Payment for Environmental Services (PES): A Mechanism for Promoting Sustainable Agroforestry Land Use Practices among Smallholder Farmers in Southern Africa

Ajayi OC, Akinnifesi FK, Sileshi G, Chakeredza, S, Mgomba S

World Agroforestry Centre (ICRAF), P. O. Box 30798, Lilongwe, Malawi

Email: O.C.Ajayi@cgiar.org

Abstract

Sustainable agricultural production systems offer opportunities for producing food while simultaneously mitigating climate change are receiving increasing attention. In many cases however, field level adoption of these technologies by smallholder farmers has generally been limited due in part to low investment, less supportive policy and institutional context, among other reasons. To bridge the adoption-policy gap, other approaches beyond moral persuasions and “wielding the stick” (regulations) are needed. Based on a field study in Zambia, this paper argues for the institutionalization of Payment for Ecosystem Services (PES) as an important additional option for promoting environmentally sustainable agricultural technologies. We discuss how incentive mechanisms could help address the problem of low adoption of technically proven sustainable land use management practices and, enhance the possibility for encouraging farmers to adopt practices that provide direct benefits to them (e.g. food production) while also contributing to provision of global goods and services (e.g. reducing green house gas emissions). We recommend policy interventions including conditional and targeted incentives for agri-environmental land use practices; cushioning financial vulnerability and bridging the time lag between investment and accrual of benefits; investment in information and capacity building of farmers and national extension systems; new institutional forms of science-policy linkages to bridge the gap between technology developers and policy makers.

Keywords: *Adoption, Agri-Environment, Ecosystem services, PES, Science-Policy linkages, Zambia*

1. Introduction

In many poor countries that experience seasonal food deficits, one of the greatest challenges is how best to formulate development strategies that integrate environmental resource conservation into food security goals. In the quest to reconcile the environmental debt of tomorrow with the food deficit of today, the trade-off between livelihood (food security) and environmental quality is high. As a result, many developing countries are in search of technological and policy approaches that are affordable for smallholder farmers, and simultaneously enhance food security and promote environmental stewardship given emerging global phenomenon of climate change. Despite this challenge, there are some land use practices based on sustainable agricultural principles and, which produce multi-outputs and thus offer potential opportunity to achieving the two mutually exclusive objectives and minimize the trade-offs. There is a consensus in the literature that most of the practices are feasible and technically sound (Ajayi et al., 2008; Sileshi et al., 2008), but the level of uptake of the practices by farmers has been low particularly in low income regions of the world, or attained only a modest success in other regions (Antle and Diagana, 2003; Mercer 2004). One of the reasons could be that the dissemination of the sustainable practices have been based primarily on two approaches: *moral persuasion* (farmer sensitization, farmer training, field demonstration) and *wielding the stick* (regulations, land use enforcements, instructions). Based on field studies in Zambia, this paper highlights agroforestry-based land use practices as a case study of production practices based on sustainable principles that can help to meet livelihood and environmental conservation goals. We discuss how incentive mechanisms could help address the problem of low adoption of sustainable land use management practices and, enhance farmers' adoption of the same tp meet food security and respond to global services such as reducing GHG emissions.

2 Overview of sustainable agroforestry land use practices

Soil degradation is a major problem to food production in most developing countries and in sub-Saharan Africa (SSA) in particular and, that this problem is often linked to food insecurity and poverty (Sanchez, 2002; Kwesiga et al., 2003). The use of mineral fertilizers is less affordable for many smallholder farmers, especially after the collapse of government support for mineral fertilizer distribution (e.g. removal of subsidies and dissolution of parastatal agricultural inputs marketing agencies) following structural adjustments of the economies in 1980s and 1990s. Fertilizer tree/shrub was developed in the late 1980s in response to the challenges that smallholder farmers encounter due to continuous depletion of soil fertility. Fertilizer tree/shrub is based on the practice of planting fast growing and nitrogen-fixing leguminous shrubs and trees to produce large quantities of leaf biomass that easily decomposes to release nitrogen for crop growth (Kwesiga and Coe,1994). The leguminous trees capture atmospheric nitrogen through biological nitrogen fixation and make it available to crop plants, thus increasing crop productivity and food security. The tree biomass easily decomposes and releases nutrients for crops (usually maize) cultivated in the soil.

