deferred in the longer-term, compensation for resource non-use are non developed or where available not applied efficiently to attract private sector involvement or to further sustainable practices by local resource users (FAO, 2007b; TerrAfrica, 2007).

Last, capital investments require adequate institutional support on securing long-term property rights over resources such as formalizing individual or community land rights. Insecurity of land tenure decreases the ability of the farm household to capture the future agronomic and economic benefits of making investments in land productivity and represents a major barrier to SLM adoption.

4. The potential of PES Programs to Protect Water Quality in SSA

4.1 PES as incentives for the Adoption of SLM Practices

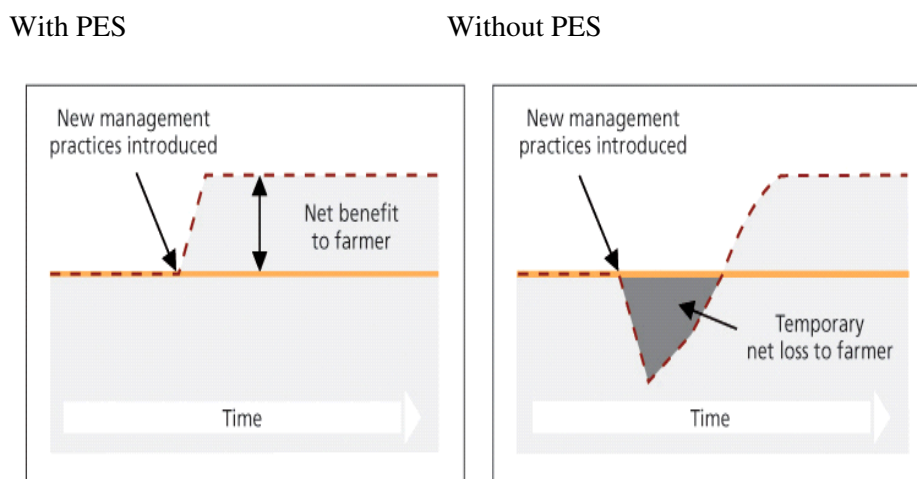
Payments for Environmental Services (PES) are an economic instrument designed to provide incentives to land users, on behalf of service beneficiaries, for agricultural land, coastal, or marine management practices, that are expected to result in continued or improved service provision, so users will benefit more broadly. PES programmes have therefore the potential to provide incentives to land managers to adopt SLM practices to generate environmental services (e.g. increase downstream water quality), depending on the profitability of SLM techniques, the presence of barriers to SLM adoption, and the beneficiaries' willingness to pay.

In the case of SLM practices which simultaneously increase farmers' net income (increasing production output, reducing input costs or both) and improve environmental quality, there would probably be no need of any PES program, as farmers are better-off with the new land-use system even in the absence of payments: the system generates sufficient private incentives to motivate farmers to maintain.

Nevertheless, in many cases, improved practices that would be potentially profitable for farmers may not be adopted because of specific barriers (see above) and producers will find it difficult to change their resource management practices in a way that could provide more environmental services. In these cases, if service beneficiaries are willing to pay the farmers for the services they provide, a PES scheme could be put in place and farmers would receive a payment conditional to the implementation of the improved practices. Establishing where (at local, regional or global level) and when (immediately or into the future) the benefits

from environmental services occur and estimating their value are essential elements for identifying the buyers from the longer list of potential beneficiaries and estimating the level of payment. Actually, most PES programmes are funded by the public sector, although the private sector is increasingly becoming involved in purchasing environmental services. The payment could help overcome the barriers to the adoption of SLM practices, which may also be only temporary (see Figure 1).

Figure 1 - PES as a temporary support to overcome barriers to SLM implementation



Source: adapted from FAO 2007a

However, if improved practices are not adopted due to significant and long-term opportunity costs (e.g. placing land under natural grass or forest cover can enhance water quality but might result in lower returns to the farmer), or simply because they are not profitable for the farmers, payments will have to be high enough to cover this loss and maintained in perpetuity to ensure a continuing stream of environmental services and this type of commitment is difficult to secure³.

