Sustainable Agriculture Research; Vol. 5, No. 3; 2016
ISSN 1927-050X E-ISSN 1927-0518
Published by Canadian Center of Science and Education

Understanding the Trade-Offs Between Environmental Service Provision through Improved Fallows and Private Welfare Using Stated Preference Approach: A Case Study in Chongwe - Zambia

Elias Kuntashula[1] & Eric Mungatana[2]

[1] University of Zambia, Department of Agricultural Economics and Extension, P. O. Box 32379, Lusaka, Zambia

[2] University of Pretoria, Department of Agricultural Economics, Extension and Rural Development, Pretoria 0002, South Africa

Correspondence: Elias Kuntashula, University of Zambia, Department of Agricultural Economics and Extension, P. O. Box 32379, Lusaka, Zambia. Tel: 260-977-748-335.

Received: April 27, 2016 Accepted: June 8, 2016 Online Published: June 29, 2016

doi:10.5539/sar.v5n3p124 URL: http://dx.doi.org/10.5539/sar.v5n3p124

Abstract

The trade-offs between environmental service (ES) provision through the uptake of improved fallows and private farmer welfare losses have rarely been evaluated. Unlike inorganic fertiliser, improved fallows provide ES in addition to improving the soil fertility. This study used contingent valuation methodologies to evaluate willingness to provide ES through improved fallows among 324 farmers in Chongwe district of Zambia. Given scenarios that improved fallows, unlike inorganic fertiliser, help in mitigating soil erosion and water pollution, more than 70% of the farmers were willing to supply these services through the technology. The willingness to be pro-fertiliser oriented was positively associated with cropped land sizes and soil fertility challenges and negatively associated with total farm size. In addition, for users of improved fallows, increases in per capita income increased the probability of willingness to embrace fertiliser. Group membership decreased the probability for the users' willingness to embrace fertiliser. For the non-users, the probability of joining the association that would ensure blockage of an improved fallow policy decreased with maize productivity. For the few farmers, there was no significant difference in the willingness to pay (WTP) ($t = 1.546, p = 0.136$) to ensure availability of fertiliser or blocking a policy compelling uptake of improved fallows between the users (WTP = K1, 050,000, US$1 = K5, 000) and non-users (WTP= K1, 380,000) of the technology. The trade-off between ES provisions through improved fallows and loss in immediate private welfare by not embracing fertiliser was similar across the technology' users divide. Therefore a payment for environmental services policy could target the farmers as a homogenous group.

Keywords: payment for environmental services, improved fallow technology, iterative bidding, willingness to pay

1. Introduction

The trade-offs between land uses that are multifunctional and simultaneously provide environmental services (ES) and private farmer welfare have rarely been evaluated in Southern Africa. ES land use activities produce services that prevent, limit, or minimise or correct environmental damage to water, air and soil mediums. Private Farmer Welfare entails the availability of resources and presence of conditions required for reasonably comfortable, healthy, and secure living for a farmer involved in agricultural activities. When these benefits accumulate to society as a whole, then this could be called society welfare. To achieve private welfare, the farmer needs to produce goods or services that would be excludable and subtractable to others in society. However most ES being public goods are non-excludable and non subtractable meaning that a farmer cannot easily prevent others from enjoying the services while at the same time the enjoyment of benefits by farmers does not make these services less available to others. On a farm, land can either be diverted from agricultural practices into environmental service provision or land use can remain in agriculture but production activities are modified to encompass environmental objectives (Bulte et al., 2008). In either case, the farmer's private welfare is affected (in most cases it is reduced) while society as a whole gains through the ES provision. It is therefore imperative to understand how a farmer would be willing to forgo some of his private benefits in exchange for the production of a public good that would not only benefit the farmer but society as a whole. Assessing this trade-off could partly provide some explanations on why adoption of agricultural technologies that provide environmental services such as the improved fallows has been sub optimal in Southern Africa.

An improved fallow is a multi-purpose land use agroforestry practice that primarily improves soil fertility as well as provides ecosystem services (Sileshi et al., 2008). Improved fallow is the targeted use of planted mainly leguminous species in order to achieve one or more of the aims of natural fallow within a shorter time or on a smaller area. The technology fixes atmospheric nitrogen (N) into the soil and this N is subsequently made available to crops such as maize. The improved fallow also improves environmental quality through the generation of several ecosystem services, the most important of which in Southern Africa, being carbon sequestration (Sileshi et al., 2007). The improved fallows can store large quantities of carbon stocks in plant biomass and in the soil. Secondly the improved fallow technology improves the conservation of biodiversity. According to Sileshi et al. (2007), the technology creates a micro-climate which maintains soil biodiversity thereby further improving soil quality. Sileshi et al. (2007) further emphasise that improved fallows are as good as the *miombo* woodland in the provision of diversity and soil invertebrates. Thirdly the improved fallows mitigate against deforestation since one of the major by-products of the technology is the provision of fuel wood (Kuntashula and Mafongoya 2005). Fourth the improved fallows generally improve the physical soil structure thereby increasing bulk density, porosity and aggregate stability (Styger & Fernandes 2006) thus decreasing soil erosion. Among the common species of improved fallows used in Southern Africa include *Sesbania sesban, Tephrosia vogelii* and *Gliricidia sepium* (Mafongoya et al., 2006).

The fact that the benefits from the adoption of improved fallows spill over to society at large, the resulting beneficial impact represents positive externality to the public (who benefits without necessarily sharing in the cost of adoption). Where such positive externalities exist, and there is no incentive system to reward individual farmers (investors) for the environmental services provided, then the level of investment (in this context, adoption of improved fallows by farmers) will be less than optimal (Ajayi & Matakala, 2006). To encourage land use practices that provide environmental services, efforts towards development of systems in which land users are paid for the environmental services they generate, thus aligning their incentives with those of society as a whole (Wunder, 2009; Zilberman et al., 2008), should be pursued. It has thus been suggested by Ajay et al. (2007) that attaining a shift in the level of adoption of improved fallow technologies may require facilitation of public investment policies that recognize and reward investors for the environmental stewardship and benefits that are produced by improved fallows to society at large. It follows that knowing whether farmers are willing to make a trade-off between their private welfare and the provision of ES through uptake of improved fallows would provide a platform for determining the empirical appropriateness of this environmental stewardship reward. The objective of this study was to evaluate farmers' willingness (and assess the factors affecting this willingness) to provide ES through uptake of improved fallows.

Farmers embracing improved fallows would leave part of their land fallow for 2 – 3 years. During this period the farmers will not be getting any benefit from the improved fallow plots. However, the improved fallows will be supplying environmental services that are beneficial to the society as a whole. In the long run fallows will improve soil fertility hence adding to the farmers' private welfare through increased crop yields. The farmers' decision to take up improved fallows will therefore involve carefully weighing current costs and benefits against future costs and benefits. Such investments in soil conservation could thus be considered as a redistribution of resource use rates towards the future. However, since the improved fallows are being promoted for soil fertility improvement (Ajayi et al., 2007; Mafongoya et al., 2006) and not necessarily for environmental service provision, it would be unreasonable to tacitly assume that farmers adopting the technology are willing to supply ES. Further, it would also be wrong to assume that farmers who have not taken up the improved fallows are not willing to supply the ES through the technology. Much is not known on farmers' willingness to provide ES through improved fallows in Southern Africa or Zambia in particular. The paper contributes to literature on adoption of improved fallows through the determination of farmers' willingness to provide environmental services through the use of improved fallows that lowers their private welfare. Further, the paper answers to questions such as: what factors would affect this willingness and to what extent would farmers be willing to pay to ensure availability of fertiliser (or non-use of improved fallows) that assure immediate gains in private welfare? Providing answers to these questions is vital as it provides important insights on the adoptability potential of improved fallows.