Fertilizer tree/shrub contributes positive impacts on the livelihood of farmers' households and the environment. It increases maize yield (the staple food crop in southern Africa) by close to two times compared with fields where maize was cultivated without external inputs (Kwesiga et al., 2003, Akinnifesi et al., 2008). A recent meta-analysis has demonstrated that the positive effects of fertilizer tree/shrub on maize yield are consistent across most of sub-Saharan Africa (Sileshi et al.,, 2008). Detailed impact assessment studies conducted in Zambia showed that based on an average of 0.20 hectares of land devoted to the technology by farmers in 2007. Fertilizer tree/shrub increased food security by generating between 57 and 114 extra person days of maize consumption per year (Ajayi et al., 2007).

In addition to improved food production through improved soil fertility, fertilizer tree/shrubs generate ecosystem services that contribute to improving environmental quality in several ways (Sileshi et al., 2007). These include the following:
i) Carbon sequestration: Studies in southern Africa have shown that fertilizer tree/shrubs can store large quantities of carbon stocks in plant biomass and in the soil (Kaonga, 2005, Makumba et al., 2007), and thus provide opportunity to potentially mitigate global greenhouse gas effect (Sileshi et al., 2007).
ii) Reduction of insect pests and weeds: Some of the improved fallow species reduce pests such as termites and noxious weeds including *Striga* species which limit cereal crop production (Sileshi and Mafongoya, 2006).
iii) Biodiversity conservation: fertilizer tree/shrubs create a micro-climate which maintains soil biodiversity thereby further improving soil quality (Sileshi et al., 2007). Studies conducted in Zambia revealed that fertilizer tree/shrubs accommodate more soil invertebrates than monoculture maize (Sileshi and Mafongoya, 2006). This diversity can, in time, provide ecological resilience and contribute to the maintenance of beneficial ecological functions such as pest suppression. The positive impact of agroforestry on the biodiversity conservation of nature reserves has mostly been attributed to the reduced pressure on the natural forest due to the ability of agroforestry to sustain their daily livelihood (Chirwa et al., 2008).

Table 1: Costs and benefits of agroforestry-based land use practice

	Farm level	**Community**
Cost	• Land • Labour • Tree establishment • Working equipment	• Potential for invasiveness of some fertilizer tree species • Reduction of free grazing area during dry season
Benefit	• 2-3 folds maize yield increase • Increase in maize stover for livestock • Fuel wood available in field, reduces time spent searching for wood • Potential to mitigate the effects of drought during maize growing season • Stakes for curing tobacco leaves	• Carbon sequestration • Reduced soil erosion through better soil water conservation • Enhanced biodiversity • Wind breaks • Alternative sources of fuel wood and potentially avoided deforestation

Source: Adapted from Ajayi and Matakala (2006)

iv) Runoff and soil erosion: Soil aggregation is higher in fertilizer tree/shrubs, and this enhances water infiltration and water holding capacity which reduces water runoff and soil erosion (Phiri et al., 2003). Thus fertilizer tree/shrubs can contribute to the reduction of the effects of droughts.

v) Fuelwood: Field experiments have revealed that improved fallows can produce up to 10 tonnes of wood per hectare within two years to meet household demand for fuel energy (Kwesiga and Coe,1994), and thus offer the potential to reduce the demand on community forests for fuel wood, especially where human population density is high. The benefits of agroforestry-based land use practices to households and the environment are well documented (Mafongoya et al., 2006, Ajayi et al., 2007c, Akinnifesi et al., 2008) and have been summarized (Table 1).