Therefore, when environmental service beneficiaries are willing to pay, obstacles to SLM adoption are minor and only present in the preliminary stages (e.g. lack of information), and farmer opportunity costs are low (or even negative), PES could have high potential to support

³ While there is considerable experience with the propagation of agricultural innovations and the adoption of SLM in Africa, most interventions have been project-based and phase-out before the results can be realized. To have a significant impact, there is the need to move toward long-term efforts (FAO, 2008c). To respond to this need, several regional and international initiatives are already underway. While the TerrAfrica Platform aims to help overcome the obstacles currently preventing the scaling up and mainstreaming of nationally-driven SLM strategies and capture additional investment, the associated GEF Strategic Investment Programme for SLM in SSA (SIP) offers a strategic and programmatic financing mechanism for GEF resources aimed at scaling-up SLM in SSA (TerrAfrica, 2008).

SLM adoption. Conversely, when willingness to pay is low or absent, SLM adoption requires substantial upfront investments (e.g. clarifying property rights of numerous smallholdings under contentious disputes), and farmers opportunity costs are high, PES is unlikely to cope with these challenges, and non-market instruments (e.g. regulations or taxes) would probably be best suitable to enhance the incentives for resource users to supply services desired by society.

Additionally, when dealing with watershed service providers in developing countries, PES schemes face additional barriers that substantially increase transaction costs: negotiating with numerous land owners, often disperse along vast areas and of difficult access, with unclear property rights, low levels of information and high poverty rates. Poor agricultural producers in rural areas of developing countries are in fact among the main suppliers of watershed services. Channelling payments to these communities in return for the provision of these services could generate benefits both in terms of improved natural resources management and improved livelihood.

Beyond improving environmental conditions, PES-supported land management measures also have the potential to improve farm income and reduce rural poverty; but this may not always be the case, and indirect costs and benefits to participating and non-participating farmers must be taken into account. Where poverty reduction is the main aim, the institutional causes of poverty need to be addressed and basic services such as health, education, sanitation and the provision of clean water should be improved (Landell-Mills and Porras, 2002; Ravnborg et al., 2007). Still, poverty and natural resource degradation are severe interrelated problems in less-favoured areas in Africa, such as much of the highlands of East and Central Africa and large portions of the humid tropics of SSA. Most of the rural poor live in these areas with low agricultural potential due to uncertain rainfall, poor soils, steep slopes and other biophysical constraints. In addition, insecure land property rights and resource degradation accentuates the threat of famine. Therefore, PES programmes aimed at addressing land management issues among rural communities living in upstream areas of the watersheds will indirectly address also problems of poverty and access to land. Such schemes, if designed with pro-poor options, could represent an additional intervention to reduce poverty and overcome problems of land tenure in upland catchments.

4.2 Marketing Watershed Services through PES Programs in SSA

Upstream farmers implementing SLM practices supply watershed services which benefit downstream users. Reducing the sediment load caused by erosion can decrease its physical impacts on reservoirs, settling ponds and outtakes and increase river discharge capacity. Also, it can reduce the presence of chemicals and biological pathogens in the water thereby reducing treatment costs. There is no dispute that better agricultural management can lead to better water quality and reduced water waste, however, whether and to what extent (and at which time and geographic scale) it will happen and will be able to lower water treatment costs remains an important question. The answer depends on demonstrable scientific evidence to linking land use to water quality and quantity.