The paper is structured as follows: discussions on the study area, sampling design, survey instrument development and implementation in this order, cover the section on methodology. This is followed by the results, discussion and conclusions sections.

2. Methodology

2.1 Study Area

Chongwe district of Lusaka province of Zambia was purposely selected for this study (Figure 1). Chongwe is among the four districts in the province. The other districts are Lusaka, Kafue and Luangwa. Most agroforestry research and development in Zambia has mainly been conducted by the World Agroforestry Centre (ICRAF) in Chipata district of eastern province, and Kasisi Agricultural Training Centre (KATC) in Chongwe district. Key informant interviews revealed that ICRAF has since 2007 drastically reduced agroforestry activities in eastern province. This has led to a reduction in farmer enthusiasm in agroforestry activities. KATC in Chongwe has been promoting sustainable agricultural production since 1994. Agroforestry is among the many sustainable practices promoted by the centre. The main agroforestry technology being promoted is the improved fallow, a practise that improves soil fertility and provides environmental services.

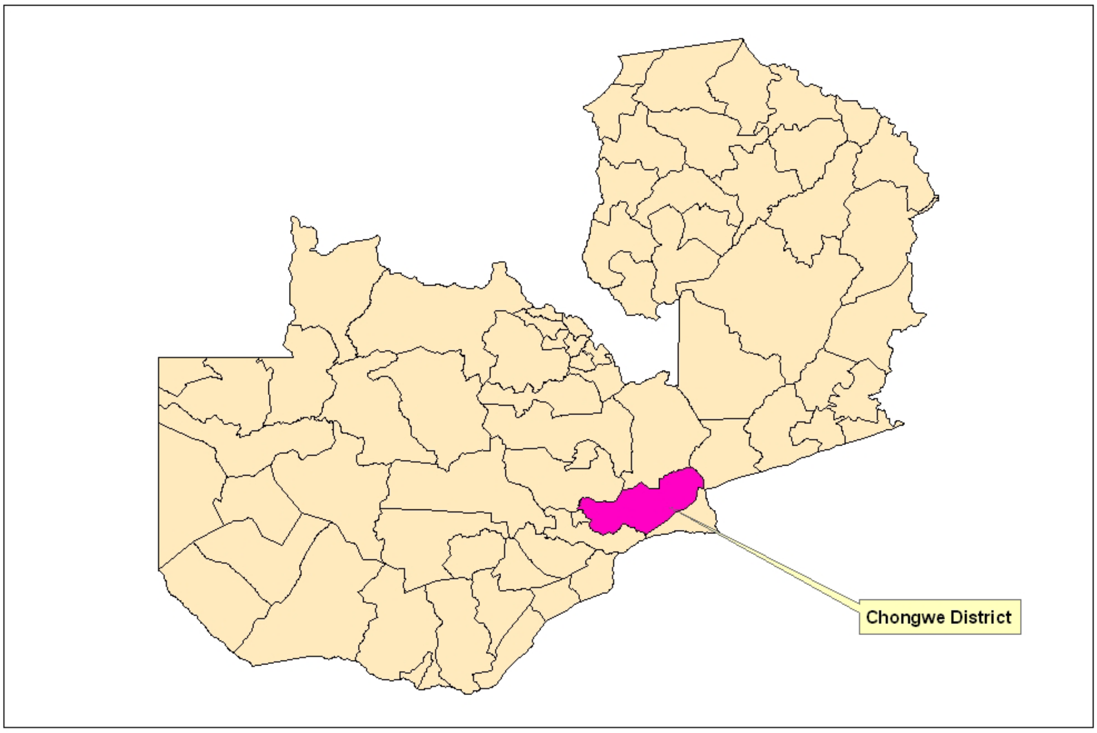

Figure 1. Location of Chongwe District in Zambia. Source: (Kuntashula & Mungatana, 2015)

After informal interviews with extension officers from KATC, three agricultural camps within Chongwe (Nyangwena, Chinkuli and Katoba) were identified as the main catchment areas with more farmers practising improved fallows. These camps were targeted for the study. The camps are mainly composed of sandy loamy soils with a gently sloping landscape. Soil infertility is one of the major challenges facing the farmers in the study area. Others include soil erosion, deforestation and lack of a ready market for some agricultural produce. In addition to improving soil fertility, the improved fallows are being promoted to prevent soil erosion and to provide fuel wood. The average household farm size in the study area is about 4 hectares of which close to 3 hectares is usually cultivated. Fallowed land that could potentially be used for improved fallows is therefore common in the study area. Farm households in the study area mainly rely on the traditional land tenure system to acquire farm land. For new land applications, the chief through the appointed headmen are responsible for allocating land. The size of land allocated depends on the ability and commitment to immediate use by the person who requested it. Once granted, the person who receives and clears the bush on the land becomes the owner. For as long as the land is being utilized, the rights of claims to land or ownership can now be handed over without restrictions from generation to another among the relatives. When the owner emigrates, the land may be re-allocated when asked for. However, the relatives of the emigrant have the first claims for the non-used portions of land. The farmers in the study area are mostly subsistence who grows mainly the staple maize crop for food and the excess for sale. They also grow groundnuts, cotton, beans and garden vegetables such as rape, cabbage, tomato and onion. The most common animals reared include cattle, chickens, and goats.

Although not titled, the system of land ownership in the study area provides some permanency that is crucial towards investing in long term technologies such as the improved fallows. Once adopted improved fallows could help the local farmers towards soil fertility improvement, soil structure improvement, soil erosion prevention, fuel wood provision and increased biodiversity. These improvements could however go beyond the study area since most of them are of a public nature. For instance protection of natural forests would ensure more carbon being sequestered. Moreover the planting of improved fallows would also improve carbon sequestration. Therefore, promotion of the improved fallows in the study area could potentially improve farmer welfare beyond the catchment area.

2.2 Sampling

The study used agricultural camp lists compiled with Ministry of Agriculture camp extension officers to come with a sampling frame. Usually the camp extension officers keep lists of farmers in their catchment areas. The lists from the three catchment areas were updated and consolidated into one. The sampling frame was then stratified between users and non-users of improved fallows. The sampling frame had a total of 7,081households of which approximately 20 percent were users of improved fallows. Due to logistical reasons the study aimed to interview at least 320 households. To carter for non-responses 335 households were sampled for the survey. From the users of improved fallows stratum, 134 households were picked out randomly using stata (Stata version 11.2, 2009). Similarly, from the non-users stratum, 201 non-users were randomly selected using Stata. Due to non-responses, 130 and 194 households using improved fallows and non-users of improved fallows respectively were eventually interviewed in November and December of 2011.

2.3 Survey Instrument Development, Pre-testing and Implementation

Considerable time and effort by the authors was expended in designing the study. The part of the questionnaire covering contingent valuation went through several refinements following the interactions between the authors. The final version of the questionnaire particularly useful for this specific study covered the basic households' demographic and socioeconomic characteristics as well as the contingent valuation section that was sub-divided for the users and non-users of improved fallows respectively.

In the contingent valuation section, the authors had the option of directly asking farmers whether they were willing to accept compensation (WTA) for planting improved fallows that in addition to soil fertility improvement which is privately beneficial to them also provide specific environmental services. However since it is well known in the literature that for the same goods and in the same setting, WTA considerably exceeds willingness to pay (WTP) (Haab & McConell, 2002) this study was designed based on WTP techniques. The use of WTP was motivated by the belief that stated preference techniques cannot be used to measure WTA because they are not incentive-compatible for this measure (Haab & McConell, 2002).

