AGR‹CULTURE AS A PROVIDER OF ECOSYSTEM SERVICES: A RESEARCH AND CAPACITY BUILDING INITIATIVE OF THE CPWF

Johnson, N1 and Maina FW2

CPWF/TSBF-CIAT. E-mail: n.johnson@cgiar.org, Nairobi, Kenya

Overview
This paper presents the experience of the Challenge Program on Water and Food in identifying ecosystem/environmental services from agriculture in Africa. The paper brings in the context of soil science research and how the researchers can identify environmental services provided as a result of soil science research findings in a bid to improve provision of watershed services.

Keywords: agriculture, ecosystem services

Introduction

The Water and People in Catchments (Theme 2) of the Challenge Program on Water and Food (CPWF) and The African Network for Soil Biology and Fertility (AfNet) are involved in a research and capacity building initiative on “Payment for Environmental Services (PES) approaches to contribute to equitable and sustainable management of soil and water in upper catchments.” The purpose of the CPWF PES in watershed initiative is to assess whether the soil and water conservation practices currently being developed to improve farm-level crop and water productivity also have landscape scale benefits, and if so, whether PES mechanisms can act as an additional incentive for their adoption by farmers. The initiative brings together social and biophysical scientists from the CPWF and from the three regional soils consortia, AfNet, MSEC (South East Asia) and MIS (Latin America).

In Africa, the overall objective of the initiative was to incorporate landscape perspectives and social science into soil research with a payment for environmental services perspective. Specifically the initiative seeks to first increase awareness amongst soil scientists on the role of their research in watershed management. The initiative also seeks to form a baseline of current basin level users and providers of watershed services from agriculture and efforts in managing their soil. The output of the initiative should contribute to strengthening research on land and water interactions at multiple scales through quantifying interactions, develop technologies and design governance mechanisms.

Dynamics of Implementation

Ecosystem and Environmental Services
Whereas the terms Ecosystem services and Environmental services are sometimes used interchangeably, some authors have sought to differentiate the two terms. According to the Millennium Ecosystem Assessment (MA), ecosystem services are defined as those services that nature provides to humans. Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. MA
divides ecosystem services into four categories along functional lines to include provisioning (e.g. production of food and water), supporting (e.g. nutrient cycling and crop pollination), regulating (e.g. control of climate and carbon sequestration), and cultural (e.g. spiritual and recreational benefits) services. Ecosystem services are distinct from other products and functions because there is human demand for these natural assets (MA 2003; FAO 2007a).

In 1997, the UN defined environmental services as the qualitative functions of natural non-produced assets of land, water and air (including related ecosystem) and their biota. According to UN (1997), there are 3 basic types of environmental services:

a) disposal services which reflect the functions of the natural environment as an absorptive sink for residuals;

b) productive services which reflect the economic functions of providing natural resource inputs and space for production and consumption; and

c) consumer or consumption services which provide for physiological as well as recreational and related needs of human beings.

More recently, the term environmental service is used to refer specifically to the subset of ecosystem services characterized by externalities. They occur as unintended consequences of the primary ecosystem activities. These externalities, positive or negative, are not incorporated into the price of products or services sold in the market (MA 2003; FAO 2007a). These services are usually categorized in 4 namely: carbon sequestration, watershed protection, biodiversity conservation and amenity value (FAO 2007a; Wunder 2005).

In summary, environmental services can hence be defined as based on the concept of externality and focus on the “what” sectors of benefits whereas ecosystem services refer more to the functions, and focus on the “how”.

**Linkage between agriculture and the environment**

According to FAO, agriculture accounts for about 70 percent of all water use in the world and up to 95 percent in many developing countries (FAO 2007b). Agricultural ecosystems are by far the largest managed ecosystems in the world and their provision of ecosystem services beyond the intended production of food, fibre or timber, depend on the decisions of farmers, fishermen and forest users that manage them. This makes farmers the biggest group of natural resource managers who both depend on and generate a large array of ecosystem services. Their actions can either enhance and/or degrade a broad number of natural and managed ecosystems.

Modern agriculture is more easily known for providing the ecosystem services (ES) for which markets exist (provisioning services/private goods) – crops, livestock, fish and wood regulating, cultural and supporting ecosystem services. However, as earlier indicated, managing agro-ecosystems to obtain the provisioning services has often come with effects on the other ecosystem services which are not covered by markets (mainly public goods). Some of these effects are positive (e.g. recharging atmospheric oxygen and views of a pastoral landscape) but others are negative (e.g. water pollution by plant nutrients, land degradation and soil erosion from slash and burn, tillage and over-grazing). However, if appropriately informed and supported, the land managers can reduce the negative environmental impacts from their production activity and improve the regulating and supporting services whose effects span
regionally and globally (FAO 2007a) – at different degrees of trade-off with agricultural production.