The uncertainty surrounding hydrological processes within and beneath the soil makes it difficult to quantify the amount of water (and its qualitative properties) provided by a specific land manager upstream to a specific water user downstream. Water travelling downstream can move between basins, remain underground or leak through deep soil. The absence of adequate soil and subsurface data leads to scientific uncertainty in tracing water from producer to consumer, especially in developing countries. The larger and more well-defined the catchment, and the fewer and larger the downstream users, the less is a problem, since the users will eventually receive all the water produced (DFID, 2005). However, this is rarely the case when setting up PES schemes in developing countries, where land units are small and disperse, which increases both this uncertainty and the monitoring costs. In the case of small-scale local community systems smaller headwater catchments facilitate a clear connection between BMPs and water quality thus facilitating the implementation and monitoring of the scheme.

Given these traceability difficulties, combined with large number of land units to monitor, PES schemes supporting watershed management do not usually monitor the actual change in water quality or quantity, but instead verify the adoption of the land management options that have a scientific basis to grant high probability of delivering the expected environmental benefits. Porras et al. (2008) report examples of impacts of watershed management and highlight that while there is some evidence based on actual monitoring, in many cases the only information available is based on local perceptions.

Due to the fact that often PES in developing countries is combined with poverty alleviation goals, payments or compensations are not conditional and sometimes completely irrevocable or not politically feasible. This is the case of investments in social improvements without

links with land management commitments, like health or education services, or temporary land-tenure. While these services are vital and must be provided to rural communities, they should not be used as compensation for environmental service provision as they do not ensure compliance, which will be a requirement for any private investor aiming to receive the expected returns on his or her investment. In the case of publicly-funded schemes, which normally have with wider development goals, the program may allow for less environmental efficiency to accommodate improvements in social equity, in which case conditionality may be less of a requirement, but these compromises must be clearly acknowledged by all parties since often there's a combination of private and public funding involved.

The combination of scientific uncertainty, high monitoring costs and difficulties in enforcement, reduces buyer's investment confidence and delays negotiations. Capturing enough demand has in fact been the main bottleneck for PES development schemes, delaying upscaling on emerging initiatives and rendering schemes dependent on donor funding for longer than expected, even in some of the larger and well established schemes (Porrás et al 2008)⁴. To overcome this, some PES schemes begin with a trial phase over a smaller area, hoping to demonstrate benefits to prospective buyers. Unfortunately given the nature of watershed functions, requiring large scale interventions over long periods of time, evidence remain limited and this has deterred buyers from engaging in earnest. Most buyers agree to pay much lower amounts that required and often as one-off donations (Porrás et al. 2008).

But establishing where and when the benefits from watershed services occur is fundamental to understand the basis of demand and payments for them. While it is difficult to assign responsibility for a specific hydrological improvement, it is relatively easy to identify the users or beneficiaries of watershed services (e.g. municipal water suppliers, hydroelectric facilities, industrial users, and irrigation systems), although they might not be easy to organize if there aren't already associative bodies in place. Even when there are, it is often difficult to engage investment for improved watershed management in addition to existing water use fees. However, in situations where water users are already bearing heavy costs associated with the degradation of watershed services, the demand and willingness to pay for watershed services may be substantial and beneficiaries may become increasingly aware of the importance and

⁴ A review of PES schemes for watershed services, carried out by the International Institute for Environment and Development IIED between 2005-2006 (www.watershedmarkets.org), revisited the case studies identified by Landell-Mills and Porrás (2002) and found that many of the initiatives emerging in 2002, were still not operational, partly due to lack of start-up funds and difficulties in achieving commitment from beneficiaries.

cost-effectiveness of improved management in the upper parts of watershed for the maintenance of water provision downstream (FAO, 2007a).

Water treatment costs are a significant component of overall supply and sanitation costs. Where water treatment infrastructure is in place, the savings from improved ecosystem management may reduce the variable costs of treatment. Where water treatment infrastructure is not yet in place, savings from improved ecosystem management may also postpone capital investments in water treatment infrastructure, or avoid expensive upgrading of the existing system. In this way, large urban areas and municipal and industrial water suppliers are prime candidates for engaging in payment programmes with land managers in the upstream watershed.