We stated earlier that the primary benefit to farmers from uptake of improved fallows is soil fertility improvement. It is thus reasonable to assume that farmers who could afford inorganic fertilisers to boost on farm soil fertility had a low probability to take up improved fallows. As such, for farmers who were observed to plant improved fallows at the time of the survey, the contingent scenario sought to elicit their WTP (and associated levels) in support of a hypothetical fund that would guarantee availability of inorganic fertilisers to them. If the farmers accepted the inorganic fertiliser offered in the contingent scenario, then they do not have to plant improved fallows for soil fertility improvement. For farmers who were not observed to plant improved fallows at the time of the survey, the contingent scenario sought to elicit their WTP (and associated levels) to support the activities of a hypothetical lobby that sought to block a proposed hypothetical government policy designed to compel them to put part of their farmland to improved fallows.

Although the contingent valuation part of the questionnaire was considerably short, the authors took ample time to design it since in CVM preparing an effective questionnaire is important (Wang et al., 2006). Before the formal survey a pre-test study comprising 16 households was carried out. The pre-test survey served two purposes; to ensure the questionnaire had WTP questions that were not misleading and were flowing in a logical way and to provide lower, median and upper bound values for use in the main survey.

The final questionnaire consisted of scenarios in which prevention of soil erosion and down stream water pollution due to uptake of improved fallows was discussed with farmers in great detail (see descriptions below). Linkages between short term welfare loss (gain) when a farmer takes up improved fallows (inorganic fertiliser) and long term consequences on soil erosion and down stream water pollution were made in the scenario description. The discussion on soil erosion and water pollution was supplemented with the aid of pictures which depicted gullies due to soil erosion on a treeless bare land and highly soil polluted stream. The study was set to find out whether the farmers would be willing to pay (and at what levels) towards the availability (or continuous use) of fertilisers given the knowledge that the fertilisers (improved fallows) will cause (will not cause) soil erosion and down stream water pollution in the long run. The summaries of the scenarios for the users and non-users of improved fallow farmers are provided below:

2.3.1 Scenario 1 – Users of Improved Fallows

By planting improved fallows on your farm, you are supplying services that directly benefit you and the farm (for example reducing on-farm soil erosion and making the soil easier to work with) and at the same time providing benefits to many other people who are situated far away from the farm (for example, by planting improved fallows instead of using inorganic fertilisers, you avoid polluting ground water and by so doing, many people benefit). Since you have to wait for 2 – 3 years before you start seeing the soil fertility improvement benefits of the improved fallows, your crop output decreases in the intervening period. However you may also be aware that your output would not have decreased had you been using inorganic fertilisers in place of improved fallows. In view of this fact, the government is considering setting up a fund that would increase the availability of inorganic fertilisers to farmers (instead of you relying on improved fallows to enhance crop output). From this fund, you will have enough inorganic fertiliser for all your cultivable land. The fertiliser will enhance your crop output. Since your crop output will be high, you do not have to maintain the acreage in your farm under improved fallows (i.e. you can reduce the area of your farm covered by improved fallows). Since availability of inorganic fertilisers enables you to reduce the area in your farm under improved fallows, the levels of environmental services produced from your farm which benefit many people beyond the farm will also reduce. For instance soil erosion on your farm will increase, which means that when it rains the water in the rivers will have increased levels of mud. The extent of soil erosion on your farm will depend on how much land is left without improved fallows. For example, if you remove all the trees on the farm and use inorganic fertilisers, the crop output would increase but the level of soil erosion may be like what you see in picture 1 and pollution down stream in picture 2. (*This was a two way discussion broken down by intermittent questions on whether farmer understood or not – until farmer understood, that is when the following question was asked*).

I would now like to ask you questions about this fund that increases the availability of inorganic fertiliser at the expense of increasing the levels of soil erosion and probably down stream water pollution on your plot. Please note that despite the fund being government sponsored, you will also be required to make a partial contribution to benefit from it.

Would you be willing to join this fund? Yes/No

If YES, continue with next Q., if NO, please explain why you would not be willing to join this fund?

The next questions took the farmer through an iterative bidding process where they were asked whether they were willing to contribute the lower value (K200, 000), if yes, the median value (K400, 000), if yes still, the upper value of K1000, 000 to the fund. For farmers who were not willing at each stage, they were asked to state the reason for their unwillingness and to state their maximum WTP to the fund.

2.3.2 Scenario 2 - Non-Users of Improved Fallows

By using inorganic fertilisers, your crop output is higher than for those farmers who are using or partly using improved fallows. This is because the farmers who have adopted improved fallows leave the fallow plots uncultivated for 2 – 3 years before they cultivate in them. However, by not planting improved fallows on your farm, you are not supplying any environmental services that could benefit you, directly and other people beyond this farm. For instance by planting improved fallows on your farm, you could benefit from reduction in on-farm soil erosion and at the same time many other people who are situated far away from the farm could be drinking less polluted ground water since the fallows reduces the rates of nutrient leaching. So, if you continue the intensive use of inorganic fertilisers, without necessarily planting improved fallows or any trees, you will experience serious soil degradation (soil erosion) on your farm in the near future like what you are seeing in picture 1. Since the continuous use of inorganic fertiliser could be very detrimental to the environment, the government is contemplating enforcing legislation where part (at least an acre) of your cultivable land will be under improved fallows every year. This will help towards mitigating of soil erosion. Since part of your farm will be planted to improved fallows, this project will decrease your crop output hence your welfare. However, since the project has not yet taken effect, you have the opportunity to lobby the government against such a policy. An association of farmers will have to be formed to spearhead the lobbying activities. The association needs funds for carrying out the lobbying activities. You will be requested to contribute to this association if you are interested in opposing this policy. (*This was a two way discussion broken down by intermittent questions on* *whether famer understood or not – until farmer understood, that is when the following question was asked*)

I would now like to ask you questions about this association that can help you oppose a policy that compels you to put part of your farm under improved fallows.

Would you be willing to join this association? Yes/No

If YES, continue with Q. 18, if NO, please explain why you would not be willing? The next questions involved a process of iterative bidding where farmers were asked whether they were willing to contribute the lower value (K200, 000), if yes, the median value (K400, 000), if yes still, the upper value of K1000, 000 to the association. For farmers who were not willing at each stage, they were asked to state the reason for their unwillingness and to state their maximum WTP.

2.4 Data Analysis

There are three important farmer classifications that can be discerned according to the responses on the WTP questions. First, there is a category of those farmers who were not willing to join a fertiliser fund or an association blocking an improved fallow policy. In this study we referred this category as farmers with a negative willingness to pay. Second, some farmers were willing to join the fund or the association but were not willing to pay or contribute anything. This category of farmers was referred to as those with a zero willingness to pay. Finally, the category of farmers who were willing to join and pay something to the fund or association was referred to as farmers with a positive willingness to pay.

Differences in several socioeconomic factors between categories based on their WTP were subjected to t and X^2 tests using SPSS version 16. The specific categories analysed included the differences in socioeconomic factors between farmers with a zero or positive WTP and negative WTP within those who planted improved fallows and within the non-users of the technology. A further analysis was made that treated farmers as a homogenous group with regards to improved fallows adoption but then compared the differences between 'zero or positive WTP' and 'negative WTP' categories. Farmer categories with positive WTP were subjected to further analyses at different iterative bidding levels of WTP.

Probit regression using stata version 11 was used to isolate the factors that had significant influence on the farmers' willingness to join either the fund that would ensure inorganic fertiliser availability or an association that would ensure blockage of a policy that compels farmers to plant improved fallows.

