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# Farmers' perspectives on payments for watershed services in Uganda

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**Abstract**

Payments for watershed services (PWS) is a market based policy tool that is increasingly being recommended for effective and sustainable management of watersheds, especially for Sub-Saharan Africa. The design of PWS projects is challenging and insights in the local context are indispensable. Using a choice experiment, we investigate the perspective of farmers on the design of a PWS program in the Mount Elgon region in Uganda. We use mixed logit and latent class models to explain preference heterogeneity for PWS attributes. We calculate willingness to accept values and perform a cost analysis to identify the most cost-efficient PWS programs. Our results point to a strong willingness of farmers to participate in a PWS contract. The majority of farmers are willing to adopt conservation measures, even in absence of a compensation; a minority is strongly averse to buffer strips along the river and does require a significant compensation. Farmers have strong preferences for individual over communal compensation, and additional in-kind rewards increase the willingness to accept a contract. The findings imply that PWS is a promising avenue for improved watershed conservation in the Mount Elgon region; and that individual compensation, differentiation and specific targeting of such programs may benefit their cost-effectiveness.

**Key Words**: Payments for ecosystem services; Choice experiment; Soil and water conservation; Contract design; Conservation adoption; Sub-Saharan Africa

**JEL classification:** Q25, Q56, Q57

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## 1 Introduction

People derive many benefits from ecosystems. These benefits are commonly called ecosystem services, a concept popularized by the Millennium Ecosystem Assessment (MA). The MA distinguishes four services related to soil and water resources: freshwater provision, water purification, water flow regulation and erosion control. The first is considered a provisioning ecosystem service, while the latter three are regulating services. Environmental degradation associated with the overexploitation of natural resources is leading to a decline in water related ecosystem services. This results in, among others, increased floods, soil nutrient loss, low water quality and the threat of freshwater scarcity (MA 2005). The problems of watershed degradation are particularly relevant in Sub-Saharan Africa, where population growth and deforestation rates are amongst the highest globally (FAO 2016; The World Bank 2018). As a result, soil erosion and nutrient depletion are reducing soil fertility and increasing sediment loads in rivers (Drechsel et al. 2001).

Sustainable watershed management is typically problematic, because not all water related ecosystem services are valued in the market and most management benefits accrue to downstream water users and not to upstream ecosystem managers (Knowler and Bradshaw 2007). Payments for ecosystem services (PES) is a market-based policy tool that is increasingly being recommended for effectively managing watersheds. In a PES program, beneficiaries of ecosystem services compensate land users for enhancing the supply of the service. In this way new markets for ecosystem services are created and conservation becomes more attractive to resource users (Engel et al. 2008). When it comes to payments for watershed services (PWS), a program usually involves downstream water users compensating upstream land users within one catchment for afforestation and/or proper soil and water management on their farms (e.g. Asquith et al. 2008; Lopa et al. 2012; Wunder and Albán 2008).

Especially in developing countries, PES is considered a very interesting solution to conservation problems. Apart from reaching environmental objectives, PES could contribute to reducing poverty through direct contributions to poor landholders' incomes (Ferraro and Kiss 2002). However, this dual goal makes PES design in developing countries more challenging as environmental objectives should be achieved efficiently, without jeopardizing social equity considerations (Muradian et al. 2010). Furthermore, factors explaining adoption of soil conservation measures are very situation specific, which makes it difficult to develop general policy measures for soil management (Knowler and Bradshaw 2007). For these reasons it is necessary to carefully adapt a PWS project to the local socio-economic and environmental context. Stakeholder consultations are thus key in PES design (Petheram and Campbell 2010). This includes the assessment of the preferences of potential service providers, especially because PES participation should happen on a voluntary basis (Wunder 2005).

This study evaluates the preferences of upstream land users for conservation techniques and compensation methods within a PWS framework in the Mount Elgon region, Uganda. We use a discrete choice experiment (DCE) among 150 farmers to ex-ante elicit preferences for PWS contract attributes from the land user perspective. In the analysis of the choice data, we explicitly focus on preference heterogeneity among farmers and sources thereof, using mixed logit (MXL) and latent class (LC) models. Based on these models we calculate willingness-to-accept (WTA) values and perform a cost analysis that allows to identify the most cost-efficient PWS programs.

Our study contributes to the literature in a number of ways. First, the focus on the Mount Elgon region is particularly relevant. This mountainous area, situated at the Ugandan-Kenyan border is a hotspot for biodiversity and a water source of national and international importance. Increasing population pressure is forcing farmers to cultivate unsuitable land, such as steep slopes and riverbanks, often without using appropriate soil conservation measures. As a result, soil erosion is a severe concern in the area as it induces fertility loss, siltation of important rivers and even life-threatening landslides (Mugagga et al. 2012). Better soil and water management is urgently needed, and many stakeholders, e.g. governmental agencies, conservation organisations and ecosystem service users, are interested in PWS as a possible solution. Our results inform these stakeholders about an effective design of PWS schemes and are, therefore, of direct policy relevance.