Current demand for watershed services originates mainly from public payments. Public watershed payment schemes currently represent by far the largest market for watershed services and are well established in the United States, Mexico, Costa Rica and China, for example. In addition, the private sector is increasingly becoming involved in purchasing watershed services, and there is often the need to top up public payments with contributions from private companies in order to meet the entire costs of service provision. Private voluntary watershed programmes are very promising in the sense that they can mobilize additional and long-term funding straight from the direct beneficiaries of the programme. However, as discussed above, translating user benefit and willingness to pay into actual revenue streams has been limiting the development of these initiatives. Still, the interest in this measure remains high and work is ongoing to overcome these obstacles and there are various operational public and private PES programs supporting the adoption of management practices to prevent risk of reduction in water quality. Box 2 reports some examples. These are mainly found in North America, Europe and Latin America, with some emerging initiatives in Asia.

Limited experience with payments for watershed services exists in Africa. Questions therefore arise as to how applicable these schemes may be to rural areas in lower income developing countries, such as in SSA. Nonetheless, various projects are currently underway in Kenya, Tanzania, Uganda and Guinea, focusing mainly on watershed services enhancement (and increasingly also on climate change mitigation). In Kenya, one of the pilot sites is in the Sasumua catchment, central Kenya, and aims to reduce water treatment costs incurred by the Nairobi Water and Sewerage Company (NCWSC), at its Water Treatment Plant in Njabini, Nyandarua District. The goal is to improve agricultural land management to reduce erosion in

steep slopes and runoff of agrochemical pollutants from intensive horticultural production in the lower areas, supplying the urban markets of Nairobi, Naivasha and Nakuru (ICRAF, 2009).

Box 2 - Examples of PES Schemes Supporting SLM Practices for Preserving Water Quality

Some PES schemes collect funds from water users to invest in improved management of the conservation areas that protect the headwaters of the water courses on which their water supply relies.

The city of Quito, in Ecuador, has been running a fund for this purpose since 1998 (FONAG, 2008). Hydropower producers in Costa Rica make substantial voluntary contributions to the national PES scheme, which pays landowners for forest conservation and other measures, to reduce the risk of increased siltation of their dams and damage caused to turbines (FONAFIFO 2008).

In Brazil, the Piracicaba water utility began providing farmers with incentives to restore riparian strips for fear of losing its new water source (the Corumbataí river) after water in the Piracicaba river had become economically untreatable (FAO, 2007b).

In 1992, instead of building a US\$ 8billion dollar filtration system to comply with more stringent regulation on drinking water quality, the New York City's Department of Environmental Protection chose to invest 1.5US\$billion in a Watershed Agricultural Programme. The programme helps farmers improve their production practices and reduce water pollution impacts. It provides technical assistance, covers a large part of the costs and is accompanied by a range of other off-farm environmental complementary measures (NYC-WAC 2008).

PES schemes have also been used to achieve quality standards beyond those required by law. Vittel-Evian (France) has been paying farmers to adopt more environmentally sound practices to reduce agricultural run-off (pesticides and nitrates) and improve soil natural filtration capacity. Investment reached 980 euros per hectare per year (INRA 1997; Agence de l'Eau 1999), equivalent to 1.52 euro per m³ of bottled water produced. (Perrot-Maître, 2006). The French National Agronomic Institute demonstrated that under the assumption that one hectare of well-managed pasture produced 3000m³ of mineral water every year (INRA 1997).

5. An illustrative example - Equitable Payments for Watershed Services: Delivering Conservation and Poverty Reduction in Uluguru, Tanzania

This section describes the Equitable Payments for Watershed Services (EPWS) programme aimed at channelling economic incentives from the private sector to farmers, for the environmental services provided through the adoption of SLM practices in the Uluguru Mountains of Tanzania⁵.

