



Tropentag, Prague, Czech Republic, September 17-19, 2014
Conference on International Research on Food Security, Natural Resource
Management and Rural Development
Czech University of Life Sciences

**Is Microcredit Enhancing Ecosystem Payments and Environmental Services among
Rural Farmers in Sudan? An Applied Dynamic Modelling Approach**

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1. Introduction

Recent literatures have shown that payments for environmental services (PES) are a crucial for poverty reduction and agricultural development policies. At the same time, agricultural expansion and ever more intensive practices are widely recognized for their contribution to ecosystem degradation. Less well recognized is that, in many cases, agriculture offers the potential to generate both poverty eradication and better environmental outcomes. The information and initiatives that currently exist on this subject are both very recent and primarily geared towards greenhouse gas mitigation, specifically with regard to financing low income households to acquire access to renewable energy (SHARDUL and CARRARO, 2010). Indeed, microcredit providers, initially offering merely life, loan and property insurance, are now looking at the linkages between micro-insurance delivery to the poor and environment sustainability. According to HAMMILL *et al*, (2008) there is strong linkages between employing microcredit for ecosystem and ability of low income group to diversify their assets and coping strategies. This is because microcredit is also being increasingly tapped to reduce the vulnerability of the poor. Particularly, small-scale farmers, pastoralists and low-income producers who inhabit, consume, and produce important agro-ecosystem services and heavily dependent on the environmental assets embodied in agro-ecosystems.

2. Problem Statement and Objectives

Despite the potential role of microcredit in helping poor to build their assets, very little is actually known about how microcredit interacts with ecosystem in practice. Access to credit is one strategy for promoting ecosystem through adoption of yield-enhancing technologies and spreading the risks. These actions would also - generally - reduce vulnerability to ecosystem risk even if there is no explicit consideration of such risks. The review of what is an increasingly sophisticated literature suggests that microcredit deserves careful consideration by the ecosystem adaptation community (HAMMILL *et al*, 2008). From this perspective ecosystem services might simply be one more reason to scale up microcredit. However, advancing credit to smallholder farmers for encouraging technology adoption is a complex policy issue. Among the related issues are the amount and form of credit, the interest to be charged, which farm households to target, and repayment performance (AHMED *et al*, 2006). Meanwhile, new challenges, including migrations of poor people displaced by drought, flooding, and storms, are appearing. Within the microcredit sector, the increasing emphasis on responsible finance has added environmental impact to the factors considered as measures of success for microcredit institutions.

So far, there have been a few studies undertaken in Sudan to analyze the impact of microcredit on ecosystem payments perception. Thus, the objective of this research is to

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identify possible links between microcredit services and ecosystem payments and to highlight the opportunities and the risks of these links for vulnerability reduction among rural households in Sudan in order to guide policy makers on ways to promote ecosystem and environmental sustainability. This, however, raises a broader and more fundamental set of policy relevant questions:

1. How far microcredit services already contribute directly to reducing vulnerability to ecosystem and environmental services?
2. Does the greater access to microcredit portfolios influence the risks of ecosystem services?

3. Data Collection and Analytical Tool

The study relies on filed survey that is conducted in North Kordofan, central west of Sudan during the season 2012, using structured questionnaire. It surveyed 300 farm households, which were selected through a multi-stage stratified random sampling technique. Subsequently, focus group discussions with the key informants in the village communities were also conducted. Descriptive statistical analysis, bivariate model and non-separable dynamic farm household modeling approach were applied to analyze the data. The bivariate probit model is useful for the analysis because it provides a correlation error term that explains how the unobserved factors affecting the first decision are related to the second. More specifically, bivariate probit model was used to identify the interaction effect between loan use and ecosystem payments variables of farm households. Non-separable dynamic farm household modeling was employed to simulate the ecosystem activities that empirically explain the future investment choices of farmers.