3. Results

3.1 Categorising Farmers' According to Willingness to Join Fertiliser Fund or Improved Fallow Blocking Association

The 324 farmers surveyed can be grouped according to their willingness to either join a fertiliser fund or an improved fallow blocking association; and also according to both their willingness to join and whether they are using improved fallows or not. A significant number of farmers (73%) were not willing to either join the fund or the association while the remainder were willing to join. Differences and/or similarities in socioeconomic characteristics between these two broad categories of farmers are shown in Table 1. The farmers willing to join either the fund or the association had significantly higher maize yields and larger cropped farms than those who were not willing to join. The two groups had similar characteristics in terms of sex, educational level, marital status and age of household heads. They also had equal household membership size, maize productivity, total land owned and per capita household income as well as the amount of fertiliser used in 2010/11 season.

Grouping the farmers using both the willingness to join and whether a household was using improved fallows or not produced four distinct categories that are also shown in Table 1; a) users of improved fallows who are not willing to join the fund (23%); b) users of improved fallows who are willing to join the fund (17%); c) non users of improved fallows who are not willing to join association (50%); and d) non users of improved fallows who are willing to join association (10%).

3.2 Farmers Using Improved Fallows and Willingness to Join the Inorganic Fertiliser Fund

In the users of improved fallow category, the farmers who were willing to join the fund to ensure availability of fertilisers had significantly higher maize yields, large cropped fields and higher per capita household income in 2010/2011 season. They were also relatively younger than those who were not willing to join the fund (Table 2).

With the knowledge that the long term effect of inorganic fertiliser use without planting improved fallows is increased soil erosion and water pollution, 43% of the 130 farmers using improved fallows were still willing to contribute to a fund that would make inorganic fertilisers available to them. The remainder (57% (74)) were not willing to contribute to the fund that would ensure availability of fertiliser. A majority of these farmers (56) indicated that they would not want inorganic fertilisers because of the long term detrimental effect that continuous use of fertiliser brings with it. In addition to long term effects, seven farmers acknowledged that improved fallows have more benefits such as the provision of firewood than inorganic fertilisers. Four farmers also cited climate change considerations and three farmers mentioned their belief in sustainable agriculture as the reasons for not willing to join the fund. The rest mentioned that improved fallows are permanent but inorganic fertilisers would not last for ever. This was in addition to the discussions on the implications of improved fallows and fertilisers on soil erosion and water pollution.

Table 1. Descriptive characteristics of farmers by willingness to join fertiliser fund or improved fallow blocking association

	Farmers not willing (N=237)	Farmers willing (N =87)	*t* or X^2 value	*P value*
Using improved fallows (%)				
No	50.3	9.6		
Yes	22.8	17.3		
Total	73.1	26.9	29.099	0.000
Sex of household head (%)				
Male headed	81.9	82.8		
Female headed	18.1	17.2	0.035	0.851
Education level of household head (%)				
Never been to school	8.4	6.9		
Attended primary	32.5	28.7		
Completed primary	27.0	23.0		
Attended secondary	27.4	27.6		
Completed secondary	3.8	12.6		
Attended tertiary	0.8	1.1	9.002	0.109
Marital status of household head (%)				
Married	82.3	82.8		
Single	4.2	5.7		
Widowed	10.5	9.2		
Divorced	3.0	2.3	0.535	0.911
Age of household head (years)	46.69 (0.825)	46.89 (1.255)	-0.129	0.898
Household size	6.75 (0.183)	7.24 (0.330)	-1.309	0.193
Maize yield per ha (ton)	1.72 (0.070)	1.81 (0.147)	-0.558	0.578
Maize yield (ton)	2.63 (0.165)	3.82 (0.361)	-3.001	0.003
Cropped land (ha)	2.44 (0.087)	3.12 (0.223)	-2.839	0.005
Total land owned (ha)	3.81 (0.159)	4.14 (0.279)	-0.995	0.321
Total fertiliser use (ton)	0.33 (0.032)	0.40 (0.042)	-1.293	0.198
Per capita income (K'million)	1.22 (0.091)	1.53 (0.166)	-1.633	0.105

Figures in parentheses are standard errors.

The main drawbacks associated with improved fallow use (when compared to fertilisers) cited by 49 of the adopting farmers included; labour intensiveness (41% of farmers), long waiting period before benefits are realised (47% of farmers), large land requirements (8%) and that some fallows harbour pests and diseases (2%).

Table 2. Descriptive characteristics of farmers by willingness to join a fund providing inorganic fertiliser within the improved fallow farmers' stratum

	Farmers not willing (N = 56)	Farmers willing (N = 74)	*t* or X^2 value	*P* value
Sex of household head (%)				
Male headed	81.1	85.7		
Female headed	18.9	14.3	0.487	0.485
Education level of household head (%)				
Never been to school	5.4	1.8		
Attended primary	24.3	25		
Completed primary	37.8	25		
Attended secondary	27	28.6		
Completed secondary	5.4	17.9		
Attended tertiary	0	1.8	8.656	0.124
Marital status of household head (%)				
Married	81.1	85.7		
Single	5.5	5.4		
Widowed	9.5	8.9		
Divorced	4.1	0	2.363	0.501
Age of household head (years)	49.12 (1.107)	46.32 (1.246)	1.680	0.095
Household size	7.55 (0.341)	7.27 (0.371)	0.567	0.572
Maize yield per ha (ton)	2.09 (0.131)	2.17 (0.189)	-0.333	0.740
Maize yield (ton)	3.61(0.312)	5.00 (0.467)	-2.479	0.015
Cropped land (ha)	2.77 (0.169)	3.72 (0.289)	-2.855	0.005
Total land owned (ha)	4.73 (0.350)	5.00 (0.360)	-0.549	0.584
Total fertiliser use (ton)	0.37 (0.042)	0.47 (0.058)	-1.434	0.154
Per capita income (K, million)	1.16 (0.117)	1.85 (0.223)	-2.708	0.008

Figures in parentheses are standard errors.

3.3 Non users of Improved Fallows and Willingness to Block a Policy on Improved Fallows

A total of 194 farmers were non-users of improved fallows. Among the non users of improved fallows, there were no significant differences in most of the socioeconomic characteristics between those who were willing to join an association that would block planting of improved fallows and those who were not. The only differences the two categories had were in maize productivity and farm size. Those willing to join the association had lower maize production per hectare and smaller farm sizes than their counter parts (Table 3).

With the full knowledge on the environmental benefits in terms of prevention of soil erosion and water pollution, of improved fallows and the long term consequences of inorganic fertiliser on these services, 16% of the non users of improved fallows were willing to join the association that would block improved fallows. In addition to soil erosion and water pollution prevention, 54% of those who would not want to join the association were aware that improved fallows did not generally degrade soils in the long run like inorganic fertiliser does. Twenty seven percent of the farmers cited added benefits such as fuel wood from improved fallows in addition to soil erosion and water pollution prevention. Ten percent of the farmers re-emphasised the controlling of soil erosion by improved fallows as reason for their unwillingness to join the association. A further 3% mentioned that they had enough land and therefore would be willing to plant improved fallows hence their unwillingness to join the association.

Eighty five percent of 65 non users of improved fallows indicated that compared to fertilisers, the long waiting period was the major drawback associated with the technology. Nine percent cited large land requirements while 3% apiece cited labour intensiveness and harbouring of pests by the improved fallows respectively.