3 Scaling up and profitability of fertilizer tree/shrubs

3.1 Financial profitability of fertilizer tree/shrubs

The financial profitability and hence the potential adoptability of fertilizer tree/shrubs vary depending on whether some items mentioned in Table 1 are included or excluded in the analysis. Field studies in Zambia show that when only food (i.e., maize yield) is taken into account, the net profit (Net Present Value) of fertilizer tree/shrub ranges from $233 to $309 per hectare (Ajayi et al., 2007). This compares with a net benefit of $499 per hectare for mineral fertilizer (subsidized at the rate of 50% by the government) and $349 for non-subsidized fertilizer. When the environmental services of fertilizer tree/shrub are taken into consideration, the profitability and adoptability of fertilizer tree/shrubs increases. Thus, the optimum level of adoption of fertilizer tree/shrubs from the private investor's perspective (i.e. local optimum) is lower than the optimum from the public perspective (i.e. global optimum). The details of this have been explained elsewhere (Ajayi et al., 2007a; Ajayi et al., 2007b) Given the superior financial performance over the *de facto* farmers' practice (continuous maize cultivation without external fertilization) and, the non accessibility of fertilizers to majority of smallholder farmers, the lower-than-expected level of adoption of sustainable agricultural practices and fertilizer tree/shrubs at farmers' level may not be explained exclusively on the basis of financial profitability or technological feasibility of the practices.

3.2 Scaling up approaches

Historically, the dissemination of environmentally-friendly land use practices has been based on wielding the stick through regulations, enforcements, instructions, field inspections. In more recent periods, scaling up efforts on agri-environmental land use practices such as fertilizer tree/shrubs assumed that lack of information and farmer awareness are the key constraints to the wider uptake of the technologies at farmers' level. As a result, a number of scaling up efforts were geared towards filling the gap in farmers' knowledge through moral persuasion including sensitization, farmer training, field demonstration, farmer exchange visits.

In addition to the two approaches mentioned above, there is an increasing realization for the use of conditional incentives and reward mechanisms as a third approach for addressing the problem of low adoption of technically proven sustainable land use management practices and, enhance the possibility for encouraging farmers to adopt practices that provide benefits to them individually (e.g. food production) while also contributing to the production of global goods and services (e.g. reducing net GHG emissions).

In most sustainable agricultural practices, there exists a time lag between the time that investments are made to adopt the practice and, the realization of benefits. This creates an adoption threshold and has important implications for low income farmers. The time lag is particularly long for tree-based land use management practices such as agroforestry.