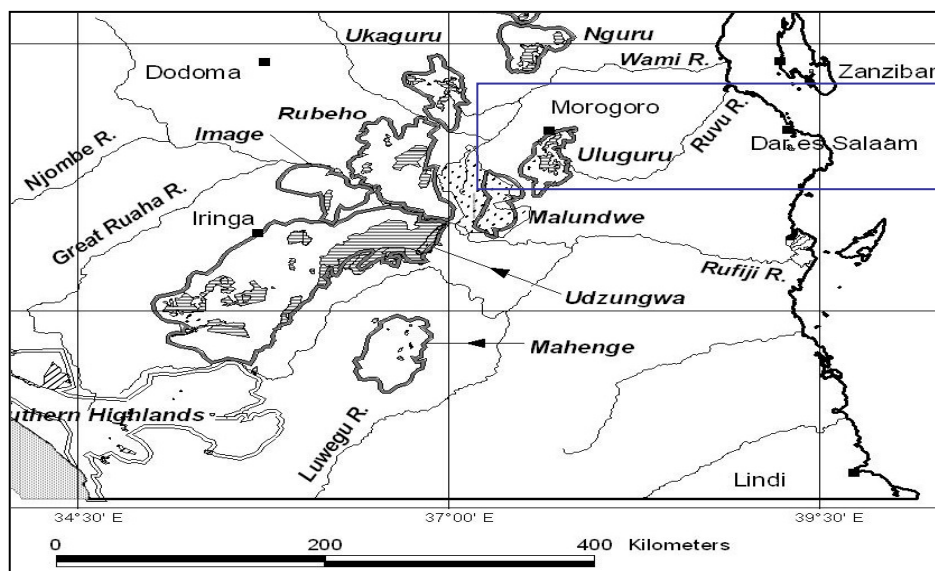
⁵ This scheme is being implemented by CARE International in Tanzania and World Wildlife Fund for Nature (WWF) in Tanzania.

5.1 Site Description

Part of the Eastern Arc Mountain Range, the Uluguru Mountains are located in the Morogoro Region, about 200km West of Dar Es Salaam, the largest city in Tanzania (4 million inhabitants). It is moderately remote and isolated small ridge of mountains lying in the altitude range of 200 – 2,638 m. High annual rainfall varies between 1,000 and 3,000 mm/year feeds the various tributaries of the Ruvu River, the principal source of water for the city of Dar Es Salaam⁶. In this area there are fifty-one villages where approximately 150,000 people live (CARE/WWF 2007a).

The EPWS programme is being piloted (2008-2011) in the south-east part of the Uluguru mountains, in the Kibungo sub-catchment⁷, focusing on the Mfizigo River which is one of major tributaries of the Ruvu River (see Figure 2). The activities of the pilot phase involve four villages (Kibungo, Lanzi, Nyingwa and Dimilo) and about 5000 farmers relying on agriculture as their subsistence activity. Farming systems are semi-intensive in both flat and mountain areas, main crops being cereals (maize and rice), tubers (cassava) and fruits (banana and pineapple) (CARE/WWF 2008).

Figure 2 – Uluguru Mountain and Ruvu River – Morogoro, Tanzania



Source: CARE/WWF 2007d

⁶ The Ruvu River provides more than 85% of the Dar es Salaam's water needs (approximately 86 million m³ in 2005-06) (CARE/WWF 2007b).

⁷ Depending on the result of the pilot phase, the programme will then be scaled up to other sub-catchments in Uluguru (Mmanga, Mvua, Mbezi, Mgeta and Ngerengere rivers) and possibly also to others catchments in Tanzania.