Options for such changes that reduce negative environmental impacts include:
- Having their land remain in agriculture but alter the production practices to increase environmental sustainability. This could include integrating conservation measures into their production process (e.g. reducing tillage or leaving more crop residues on fields – this can enhance soil fertility and lessen run-off, reducing the need for chemical inputs as well as increasing soil carbon sequestration potential),
- Diverting part of the land from crop and livestock production to other uses (e.g. the practice of leaving a proportion of farm land uncultivated or put to non-agricultural use for a period of time), or
- Avoiding a change in land use (e.g. not converting land from forest to agriculture)

However, the trade-offs need to be understood before such decisions are made. It is important to understand its impact on the farmers (especially small-scale) livelihood as well as the macro-economic effects on food and labour availability as well as prices. The individual resource-poor farmers in most tropical countries often rely on their farm production first as a main source of food, then as a source of income – whether it degrades the environment or not (FAO 2007a). Any initiatives and/or interventions should, not only focus on environmental sustainability, but also take into consideration the short-term subsistence needs of the population, and social and financial viability of the activities. If these factors are taken into consideration, it is possible to have the communities manage the environment sustainably, as opposed to forceful evictions or total banning of their activities.

This challenge of producing food and other products while delivering environmental services is particularly relevant in Africa, where food security and poverty reduction are pressing concerns. Recent research shows that growth in agriculture is the most beneficial for the poor: a one percent increase in yields results in a decrease of 0.6 to 1.2 percent in the number of people living on less than one dollar per day (Fresco 2005). However, most incentives promote agricultural production at the expense of (or without considering) other services. Hence, for sustainability the challenge is to develop interventions that integrate environmental conservation (service provision) with social and financial viability of the relevant communities.

However, it is evident that poverty is one of the major causes of agricultural-induced environmental degradation and is often characterised by insecure land tenure, lack of land title, small farm holdings or lack of access to credit. These factors often lead to land users managing an ecosystem for short-term subsistence needs at the expense of future benefits. For the near future, therefore, dealing with poverty, hunger and environmental sustainability in much of the world means confronting the problems that small farmers and their families face in their daily struggle for survival. Most of these small land owners/users do not consider their small actions to have landscape effects. However, the cumulative effect of the small land users can lead to major externalities at a landscape level. There is need to hence understand how programs can be designed to maximise poverty reduction, while minimizing possible negative
effects and at the same time not undermining the achievement of sustainable environmental goals.

There is evidence that most conservation measures often reduce short-term profits of the land users due to requirement of additional labour, land and organic input investment. Thus, from a conservation point of view, technology uptake is often discouraging to farmers as they try to find a compromise between their different objectives, possibilities and constraints. Cases of success have blended local adaptive research with innovative dialogue that incorporates traditional and innovative techniques adapted to local conditions (Drechsel et al 2005).

According to FAO, substantial benefits would be derived from a renewed focus on improved agricultural sector policies. Two major priority areas stand out in this respect: (i) resource user rights and (ii) long-term investments in public goods. Examples of the latter include good land husbandry; sustainable natural resource management; soil and water conservation; environmental protection; maintenance of biodiversity; tsetse eradication; and, carbon sequestration. The natural resource abundance in sub-Saharan Africa provides sufficient basis for pro-poor sustainable agricultural development if the appropriate incentives are created. (FAO 2001)

Such programs are often referred to as payments for Environmental (or ecosystem) services (PES), Rewards (or Compensation) for Ecosystem services (R/CES) or Markets for Ecosystem Services (MES). The choice of term implies what one should expect the mechanism to achieve: Is it the competitive interaction between multiple agents (“markets”), the just and equitable prize for services rendered (“reward”), or the recompense for a cost the service supplier has suffered (“compensation”) (Wunder 2005)?

### Environmental Services from Agriculture

Nowhere is the need for the application of sound ecological science more acute than in agriculture (Robertson and Swinton 2005). Globally, the 5 billion ha under agricultural management (38% of land area) exceeds the area covered by forests and woodlands (30% of land area), and some 3 million ha are annually converted to agricultural use, mainly from forests (Table 1) (FAO 2002, 2005).