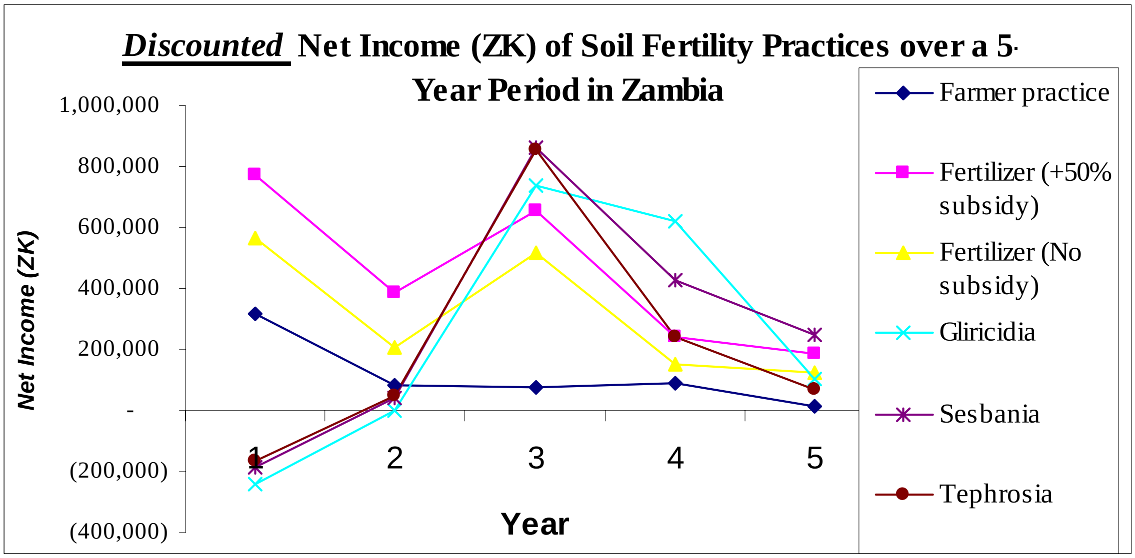

Fig. 1: Cash flow for different land use practices in Zambia

Studies in Zambia show that while fertilizer tree/shrubs are profitable over time (i.e. positive net present values), farmers often have to wait for about 2 years before they begin to realize these benefits whereas, they start to accrue some benefits from the conventional land use practices from the first year of investment, even though farmers' practices is less profitable over the five-year period (Figure 1). This implies that smallholder farmers must absorb net losses for two or more years before receiving profits from their investment. During the "waiting" period, farmers are at their most financially vulnerable state and may need some support. Incentives such as "carbon credit" schemes are innovations to help farmers overcome adoption thresholds. Farmers may then be weaned from the support from the third year when farmers begin to enjoy the benefits of increased crop yields as a result of the improved fertility of their soils due to fertilizer tree/shrubs. Examples of "carrot" initiatives (mainly Carbon payments) to encourage the adoption of agri-environmental practices in Malawi & Zambia include the government of Malawi Tree planting (for carbon) initiative, Clinton-Hunter Foundation carbon initiative and COMESA Carbon Poverty Reduction initiative. Several factors affect the incentives that influence smallholder farmers' land use management decisions which ultimately result in either soil conservation or soil degradation. These include property rights; market failures caused by a lack of well-functioning political, legal, and economic institutions.

4 Policy support for increasing the adoptability of fertilizer tree/shrubs

Review of existing policies on land use practices: In many countries, conventional soil fertility practices are often subsidized by the government through various price and institutional supports. Over several years, these government policies have created structural shifts and path dependencies that make sustainable land us practices to be less financially attractive to smallholder farmers. For example, alley farming was considered impractical as a soil fertility technology in some parts of West Africa some years back because the prices of mineral fertilizer were artificially low and this made fertilizers a cheaper and more rationale option from the perspective of individual farmers (Sanchez 1999). The situation has changed in recent years with global rise in the cost of fossil fuels, and consequently on chemical fertilizers.

Innovative information system to support incipient technologies: fertilizer tree/shrubs are incipient technologies compared with conventional practices which farmers are more familiar with due to the trainings acquired by farmers over a long period. Given its "new" status, the human capacity, infrastructure and institutional supports for ALUPs are low in most national extension programs and thus the need for increased support to reach many more farmers to adopt the technologies. Relative to conventional land use practices, fertilizer tree/shrubs are more knowledge-intensive, requiring skills in terms of management of the technology. The costs of providing information greatly decrease over time, but they are critical when helping farmers get started with the practice.

Continuous bridging of gap between science and policy making on land use: There is a need to initiate new institutional forms to bring science (technology development) and policy making together to examine food security through a sustainable multi-faceted development lens. The forums should provide a knowledge base and form the basis for dialogue among representatives from broader public viewpoints including policymakers, researchers and other stakeholders.

5 Summary and conclusion

Southern African sub-region faces the challenge to implement policies for achieving food security while ensuring environmental quality and conservation of natural resources base. In food deficit regions, there is therefore the need to respond to climate change from an integrated land-use management perspective taking cognizance of livelihood and food security. Fertilizer tree/shrub and related land use practices are important but untapped strategies to meet both livelihood needs, promote environmental stewardship and respond to climate change by smallholder farmers. In addition to farmer persuasion and regulation, "carrot initiatives" such as conditional incentives and reward mechanisms provides an additional approach for addressing the problem of low adoption of technically proven sustainable land use management practices among small scale farmers. Beyond "getting the technology right", it is also important to focus on the efforts to get the politics, market and policy right. The options will help to align smallholder farmers' incentives with those of the society, and encourage them to pay attention to environmental quality issues when they are making agricultural production decisions.