5.2 The Environmental Problem

Current farming systems and agricultural practices are unsustainable over the long-run and are leading to accelerated degradation of land and water resources, with consequent decline in soil productivity. Farmers have poor technical knowledge and lack the capacity to invest in new technologies (low income, inadequate access to credit and extension services). Crop production is often realised on fragile steep slopes and using techniques that result in insufficient ground cover during the rainy season (e.g. slash and burn). In addition, land is often abandoned when productivity declines, leaving the areas completely bare and prone to severe erosion. These problems have been exacerbated by population growth (2.7% annual growth rate) which has led to significant conversion of forest to farmland: between 1995 and 2000 the extent of cultivated land increased by 300%, with a reduction of 2% in high forest, 20% in woodlots and 12% in bush land (CARE/WWF 2007a).

Such conditions lead to high sediment loads in water courses, with subsequent reduction in water flows, increase in water turbidity and overall decline in water quality. Hydrological analysis undertaken over the 1992-2003 period indicates that water turbidity in Ruvu River increased at an average of 5 NTU⁸ per year, with overall turbidity values concentrating in the range 100-200 NTU towards the end of the decade. Projections in the hydrological analysis suggest turbidity levels will increase by 1.5- 3% annually, over the next 20 years, with more frequent episodes of high turbidity above 300 NTU (CARE/WWF 2007a;d). Considering that the standard for drinking water is normally set at 1 NTU (although values up to 5 NTU are usually considered safe), and that water of 10 NTU and above can interfere with or damage treatment filters and result in intake closures at drinking-water facilities (USGS 2003), any public or private company using water from the Ruvu River incurs considerable water treatment costs.

5.3 The Supply of Watershed Services

The PES mechanism being proposed here seeks to translate willingness to pay for avoided increase in water treatment costs for users in Dar es Salaam, into incentives for farmers in Uluguru Mountain to implement SLM practices and thereby reduce the risk of increasing negative externalities associated with unsustainable agricultural activities. The pilot phase of

⁸ Nephelometric Turbidity Unit, a unit used in measuring water quality.

the EPWS programme will involve 1,215 households which will receive support in changing the current agricultural practices and implement SLM interventions over the total farmland area of 2,240 ha (CARE/WWF 2007c).

The SLM strategy adopted by the programme includes several soil conservation technologies: terraces (Kilaka, Fanya juu)⁹, afforestation and reforestation, pineapple contour strips, agro forestry and grass strips and riparian restoration or sugar cane strips or tree planting in riparian areas (7.5m either side of rivers). The goal of these measures is to reduce soil erosion and overall land degradation, thus enhancing downstream water quality are averting future worsening conditions. It is also expected that such practices will boost crop productivity as a consequence of gains in soil conservation and improved fertility and increase farm incomes, as already experienced in similar sites of the region, for example using pineapple contour farming in Tandai, north Uluguru. (CARE/WWF 2008, UMADEP 2000).

The implementation costs of the proposed SLM practices have been considered adding one-off establishment cost of each technology and the annual maintenance costs (labour and other inputs) to the annual opportunity costs for the land taken out of productive use (see table 5).

**Table 5 - Costs of Implementing SLM Practices in the Kibungo Sub-Catchment
Over the 4-years Period of Trial**

	Implementation Area ha	Establishment costs Yr1 US\$/ha	Maintenance costs Yr1-4 US\$/ha	Opportunity costs Yr1-4 US\$/ha	Total costs by Yr4 US\$/ha	Trial total costs US\$
Afforestation, reforestation	300	87	76	756	3.415	1.024.500
Kilaka terraces (with agroforestry and grass strips)	100	334	192	1.058	5.334	533.400
Pineapple contours (with agroforestry and grass strips)	940	58	116	176	1.226	1.151.970
Fanya Juu terraces (with grass strips)	600	320	38	44	648	388.800
Riparian restoration, sugar cane planting, tree planting	300	8	40	58	400	120.000
Average implementation costs	-	137	83	242	1.437	-
Total	2.240	-	-	-	-	3.218.670

Source: adapted from CARE/WWF 2008 and WOCAT 2007

⁹ The *Kilaka* terrace consists of a shelf-like embankment of earth, usually man-made, along a contour of sloping land, to control runoff and erosion. A *Fanya juu* ("throw it upwards" in Kiswahili) terrace comprises embankments (bunds) which are constructed by digging ditches and heaping the soil on the upper side to form the bunds which are usually stabilized with grass strips (WOCAT 2007).