Table 3. Descriptive characteristics of farmers by willingness to join association that would block compelling inorganic fertiliser farmers to plant improved fallow

	Farmers not willing (N = 163)	Farmers willing (N = 31)	*t* or X^2 value	*P* value
Sex of household head (%)				
Male headed	82.2	77.4		
Female headed	17.8	22.6	0.396	0.530
Education level of household head (%)				
Never been to school	9.8	16.1		
Attended primary	36.2	35.5		
Completed primary	22.1	19.4		
Attended secondary	27.6	25.8		
Completed secondary	3.1	3.2		
Attended tertiary	1.2	0	1.466	0.917
Marital status of household head (%)				
Married	82.8	77.4		
Single	3.7	6.5		
Widowed	11.0	9.7		
Divorced	2.4	6.5	1.968	0.579
Age of household head (years)	45.59 (1.080)	47.90 (2.733)	-0.787	0.436
Household size	6.38 (0.212)	7.19 (0.648)	-1.192	0.241
Maize yield per ha (ton)	1.55 (0.078)	1.16 (0.179)	1.971	0.055
Maize yield (tons)	2.19 (0.184)	1.70 (0.309)	1.362	0.179
Cropped land (ha)	2.29 (0.099)	2.04 (0.253)	0.935	0.356
Total land owned (ha)	3.41 (0.160)	2.58 (0.269)	2.635	0.011
Total fertiliser use (tons)	0.32 (0.043)	0.27 (0.049)	0.660	0.511
Per capita income (K, million)	1.25 (0.121)	0.97 (0.201)	1.213	0.230

Figures in parentheses are standard errors.

3.4 Factors Affecting Willingness to Join Fertiliser Fund or Improved Fallow Blocking Association

Table 4 describes the various factors considered in analysing the willingness to join the fertiliser fund or an improved fallow blocking association. There was a positive and significant relationship between the likelihood that a farmer would be willing to join the fertiliser fund or an improved fallow blocking association and, if the farmer was using improved fallows, household per capita income, size of land cropped, if soil fertility was a major challenge and if the soils on the farm were mostly sandy (Table 5). These factors significantly contributed to the probability of accepting to join the fund or association despite farmers' knowledge that compared to improved fallows, inorganic fertilisers would be detrimental to society at large through soil erosion and hence water pollution increases.

If a farmer without improved fallows switches to planting the improved fallows, the probability of willingness to join the fertiliser fund would increase by 32%. Increasing household per capita income by a unit (a million kwacha) would increase the probability to join the fertiliser fund or the policy blocking association by 3%. For a unit or hectare increase in cropped land, the probability of willingness to join to ensure availability of inorganic fertiliser or blockage of improved fallow policy would increase by 10%. A discrete change to the perception that soils are a major agricultural challenge would increase the probability of willingness to join the fund or association by about 10%. Having a lot of sandy soils on the farm would increase the probability of willingness to join the fund or association by 14%.

Table 4. Descriptions of the variables used in the probit models on willingness to join the fund of association

Variable	Description	Units/Codes		Mean (N = 324)
Mzyperha	Maize yield per hectare			1.75 (0.064)
Totmzyield	Total farm maize yield	*Tons*		2.95 (0.157)
HHSex	Household head sex	*1 = male, 2 = female*		1.18 (0.021)
HHEduc	Educational level of household head	*1= Never been to school, 2 = Attended primary, 3= Completed primary, 4 = Attended secondary, 5 = Completed secondary, 6 = Attended tertiary, 7 = Completed tertiary*		2.95 (0.062)
HHAge	Age of household head	*Years*		46.74 (0.690)
Mstatus	Marital status of household head	*1 = Married, 2= Single, 3 = Widow(er), 4 = Bachelor, 5 = Spinster, 6 = Divorced*		1.33 (0.043)
PerIN	Per capita Household income	*Zambian kwacha*		1.31 (0.080)
Cropped land	Size of cropped land	*Hectares*		2.62 (0.689)
Totfertuse	Total fertiliser use	*Tons*		0.35 (0.026)
Group	Household group membership	*1= Yes*	*2= No*	0.77 (0.024)
SoilfertCH	Whether household cited soil fertility as number 1 challenge	*1= Yes*	*0= otherwise*	0.42 (0.027)
SandySoil	Whether most parts of farm is composed of sand soils	*1= Yes*	*0= otherwise*	0.21 (0.023)
Farmsi	Size of farm	*Hectares*		3.90 (0.139)
Hsize	Household membership size	*Number*		6.88 (0.161)
Erosion	farm experiences soil erosion	*1= Yes*	*0= otherwise*	1.73 (0.025)

Figures in parentheses are standard errors of means.

On the other hand the probability that the farmers' would join the fund or association decreased with maize productivity, group membership and farm size. A one ton increase in maize production per hectare would decrease the probability of willingness to join the fund or the association by 4%. Being a member of agricultural association would decrease the probability by about 17% while a unit or hectare's increase in farm size, would decrease the probability of willingness to join the fund or association by 6% (Table 5).

Table 5. Probit regression results on the factors affecting farmer willingness to join the inorganic fertiliser fund or an association blocking planting of improved fallows

				Observations	317
				LR chi2 (14)	62.06
				Prob>chi2	0.000
				Log likelihood	-154.27
				Pseudo R2	0.17
Varible	Coefficient	Std. error	Z	P>|z|	Marginal effects (dy/dx)
Planted IF	1.026	0.206	4.98	0.000***	0.324
HHSex	-0.093	0.282	-0.33	0.742	-0.028
HHEduc	0.010	0.078	0.13	0.896	0.003
HHMstatus	0.070	0.143	0.49	0.625	0.021
HHsize	0.030	0.031	0.98	0.328	0.009
Mzydperha	-0.132	0.077	-1.71	0.088*	-0.040
PercapitaIN	0.109	0.064	1.72	0.085*	0.033
Croppedland	0.317	0.099	3.21	0.001***	0.096
Totfertuse	-0.135	0.236	-0.57	0.566	-0.041
Group	-0.506	0.226	-2.24	0.025**	-0.167
SoilfertCH	0.341	0.167	2.04	0.042**	0.105
Sandysoil	0.436	0.196	2.23	0.026**	0.143
Farmsi	-0.210	0.069	-3.04	0.002***	- 0.064
Erosion	0.224	0.185	1.21	0.227	0.070
Constant	-1.164	0.495	-2.35	0.019**	-

*, ** and *** significant at 90, 95 and 99% confidence levels.

3.5 Factors Affecting Improved Fallow Farmers' Willingness to Join the Inorganic Fertiliser Fund

Despite embracing improved fallows, 43% of the 130 farmers would join the fund that would make inorganic fertiliser available. The preceding section also shows that planting of improved fallows does not necessarily reduce the probability of farmers seeking inorganic fertiliser. This is even with the full knowledge of the implications of fertiliser to soil erosion and water pollution in the long run. When analyzed as a homogenous group (improved fallow farmers), household per capita income, cropped land size and if soil fertility was a major agricultural challenge were found to be positively increasing the likelihood of joining the inorganic fertiliser fund (Table 6). Increasing household income by one million kwacha would increase the probability of joining the fertiliser fund by 12%. A hectare's increase in cropped land increased the probability of joining the fund by 16%. If a farmer changes from not perceiving to perceiving soil fertility as a major agricultural challenge, the probability of this farmer joining the fund that would ensure availability of fertiliser would increase by 24%. On the other hand, belonging to a farmer group and farm size were negatively associated with willingness to pay to a fund that would make inorganic fertiliser available. A switch from being a non-member to being a member of a farmer group would decrease the probability of willingness to pay to join the fund by about 49% while a hectare's increase in farm size would decrease this probability by 6% (Table 6).