References

Ajayi OC, Place F, Kwesiga F, and Mafongoya P 2007a Impacts of Improved Tree Fallow Technology in Zambia. In: Waibel H. and Zilberman D (eds) *International Research on Natural Resource Management: Advances in Impact Assessment* CABI Wallingford, UK and Science Council/CGIAR, Rome pp.147-168 ISBN: 976-1-84593-283-1

Ajayi OC, Akinnifesi FK, Gudeta S and Chakeredza S 2007b Adoption of renewable soil fertility replenishment technologies in southern African region: lessons learnt and the way forward *Natural Resource Forum* 31(4): 306-317

Ajayi OC, Akinnifesi FK, Sileshi G, Chakeredza S and Matakala P 2007c Economic framework for integrating environmental stewardship into food security strategies in low-income countries: case of agroforestry in southern African region *African Journal of Environmental Science and Technology* 1(4): 59-67

Akinnifesi FK, Chirwa P, Ajayi OC, Sileshi G, Matakala P, Kwesiga F, Harawa R and Makumba W 2008 Contributions of agroforestry research to livelihood of smallholder farmers in southern Africa: Part 1. Taking stock of the adaptation, adoption and impacts of fertilizer tree options *Agricultural Journal* 3(1): 58-75

Antle J.M.; Diagana, B. 2003 Creating incentives for the adoption of sustainable agricultural practices in developing countries: the role of soil carbon sequestration *Amer. J. Agr. Econ.* 85 (5): 1178–1184

Chirwa PW, Akinnifesi FK, Sileshi G, Syampungani S, Kalaba FK and Ajayi OC 2008 Opportunity for conserving and utilizing agro-biodiversity through agroforestry in Southern Africa *Biodiversity* 9 (1&2): 45-48

Kaonga M. (2005). Understanding carbon dynamics in agroforestry systems in Eastern Zambia. PhD Thesis, Fitzwilliam College, University of Cambridge, UK.

Kwesiga F., Coe R. (1994). The effect of short rotation Sesbania sesban planted fallows on maize yield. *Forest ecology and management* 64: 199–208.

Kwesiga, F., Akinnifesi, F.K., Mafongoya, P.L, McDermott, M.H., Agumya, A. 2003. Agroforestry research and development in southern Africa during the 1990s: review and challenges ahead. *Agroforestry systems,* 59(3): 173-186

Mafongoya, P. L., Bationo, A., Kihara, J., Waswa, B. S. 2006. Appropriate technologies to replenish soil fertility in southern Africa. *Nutrient Cycling in Agroecosystems,* 76:137–151.

Makumba, W., Akinnifesi, F.K., Janssen, B., Oenema, O. 2007. Long-term impact of a gliricidia-maize intercropping system on carbon sequestration in southern Malawi. *Agriculture, Ecosystems and Environment*, 118:237-243.

Mercer, D.E. (2004) Adoption of agroforestry innovations in the tropics: a review *Agroforestry systems* 61: 311-328

Phiri, E., Verplancke, H., Kwesiga, F., Mafongoya, P. 2003. Water Balance and Maize Yield following Sesbania sesban Fallow in eastern Zambia. *Agroforestry systems* 59(3): 197-205.

Sanchez, A. P. 1999. Improved fallows come of age in the tropics. *Agroforestry Systems,* 47: 3–12.

Sanchez, P.A. 2002. Soil fertility and hunger in Africa. *Science,* 295: 2019 – 2020.

Sileshi G, Akinnifesi FK, Ajayi OC and Place F 2008 Meta-analysis of maize yield response to woody and herbaceous legumes in sub-saharan Africa. *Plant and Soil* 307 (1&2): 1-19

Sileshi G, Akinnifesi FK, Ajayi OC, Chakeredza S, Chidumayo EN and Matakala PW 2007 Contributions of agroforestry to ecosystem services in the *Miombo e*co-region of eastern and southern Africa *African Journal of Environmental Science and Technology* 1(4): 68-80

Sileshi G, Akinnifesi FK, Ajayi OC, Chakeredza S, Chidumayo EN and Matakala PW 2007 Contributions of agroforestry to ecosystem services in the *Miombo e*co-region of eastern and southern Africa *African Journal of Environmental Science and Technology* 1(4): 68-80

Sileshi, G., Mafongoya, P.L. 2006. Long-term effects of improved legume fallows on soil invertebrate macrofauna and maize yield in eastern Zambia. *Agriculture, Ecosystems & Environment*, 115: 69-78