Hydrological monitoring stations will be strategically located within the Kibungo sub-catchment for Mfizigo River, in order to measure and monitor hydrological changes in terms of reduced sedimentation and turbidity. Also, farmlands will be mapped through GPS systems and monitored to document adoption of the technologies applied by farmers. If the scheme does deliver less turbid water at the sub-catchment level after the four years trial period, the programme will likely be scaled-up.

5.4 The Demand for Watershed Services

Water users in Dar es Salaam include 80% of Tanzanian industries and about 4 million inhabitants, thus there is potentially significant demand for watershed protection services. Following a buyers profiling exercise, CARE/WWF identified two buyers that showed the highest willingness and ability to pay for reduced water treatment costs as a result of SLM practices implementation: the public water utility DAWASCO (Dar es Salaam Water Supply and Sewerage Corporate) and the private company Coca Cola KL (Kwanza Limited) to which DAWASCO supplies water¹⁰. DAWASCO currently spends nearly 2 million US\$/year in water treatment costs due to increased sediment load in the Ruvu river. These costs are likely to increase in the future as a result of the expected increase in frequency of high turbidity episodes, which could even cause temporary stoppages in water supply (CARE/WWF 2007b, c).

It is estimated that the reduction in sediment load in Ruvu River, resulting from the implementation of SLM practices in the Ulugurus area, could reduce DAWASCO's treatment costs by 10% (i.e. 200,000 US\$/year). It has been also estimated that by 2018 DAWASCO could reduce total costs – both reduced costs and the saving of costs which would otherwise be incurred – by more than 400,000 US\$/year. Costs savings will also be passed on to domestic and industrial water consumers such as Coca Cola KL. Per day, this company requires a supply of approximately 1,500m³ of water and 40% of its profits depend on water supply from DAWASCO. If, due to an increase in the frequency of high turbidity episodes, Coca Cola KL would have to resort to trucking in the necessary water, this could have a cost of about 200,000 US\$/year. It is worth to mention here that water consumers in urban areas would be willing to pay an extra amount of 0.11-0.18 \$US/m³ if such money was used to

¹⁰ A third buyer was also identified: *Tanzanian Breweries* which rely mostly on groundwater and do not have incentives to participate to the EPWS scheme. However, it is reported that the company has been recently experiencing problems of water salinization and is relying more heavily on DAWASCO as water supplier, which could constitute an incentive for participating in the scheme in the medium term.

secure watershed services provided by the Ruvu catchment. Given DAWASCO water production and rates of revenue collection, this suggests that the market could bear additional annual tariffs amounting to 2.8 to 4.7 million \$US/year (CARE/WWF 2007b,e).

5.5 The Market for Watershed Services

The status of supply and demand described above makes it possible to create a market for watershed services. Whilst it is unlikely that there will be any discernable improvement in watershed service provision over the period of the trial, or for a number of years following scale-up given the size of the catchment, the two companies DAWASCO and Coca Cola KL have shown their interest to support the EPWS scheme. Indeed, DAWASCO has agreed to contribute 100,000 US\$ over the period of 4 years to the EPWS programme and Coca Cola KL has agreed to make a contribution of 200,000 US\$ over the same period, as an initial form of payment which should help farmers to overcome the costs to the adoption of the SLM measures (CARE/WWF, 2007b,e).

These incentives are to be in the form of in-kind payments (vouchers that participants are free to use as they wish), provided to the farmers that have already implemented part of the practices (as a payment for work done), and calibrated to compensate the costs associated with implementation and maintenance of SLM practices.