Table 6. Probit regression results on the factors affecting farmer willingness to join the inorganic fertiliser fund

				Observations	129
				LR chi2 (13)	36.43
				Prob>chi2	0.0005
				Log likelihood	-69.80
				Pseudo R2	0.21
Varible	Coefficient	Std. error	Z	P>|z|	Marginal effects (dy/dx)
HHSex	-0.022	0.584	-0.04	0.970	-0.008
HHEduc	0.135	0.121	1.11	0.266	0.052
HHMstatus	-0.062	0.314	-0.20	0.845	-0.024
HHsize	-0.022	0.049	-0.46	0.648	-0.009
Mzydperha	-0.147	0.121	-1.21	0.226	-0057
PercapitaIN	0.312	0.119	2.63	0.009***	0.121
Croppedland	0.420	0.139	3.02	0.002***	0.163
Totfertuse	-0.646	0.435	-1.49	0.138	-0.250
Group	-1.450	0.746	-1.94	0.052**	-0.492
SoilfertCH	0.636	0.259	2.46	0.014**	0.247
Sandysoil	0.214	0.289	0.74	0.460	0.083
Farmsi	-0.163	0.086	-1.91	0.056*	-0.063
Erosion	0.078	0.268	0.29	0.774	0.030
Constant	0.247	1.119	0.22	0.825	-

*, ** and *** significant at 90, 95 and 99% confidence levels.

3.6 Farmer WTP and Maximum WTP for Fertiliser Availability among the Improved Fallow Farmers

Despite the full knowledge that continuous use of inorganic fertiliser without planting trees could lead to soil erosion and down stream water pollution, some improved fallow farmers were willing to join and contribute to a fertiliser fund. The numbers of improved fallow farmers willing to join and contribute (at different bid prices) to the fund are shown in Figure 2. Out of 130 improved fallow farmers 43% (56) were willing to join the fund. From the 56 farmers, 53 were willing to pay K200, 000 towards this fund. The remainder (3 farmers) could not afford this amount. Out of the 53 farmers, 47 were still willing to pay K400, 000 to the fund. The remainder (5 farmers) could not afford this amount. Twenty seven farmers from the 47 were still willing to pay K1000, 000 towards the fund. The remaining 20 felt K1000, 000 was too much for them. The maximum amount improved fallow farmers with positive WTP were willing to pay to the fund to ensure availability of inorganic fertiliser and hence accept consequences of soil erosion and water pollution) for an acre of land was K1, 050, 000 (std. error = K121, 367) on average.

3.7 Factors Affecting Farmer Willingness to Join an Association Blocking Planting of Improved Fallows

Out of the 194 non-users of improved fallows 16% were willing to join an association that would ensure a blockage of policy that would compel farmers to plant improved fallows. Size of cropped land and if the farm was mainly composed of sand soils, were found to be positively influencing the likelihood of farmers' willingness to join an association whose objective would be to block an improved fallow policy. A unit increase in cropped land increased this probability by 6%. The probability on the willingness to join the association to block the improved fallow policy for a farmer whose farm is characterised by sandy soils increased by about 16%. However, maize productivity and farm size had a negative influence on the non-users of improved fallows willingness to join an association that would block a policy on improved fallows. The probability on the willingness to join to block the policy that compels farmers to plant improved fallows decreased by 5% and 7% for a unit increase in maize and farm size respectively (Table 7).

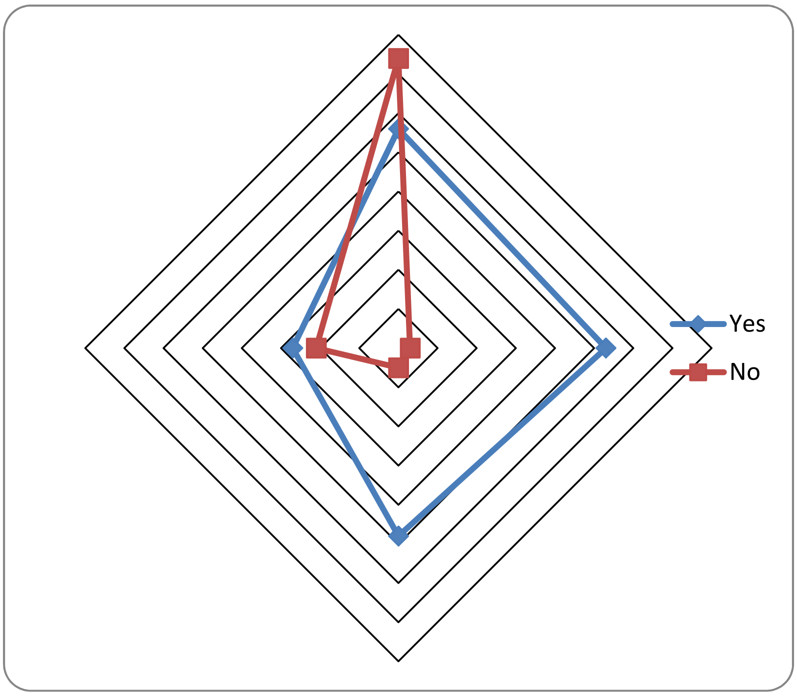

Figure 2. Number of improved fallow farmers willing (not willing) to join and contribute to the fertiliser fund

Table 7. Probit regression results on the factors affecting farmer willingness to join an association blocking planting of improved fallows

				Observations	188
				LR chi2 (13)	24.42
				Prob>chi2	0.027
				Log likelihood	-71.96
				Pseudo R2	0.15
Varible	Coefficient	Std. error	Z	P>|z|	Marginal effects (dy/dx)
HHSex	-0.146	0.366	-0.40	0.689	-0.030
HHEduc	-0.069	0.116	-0.59	0.552	-0.014
HHMstatus	0.111	0.177	0.63	0.530	0.023
HHsize	0.071	0.045	1.56	0.118	0.014
Mzydperha	-0.252	0.146	-1.73	0.083*	-0.051
PercapitaIN	0.011	0.101	0.11	0.916	0.002
Croppedland	0.292	0.184	1.58	0.095*	0.060
Totfertuse	-0.093	0.307	-0.30	0.762	-0.019
Group	-0.367	0.276	-1.33	0.184	-0.079
SoilfertCH	0.041	0.249	0.17	0.868	0.008
Sandysoil	0.624	0.309	2.02	0.043**	0.160
Farmsi	-0.309	0.141	-2.18	0.029**	-0.063
Erosion	0.445	0.280	1.59	0.113	0.104
Constant	-0.629	0.682	-0.92	0.356	-

*, ** and *** significant at 90, 95 and 99% confidence levels.

3.8 Farmer WTP and Maximum WTP to Block an Improved Fallow Policy among the Non-Improved Fallow Farmers

Most of the non-users of the improved fallows were not willing to block an improved fallow policy that would compel farmers to plant part of their land with improved fallows (Figure 3). This is amidst the knowledge that improved fallows could help in preventing soil erosion and water pollution. As shown in Figure 3, out of the 194 farmers only 16% (31) were willing to pay to the association that would block the improved fallow policy, 83% (25) were willing to pay K200, 000 while the rest indicated that this figure was too much. Nineteen (19) of the 25 farmers were still willing to contribute K400, 000 while 4 of the farmers indicated that the figure was too much and 2 farmers mentioned that this was beyond their budget. At K1, 000, 000 level 12 or 63% of the 19 farmers were willing to pay to the association and the rest thought the figure was too high.

The maximum willingness to pay to the association that would ensure blockage of the government policy compelling farmers to have a hectare of improved fallows every year was estimated at an average of K1, 380, 000 (std. error = K186,439). This estimate was not significantly different (t = 1.546, *P* = 136) from that of the users of improved fallows.