<table>
<thead>
<tr>
<th>Country area (‘000 ha)</th>
<th>World</th>
<th>Eastern Africa</th>
<th>Southern Africa</th>
<th>Western Africa</th>
<th>Middle Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural area</td>
<td>37.0</td>
<td>47.4</td>
<td>62.9</td>
<td>44.6</td>
<td>24.2</td>
</tr>
<tr>
<td>Forest area</td>
<td>29.4</td>
<td>25.2</td>
<td>11.0</td>
<td>12.1</td>
<td>44.5</td>
</tr>
<tr>
<td>Inland water area</td>
<td>3.2</td>
<td>4.8</td>
<td>0.8</td>
<td>1.3</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Source: FAO Statistics, 2005

Modern agriculture has had a destructive impact on the environment. However, not all practices are destructive within agriculture and some of the destructive practices are worse than others. Whether positive or negative, the impacts (externalities) of these
practices are not typically reflected in farmers’ incomes; therefore their provision is not a key consideration in most farmers’ choices (FAO 2007a). This implies that without interventions, increasing demand for food as well as an increase in population might fuel further the negative impacts of agriculture on the environment.

Further, the initial yield decline often encountered on adoption of agricultural practices with positive environmental impact has often lead to farmers reverting back to destructive practices. To avert this, some initial incentive/compensation could be made commensurate to the opportunity cost of income foregone. Previously the polluter pays principle was advanced where the manager who pollutes was required to bear the cost of the measures needed to ensure that the ecosystem is and remains in an acceptable state (Dommen 1993).

The Polluter Pays Principle, which is well established in the literature related to pollution and sustainable development, provides that "the polluter should bear the cost of the measures needed to ensure that the ecosystem is and remains in an acceptable state" (Dommen, 1993).

The User Pays Principle is also abundantly referred to in the literature about sustainable use and, just like the Polluter Pays Principle, it also aims at fuller internalization of production costs. It states that "all resource users should pay for the full long-term marginal social cost of the use of a resources and related services including any associated treatment cost" (Dommen, 1993, p.151).

However, the success of such principles, which often require the use of force, is dependent on where the poor are situated in the landscape and how much the landowners are involved in the decision-making process. Adapting the user-pays principle, where the environment managers are given an incentive that ensures they manage the environment for sustainability while being able to meet the subsistence and income requirements would be more sustainable.

Efforts have been put in restoring the damage to the environment through paying the land users for conserving the environment hence increasing environmental service provision e.g. watershed services (cleaner and more water from reduced runoff and eutrophication), carbon sequestration through increased aorestation. Most of these efforts have been done through forestry as opposed to agriculture. However, in the recent past, a lot more effort has been put in studying ways of providing the services from agricultural systems.

Agricultural systems are systems set up to respond to economic incentives. The managers are accustomed to managing them for economic incentives and hence asking them to abandon the practices entirely for environmental protection, without better alternative options, is not sustainable. Environmental services generated through changes in agricultural practices rather than land use may reduce trade offs between food production, poverty, and environmental conservation and may, therefore, be easier and less costly to achieve (Quintero et al 2006; Swinton et al 2006).

Several success stories, especially in Latin America, have shown that agriculture can be managed in a way that meets both the provisioning as well as the regulating
services that result in sustainable environment conservation. Two projects in the Challenge Program on Water and Food implemented in Colombia targeted this.

In Fuquene basin, Colombia, 53% of the land is used for agricultural activities, especially the production of wheat, potato, peas and corn. Agriculture consumes at least 85% of the available water, as compared to domestic (8.8%). The major problem in the basin arose, arose from forest destruction in the upper part of the watershed, is erosion and sedimentation, pollution, health concerns and loss of biodiversity. Improper agricultural techniques and monoculture are mainly to blame for this. Sedimentation arises from 2 reasons: (a) improper farming on the hilly slopes that have been cleared off trees hence generating soil loss in event of rain; and (b) intense stock breeding and agriculture generating contaminants that end up in the lake, causing eutrophication.

A machinery bank was set up and soft-credits given to farmers to promote the cultivation of green manures. Increasingly large numbers of farmers participated in the scheme with 1,000 hectares of arable land covered within the 2 years of operation. The scheme was managed directly by the farmers, with special efforts to include the poor, and within 2 years of existence, 100% of the capital had been recovered. However, this came after thorough groundwork that took a long time and resources being invested in understanding, together with the farmers, the water-poverty relationships as well as engaging the stakeholders in a “conversatorio”. The “Conversatorio” is a legal mechanism through which communities hold authorities accountable. Its success depends on the extent to which the community is united, technically prepared, and capable of interacting with representatives of the various institutions. This hence called for lots of empowering farmers to realize that they have a voice and can hold their leaders accountable for public issues concerning them. As the farmers realized their potential, they were also able to manage effectively and successfully the soft-credit scheme. (Effect on yields, soil fertility, runoff e.t.c.)