4. Results and Discussion

4.1 Descriptive results

The results of descriptive analysis show that 79% of rural households had a tendency to pay for environmental services and ecosystem enhancement, while 75% of rural households are more likely to be trained in business related to environmental issues (see Fig 1). This result implies that households in North Kordofan had a substantial awareness in environmental values and often associated with risk-taking behaviour. Therefore, their chance to invest efficiently in ecosystem and environmental services are much higher.

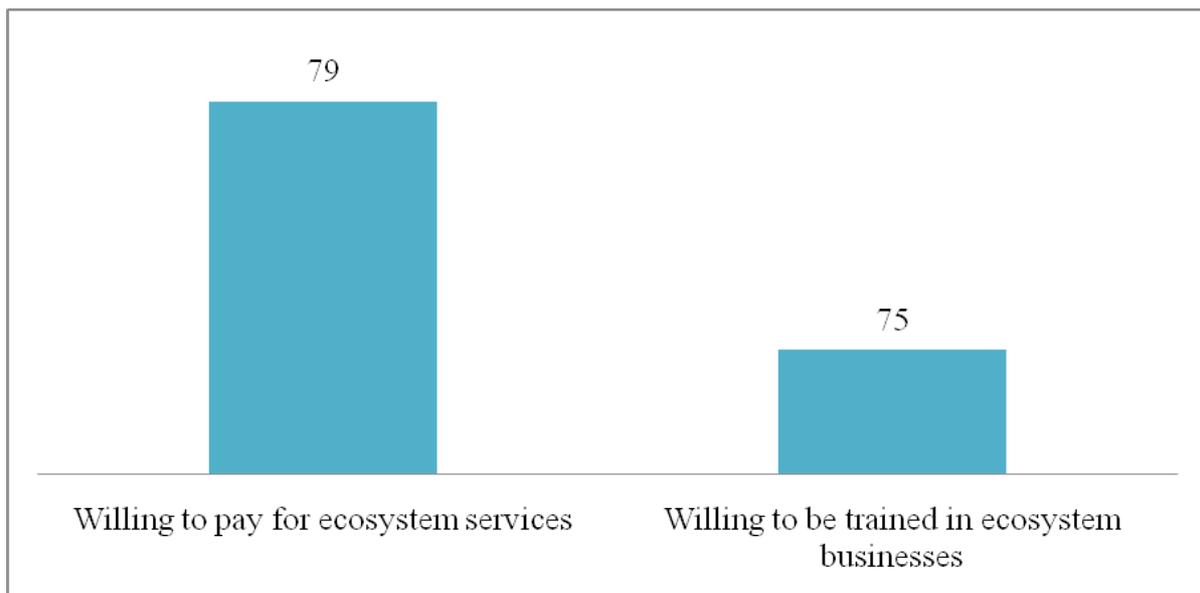


Figure 1: Tendency of household to pay for ecosystem services

Due to the aim of the Sudanese government to enhance ecosystem through agricultural investment among rural farmers, we simulated how farmers would choose to use their loans if they could use them on any activity. Interestingly, the results of the simulation demonstrate that, about 77% of credit users decided to invest in ecosystem payments, of which 50% did so in agricultural activities that enhance environmental sustainability (groundnuts 27% and sesame 23%). The other 23% invested the loans in livestock raising or fattening, particularly sheep (14%) and goats (9%) (see Fig 2). These investment expenses may partially be the reason for the positive indirect effects of credit on environmental services in the study area. At the time of the survey, it was observed that most households that had received loans and invested in livestock activities were defaulting less than those who had taken loans to invest in agricultural crops. More precisely, those who had taken a loan and invested in food crops reported lower repayment rates when compared to those who had invested in cash crops. This suggests that any future credit policy neglecting cash crop and livestock investments may have an ambiguous effect on the level of ecosystem and environmental services, at least in the short run. Considering the previous results, one can reasonably assume that, if borrowers keep using loans in the ways shown in Figure 2, access to credit will improve to the point of becoming significant and positive, not only in ecosystem services, but also in relation to sustaining environment friendly. On the other hand, the results of bivariate probit model showed strong interaction effect between loan use and ecosystem payments variables of farm households, revealing that loan utilization was significantly influenced by loan volume, off-farm income, improved seeds, type of land, cultivated area and rainfall. On top of that, the results further demonstrate that the loan utilization mechanism adopted by microcredit providers in the study area was somehow linked to the government policy that enhancing the cost-effectiveness of ecosystem payments.