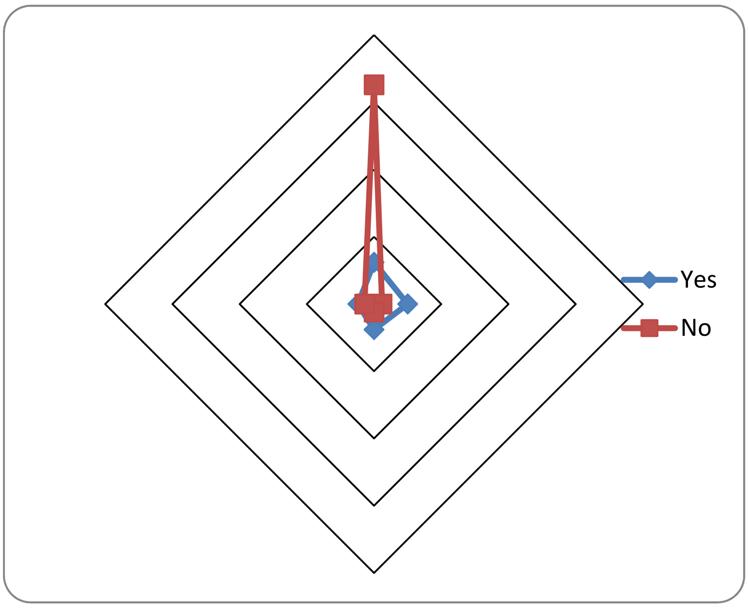

Figure 3. Number of non-improved fallow users willing (not willing) to join and contribute to an improved fallow policy blocking association

4. Discussion

The provision of environmental services (ES) through improved fallows has widely been noted (Ajayi et al., 2007; Sileshi et al., 2007). Since improved fallows are mainly promoted for soil fertility improvement among the farmers, assessing how willing the farmers are to provide ES and to be compensated for the provision of ES through improved fallows becomes pertinent. Since WTP is a more robust measure than WTA, this study used indirect WTP approaches to elicit information about farmers' willingness to provide ES and for their WTP for a technology (the inorganic fertiliser) that is in contrast to improved fallows in the provision of ES.

Soil erosion and water pollution are among the many ES that farmers associate with the use of fertiliser and the improved fallows. The long term effect of inorganic fertiliser use may result in soil erosion and water pollution. Conversely the long term effect of improved fallows use could be prevention of soil erosion and reduced water pollution. More than 90% of the 324 farmers surveyed in Chongwe district in 2011 were knowledgeable about the link between improved fallows and the provision of these services, and also about continuous use of fertiliser (without planting trees) and the long term effect on soil erosion and water pollution. Discussions on these linkages were held with both knowledgeable and non-knowledgeable farmers. Pictures on soil erosion and water pollution from run-off water on bare lands were used to illustrate these scenarios. Only after a farmer fully understood the implications of continuous use of fertiliser versus improved fallows on soil erosion and water pollution, did the study seek to find out the WTP to a fund that would provide fertiliser or an association that would block an improved fallow policy. Fundamentally, we sought to understand if a farmer who was observed to be planting improved fallows and supplies environmental services by so doing was willing to reduce the supply of these services in the interest of increased benefits of private maize production. Similarly, for a farmer who was observed not to be planting improved fallows and does not supply environmental services by so doing, the study was interested in knowing whether this farmer would be willing to block a policy that encourage increasing the supply of the services at the expense of reduced benefits of private maize production. Further, the study sought to understand factors that could predict unwillingness to provide the environmental services.

The majority of the farmers (more than 70%) involved in the survey were willing to prevent soil erosion and water pollution through their unwillingness to join a fund that would have ensured availability of inorganic fertiliser or an association that would block a policy promoting use of improved fallows. The willingness to supply these ES catered across the improved fallow adoption stratum. Although there were expected categories of farmers i.e. those using improved fallows and hence willing to provide ES; and those not using improved fallows and hence unwilling to provide ES, this study found that the supply of ES was not directly associated with using of improved fallows.

First, not every farmer who was using improved fallows was willing to provide ES through improved fallows. There were some (17%) who were willing to pay for availability of inorganic fertiliser amidst the knowledge that they can enhance soil erosion and water pollution. The planting of improved fallows by these farmers could solely be for food security reasons. This group of farmers can easily stop the use of improved fallows if alternative and affordable options for improving soil fertility are available. Private welfare is more important for this group of farmers than the provision of social or public environmental goods. For this particular group of farmers, it can be deduced that absence of resources to purchase fertiliser is the main driving force towards adoption of improved fallows. This is not surprising since the primary objective of adopting improved fallows is soil fertility replenishment (Mafongoya and Kuntashula 2005) and not necessarily the provision of ES.

Second, not every farmer who was not using improved fallows did not want to supply ES through improved fallows. It was found that there are some farmers who are willing to provide ES through improved fallows although they have not taken up the technology yet. This category of farmers was in the majority (50%) among the 324 surveyed households in Chongwe district in 2011. Indirectly these farmers were willing to provide ES specifically the prevention of soil erosion and water pollution through their refusal to join an association that would block planting of improved fallows policy. Although they have not yet put it into practice this group of farmers' social preferences overrides their private benefits. Surprising only a few (10%) of farmers who were not using improved fallows were willing to join an association that would block a policy compelling farmers to plant improved fallows.

Several covariates influenced the willingness to join either the fund or an association that would one way or another promote the use of inorganic fertiliser hence encourage soil erosion and water pollution. Planting of improved fallows, household per capita income, the size of land cropped, if the farmer conceived soil fertility as the major farm challenge and if the farm was composed mostly of sand soils significantly contributed to the probability of accepting to join the fund or association. This was despite farmers' knowledge that compared to improved fallows, inorganic fertilisers would be detrimental to society at large through soil erosion and hence water pollution increases. On the other hand the probability that the farmers' would join the fund or association decreased with maize production per hectare, farmer group membership and farm size.

We noted earlier on that planting of improved fallows was mainly promoted for soil fertility improvement. Therefore it is not surprising that farmers seeking alternatives for soil fertility replenishment would equally opt for inorganic fertilisers. The increase in household per capita income would make more cash available to contribute to other soil improving options such as fertilisers or blocking of an improved fallow policy. The more the farmer cultivates most of the land, the more the pressure for inputs and the more likely that they would opt to have inorganic fertilisers or block an improved fallow policy since compared to improved fallows, fertilisers are less labour intensive and provides the benefits immediately (Ajayi et al., 2007). Moreover if more land is cultivated, there will be less land for fallowing with improved fallows. If soil fertility problems are very pressing, the immediate response of a rational farmer would be to apply fertilisers. Both facing soil fertility as the major agricultural challenge and the general perception that sandy soils are less fertile would compel farmers to seek inorganic fertiliser as an immediate solution.

High maize productivity would ensure less demand for alternative soil improvement options hence the negative relationship between maize productivity and willingness to embrace fertilisers at the expense of soil erosion and water pollution. Informal interviews in the study area revealed that most farmer groups had the objective of sustainable agriculture as their major focus. Therefore the negative relationship between group membership and willingness to embrace fertiliser or to block planting of improved fallows is expected. The negative relationship between farm size and willingness to join either a fertiliser fund or an association that would block an improved fallow policy is also expected. The larger the farm sizes the more the available land to put under improved fallows. The farmer who puts some of the land to improved fallows would not compromise much on the amount of land to cultivate if he has a large farm. For such farmers, it is easy to consider the long term effects of soil fertility investments.