The contractual framework under which SLM practices are adopted and in-kind payments made, involves the aggregation of land-owners and disbursement of in-kind payments by Village Authorities, to avoid the higher costs of contracting individual land-owners. Also, since the land is public, farmers do not have land entitlements, while the Village Authorities manage the land on behalf of central government and are entitled to enter into such contracts and enforce the commitments taken up by individual farmers. .

A participatory approach is adopted in order to ensure the sustainability of the PES programme. An Intermediary Group (IG) has been created involving the members from key sectors with a stake in forestry and water resources, particularly the Ministry of Water through the Directorate of Water Resources and the Wami-Ruvu Basin Water Office in Morogoro, local communities, private companies as well as the Civil Society Organisations. This body will oversee the programme implementation, mobilize farmers, identify the institutions

devoted to collect and distribute the payments to farmers¹¹, and lead the scaling up and replication of the scheme into other watersheds across Tanzania (e.g. the East Usambara Watershed where the Sigi River supplies water to the city of Tanga).

6. Conclusions

Ex-ante measures to control water pollution can reduce water treatment costs and ensure against future increases. This is the major drive for the supporters of PES schemes to invest in improved watershed management. Adoption of Sustainable Land Management (SLM) practices to reduce upstream land degradation and raise soil productivity can improve watershed functions of interest to downstream water users. However, lack of information and technical capacity to implement these measures, coupled with lack of financial resources to cover short-term establishment costs and long-term maintenance and opportunity costs, have largely prevented these measures from being widely used.

Market-based incentives like PES could bridge this gap, pool funds from public and private sources to help cover establishment and maintenance costs, and may also provide continuous payments to compensate recurrent opportunity costs, if the changes in land management do not offset these by increasing productivity. By establishing a rapport between upstream land managers and downstream water users, PES schemes have begun mobilizing funds to create or improve existing information and technical capacity building platforms for improved land management. They have also secured funds to compensate farmers for the additional costs of adopting SLM practices. Ultimately, PES schemes strive to become financially independent from public funds by encouraging the private sector to act as buyer of environmental services and commit to financing PES programmes in the long run. In this sense, the main obstacle preventing private firms from being involved further is the lack of information that can make a strong “business case” to justify investments.

Despite this potential, the results from the development process of the case study discussed in this paper show that PES initiatives must overcome much of the same obstacles as those already faced by SLM interventions: start up funding forcing to rely on external resources, lack of awareness for the benefits of improved watershed management, missing technical capacity to assess feasibility and design of the mechanism, and legal and institutional

¹¹ Potential institutions to take lead in collecting and distributing payments are Wami-Ruvu Basin Water Office and Eastern Arc Mountains Endowment Fund. Nevertheless, at the initial stages of the EPWS scheme, the transfer of payments will be done through the CARE/WWF Consortium.

framework that can facilitate the required partnerships and funds transfer, unclear use and property rights over land. Low awareness of current poor service provision and difficulties in monetising economic values of improved provision of services has been limiting the demand pool and the size and timeframe of their contributions. While in the feasibility phase costs were covered by donor funding, strong partnership within civil society acted as the bridge between the farmers upstream and the major water users downstream, generating information to clarify the expected roles and potential cost and benefits borne by involved parties, and facilitating the negotiation process, securing funding commitment from water users.

More research is needed to better understand the potential to combine PES incentives with SLM adoption. Increasing the technical capacity of regional natural resource management organizations could play an important role in facilitating the implementation of PES schemes well informed in terms of the possible biophysical impacts and grounded on solid business arguments. In addition, because PES schemes are evolving largely based on a learning-by-doing basis, greater emphasis should be placed on the dissemination of experiences; on successes and failures alike. This would increase awareness of policy makers and generate incentives for better collaboration and combined investment, from the various public organisms entrusted with the adequate management of water and land resources for rural development, urban water needs and industrial growth, especially pressing in a context of increasing demand and climate change forcing.

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