The Alto Mayo case, Peru
In the Alto Mayo watershed, located in the eastern slopes of the Andes Cordillera draining in to the Amazon Basin, agriculture is the main activity. Unfavorable agricultural practices, mainly slash and burn, led to deforestation, erosion and loss of biodiversity (Ramirez 2007).

The potential service providers are the population living in the upper part of the watershed (sub-watersheds Mishkiyacu and Rumiayacu). This population cut down forests and replaced them with coffee plantations, altering the soil properties and leading to soil erosion problems including reduction in the quality and quantity of water in the watershed. The users of the services are the population living in the lower part of the watershed, (urban population of the Moyobamba, Nueva Cajamarca and San Fernando districts, Valle de la Conquista inhabitants, and irrigation groups) whose water quality and quantity are compromised by the inappropriate agricultural practices in the upper part of the watershed. The service required was the protection of the quality and quantity of the water resource.

In order to establish the priority hot-spots of the upper watershed that were critical regarding sediments and water flows, as well as the potential to produce the environmental service, hydrological analysis was carried out using the SWAT
software (Soil and Water Assessment Tool). Using the prioritized areas a scenario analysis was carried out in order to assess the impact of different land uses (shadow coffee, reforestation, and live barriers) comparing them with the traditional slash and burn (burn-corn-grass cycles) practices. The variables analyzed were farmers’ income, the initial investment, the sediments generated, and the flow changes. The result of the evaluation showed that the best alternative was shadow coffee; this was also the most expensive option regarding initial investment.

To seek options to encourage adoption of this more expensive investment, the next step undertaken was to calculate the cost of each reduced ton of sediment as well as the cost of reducing erosion by hectare. To determine the value the users place on the services received and hence their willingness to pay, the contingent valuation method was used. From all the analysis a fund was set up and a fund committee in charge of the administration of the financial mechanism was established and negotiation for a PES scheme done. The scheme resulted in empowerment of the local stakeholders who are now promoting the economic mechanism by themselves. This process has resulted in a participatory process to obtain the authorization to increase water rates charges. It was necessary because by law, it is not possible to make increments on water charges without following a prior process starting in the National government and finally approved by the water users.

The challenge for soil scientists’ research

The major challenges of studying environmental services and linking these to soil science is mainly on the options to use, for example modeling to
a) Quantify services
b) Inform policy and stakeholders
c) Target research

To build on the Latin America experience, the Theme 2 initiated workshops on PES in Agriculture and commissioned several case studies to be conducted in Honduras, Thailand, Vietnam, Kenya and Zimbabwe. In addition, the Theme has trained African scientists affiliated to the African Network for Soil Biology and Fertility (AfNet) on the use of two models used in determining the water quality and quantity relationship with the environment (including soil), economic and social factors of the communities. The two models are the Soil and Water Assessment Tool (SWAT) and the ECOSAUT (Spanish acronym for: A model for the Economic, Social and Environmental Evaluation of Land Use).

The objective of targeting researchers in soil science across the continent is because there is need for us all to see soils in a broader context that incorporates landscape scale and social context (integrated approaches since they are self-reinforcing). The greatest challenge to attaining this is availability of data and methods. However, with increased focus on sustainability and environmental protection, different methods and models are being developed. The challenge is for the soil scientists and other related researchers in Africa, to modify and adapt the existing tools to local conditions and farming systems and/or use the knowledge from existing tools to develop specific tools for their farming systems.
Summary
Potential exists to improve agricultural output and reduce poverty while ensuring a sustainable environment through engaging in markets for ecosystem services. The current challenge for African countries in particular is to identify and bring in willing buyers of the services, especially watershed conservation services. Adoption of sustainable soil management practices would contribute to improved water quality and quantity in watersheds. It is the task of soil scientists, and other related scientists to determine the contribution of the practices to specific watersheds as well as identify who would be willing to pay for such services. Incorporating government agencies at the onset of such an activity would encourage participation of government and other stakeholders who would benefit, both in the short and long term, from improved provision of such services.

References:
FAO (Food and Agriculture Organization of the UN). 2002. FAOSTAT Statistics Database. Rome, Italy: UN Food and Agriculture Organization.