When the improved fallow farmers were analyzed on their own, per capita income, the amount of cropped land and soil fertility as a major on-farm challenge increased the likelihood that a farmer would join the fund to provide inorganic fertiliser. On the other hand belonging to a farmer group and farm size decreased the probability of willingness to pay to a fund that would make inorganic fertiliser available. The explanations on per capita income, cropped land and soil fertility challenge provided above still hold here. Likewise the discussions on the negative association between group membership and farm size on the probability of willingness to join a fertiliser fund can also apply here.

Again cropped land was found to be positively influencing the likelihood of the non-users of improved fallow willingness to join an association to block an improved fallow policy. The likelihood of joining the association was also positively related to a farmer whose farm was mostly characterized by sandy soils. Just like for the other categories, farm size had a negative influence on the non-users of improved fallows willingness to join an association that would block a policy on improved fallows. Maize productivity among the non-users of improved fallows had also a negative influence on their willingness to join an association that would block a policy on improved fallows. The explanations given above on why these factors were influencing the probability of joining either the fund or the association still hold here.

Farmers could be willing to join the fund or an improved fallow blocking association, but to what extent would they be willing to pay to these organisations and thus contribute towards degradation through soil erosion and water pollution? The maximum amount improved fallow farmers with positive WTP were willing to pay to the fund to ensure availability of inorganic fertiliser for a hectare of land was K1, 050, 000. For the non-users of improved fallows the maximum willingness to pay to the association that would ensure blockage of the government policy compelling farmers to have a hectare of improved fallows every year was estimated at K1, 380,000. These estimates were statistically the same implying that the willingness to embrace fertiliser carters across the improved fallow adoption spectrum. The trade-off between immediate private benefits sought from the use of fertiliser in place of the improved fallows that at the same time provide environmental services could be said to be the same among the adopters and non-adopters.

5. Conclusions

The majority of the farmers in the study area were willing to plant improved fallows and thus help towards the prevention of soil erosion and water pollution. This is regardless of whether the farmers were using the technology or not. The implication is that farmers could be targeted with the message of improved fallows being able to provide ES in addition to improving soil fertility. There are factors such as cropped land sizes and challenges related to soil fertility that would push farmers (across the adoption divide) towards seeking faster means of producing food (use of fertiliser) without due regards to the environment. Larger farm size could discourage joining the fertiliser fund or an improved fallow blocking organization and hence encourage the prevention of soil erosion and water pollution through improved fallows. Increases in per capita household income could potentially encourage increased fertiliser use among improved fallow farmers. Whereas group membership was important towards the unwillingness to join the fund by improved fallow farmers, it was maize productivity that mattered among the non-users of improved fallows. The willingness to pay for fertiliser availability or blocking the improved fallow policy was the same among the adopters and non-adopters of improved fallows. A payment for environmental services policy scheme as an alternative policy could therefore be designed to treat the farmers as a homogenous group. However, these findings need to be validated through the use of a more national wide representative sample.

Acknowledgements

Resources for this research were provided by the Collaborative Masters in Applied Agricultural Economics (CMAAE), PhD Fellowship programme. The Centre for Environmental Economics Policy in Africa (CEEPA) provided PhD tuition and living expenses to the first author during his studies at University of Pretoria. We are highly indebted to these two institutions. We would also like to acknowledge Kasisi Agricultural Training Centre

(KATC) for allowing us to interview the farmers in their catchment areas and the farmers themselves for the cooperation during the interviews. Finally, we would like to thank John Phiri, Kenthern Banda and Fridah Chipambala for assisting during data collection.

References

Ajayi, O. C., Akinnifesi, F. K., Sileshi, G., Chakeredza, S., & Matakala, P. (2007). 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), 059-067.

Ajayi, O. C., & Matakala, P. (2006). Environmental conservation and food security in developing countries: Bridging the disconnect. Plenary paper presented at the 26th triennial Conference of the International Association of Agricultural Economists (IAAE), Queensland, Australia August 2006 (*AgEcon Search* website, University of Minnesota, http://agecon.lib.umn.edu).

Bulte, E. H., Lipper, L., Stringer, R., & Zilberman, D. (2008). Payments for ecosystem services and poverty reduction: concepts, issues, and empirical perspectives. *Environment and Development Economics, 13*, 245-254. http://dx.doi.org/10.1017/S1355770X08004348

Haab, T. C., & McConnell, K. E. (2002). Valuing environmental and natural resources: the econometrics of non-market valuation. *New Horizons in Environmental Economics*, Edward Elgar Publishing House, Cheltenham, UK • Northampton, MA, USA. http://dx.doi.org/10.4337/9781843765431

Kuntashula, E., & Mafongoya, P. L. (2005). Farmer participatory evaluation of agroforestry trees in eastern Zambia. *Agricultural System, 84*, 39-53. http://dx.doi.org/10.1016/j.agsy.2004.06.009

Kuntashula, E., & Mungatana, E. (2015). Estimating the causal effect of improved fallows on environmental services provision under farmers field conditions in Chongwe – Zambia (*Environment and Development, 20*(01), 80-100. http://dx.doi.org/10.1017/S1355770X14000011

Mafongoya, P. L., & Kuntashula, E. (2005). Participatory evaluation of Tephrosia species and provenances for soil fertility improvement and other uses using farmer criteria in eastern Zambia. *Experimental Agriculture, 14*, 69-80. http://dx.doi.org/10.1017/S0014479704002339

Mafongoya, P. L., Kuntashula, E., & Sileshi, G. (2006). Managing soil fertility and nutrient cycles through fertiliser trees in Southern Africa. In U. Norman, S. A. Ball, C. M. E. Fernandes, H. Herren, O. Husson, C. Palm, J. Pretty, N. Sanginga, J. E. Thies (eds), *Biological approaches to sustainable soil systems* (pp. 425-437). Taylor & Francis Group, Boca Raton, Florida, USA. http://dx.doi.org/10.1201/9781420017113.ch19

Ministry of Agriculture Cooperatives (MACO). (2007). CAADP implementation in Zambia under the Fifth National Development Plan (FNDP): Review and stocktaking report on ongoing development efforts and their alignment with CAADP targets and principles, Lusaka, Zambia, pp 1-231.

Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., Chakeredza, S., Kaonga, M., & Matakala, P. (2007). Contribution of agroforestry to ecosystem services in the miombo eco-region of eastern and southern African. *African Journal of Environmental Science Technology, 1*(4), 068-080.

Sileshi, G., Akinnifesi, F. K., Ajayi, O. C., & Place, F. (2008). Meta-analysis of maize yield response to woody and herbaceous legumes in sub-Saharan Africa. *Plant Soil, 307*, 1-19. http://dx.doi.org/10.1007/s11104-008-9547-y

Styger, E., & Fernandes, C. M. E. (2006). Contributions of managed fallows to soil fertility recovery. In U. Norman, S. A. Ball, C. M. E. Fernandes, H. Herren, O. Husson, C. Palm, J. Pretty, N. Sanginga, J. E. Thies (eds), *Biological approaches to sustainable soil systems* (pp. 425-437). Taylor & Francis Group, Boca Raton, Florida, USA. http://dx.doi.org/10.1201/9781420017113.ch29

Wunder, S. (2009). Payments for environmental services and the poor: concepts and preliminary evidence. *Environment and Development Economics, 13*, 279-297.

Zilberman, D., Lipper, L., & Mccarthy, N. (2008). When could payments for environmental services benefit the poor? *Environment and Development Economics, 13*, 255-278. http://dx.doi.org/10.1017/S1355770X08004294