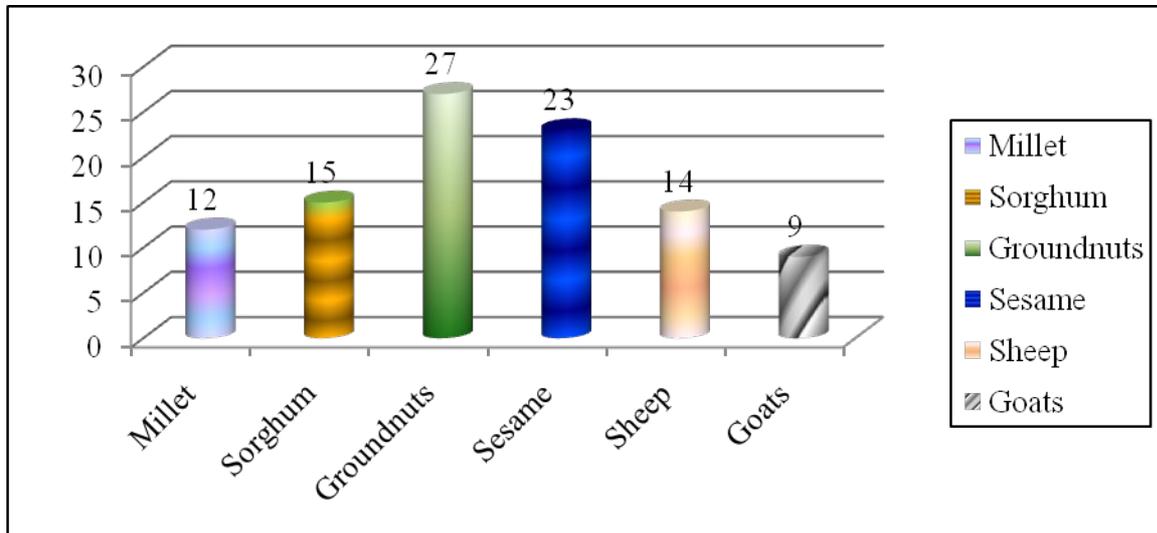


Figure 2: Simulation of the future investment choices of farmers

5. Conclusion and Recommendations

The potential services introduced by microcredit institutions are considered a crucial factor for enhancing ecosystem payments, since they determine whether the farmers benefit from the services offered or whether the services themselves respond to the needs and conditions of such clients. In this paper, we analyzed the impact of microcredit on ecosystem and

environmental sustainability among rural farmers in North Kordofan State of Sudan. The result of descriptive statistics reveals that the farm households are willing to invest and to be trained in ecosystem services. Moreover, the simulation of the future investment choices of farmers demonstrate that, credit provision is a necessary condition for enhancing ecosystem and environmental services in rural areas, however the heavily skewed portfolio with more than 70% of all loans deployed in livestock and agricultural activities can result in heavy losses and wipe out the entire program in one stroke. Therefore, it is recommended to develop appropriate market linkages and other opportunities to diversify the portfolio in activities that enhancing ecosystem and environmental sustainability. This could be possible through designing appropriate loan products, that promoting the future of environment in the area. On the other hand, the evidence of bivariate model analysis shows that the effect of loan invested in ecosystem services is significantly influenced by loan volume, off- farm income, improved seeds, type of land, cultivated area and rainfall quantity and distribution. This result reveals that there are strong linkages effects between microcredit and ecosystem services. Since, many of the poor are directly dependent on ecosystem services for their survival and wellbeing. Therefore, it is highly recommended to support credit policy that concentrates on Green microcredit, through service conditions that incentivise sustainable resource stewardship. This can be applied by offering more loans at lower interest rates to farmers who agreed to undertake sustainable soil and water management practices.

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