Second, we use a DCE, which is a powerful tool to evaluate preferences for multiple scenarios at once and to estimate WTA compensation in conservation (or other) projects. While originally developed for research in the marketing and transport sector, this stated preference method is now commonly used for valuing environmental benefits and studying preferences for environmental projects. Several studies use DCEs to assess farmers' preferences for agri-environmental schemes, such as PES, in the European farming sector (e.g. Beharry-Borg et al. 2013; Christensen et al. 2011; Franzén et al. 2016; Horne 2006; Ruto and Garrod 2009; Santos et al. 2016). Studies on preferences for PES contracts in a developing country setting are more scarce and focus mostly on contracts for forest conservation or afforestation (e.g. Costedoat et al. 2016; Kaczan et al. 2013; Balderas Torres et al. 2013). There are only a handful of studies that analyse farmers' preferences for incentives for soil and water conservation, including a study on preferences for compensation for communal and private conservation actions in a PWS program in Kenya (Mulatu et al. 2014); three studies on incentives for soil conservation in Ethiopia (Tesfaye and Brouwer, 2012; Kassahun and Jacobsen, 2015; Tarfasa et al. 2018); and a study on preferences for conservation agriculture in Malawi (Ward et al. 2016). We complement this scarce evidence with a study on preferences for PWS schemes in Uganda. As the design of existing DCE studies on PES vary greatly and as results of such studies are very context specific, additional evidence is needed to understand the potential for effective PES programs in developing countries. In addition, in our analysis we explicitly focus on correcting for hypothetical bias and attribute non-attendance (AN-A) bias. The influence of the latter is still often overlooked in many studies (Caputo et al. 2018).

## 2 Research Background

### 2.1 Research area

The study site is the Mount Elgon region, located in Eastern Uganda. This area comprises nine districts, namely Namisindwa, Manafwa, Mbale, Bududa, Sironko, Bulambuli, Kapchorwa, Kween and Bukwo (Figure 1). All of these districts are bordering a protected area, the Mount Elgon National park, which is a transboundary park spanning the Ugandan-Kenyan border. The area comprises the slopes and summit of Mount Elgon, an extinct volcano, and has an altitude ranging from approximately 1,053 up to 4,321 metres above sea level. The region is characterised by fertile, volcanic soils and a tropical climate with an average annual temperature of 23°C and average annual precipitation of 1,500 to 2,000 mm (Norgrove and Hulme 2006).

Because of the favourable agricultural conditions, the slopes of Mount Elgon are among the most densely populated areas in Uganda. On average, the population density of the whole region is 493 people per $km^2$, while the national population density is 222 people per $km^2$. In Bududa and Mbale districts, population density is even above 900 people per $km^2$. Population levels continue to rise with growth rates ranging from 1.93 to 4.91% annually (UBOS 2016). The region is inhabited by two ethnic groups; the Bagisu in Namisindwa, Manafwa, Mbale, Bududa, Sironko and Bulambuli, and the Sabiny in Kapchorwa, Kween and Bukwo (Scott 1998). The dominant livelihood activity is smallholder agriculture, since few other employment opportunities are available. Agriculture is mostly rain fed and important crops are banana, coffee, beans, sweet potato and onions. In the Sabiny districts, maize cultivation is also common. In addition, most farmers produce coffee, especially Arabica coffee, for the market (Vanderhaegen et al. 2018).

## 2.2 Water resources of Mount Elgon

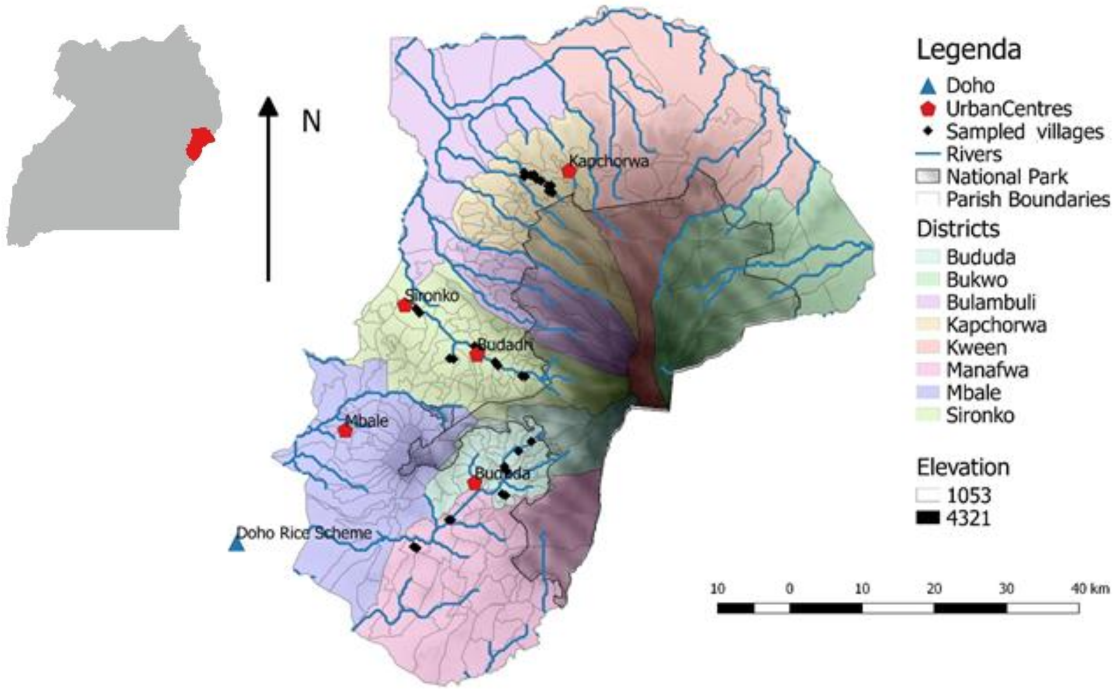


**Figure 1: Map of the study area with important rivers.**

With its many rain fed rivers, the Mount Elgon area is, along with the Victoria Nile, the main water source of the lake Kyoga catchment, one of the largest in Uganda and an important part of the river Nile's basin (NEMA 2008). At the local level, the water is used by inhabitants of the Mount Elgon region and surrounding districts for domestic and irrigation purposes (UWA 2009). Several large enterprises use the water provided by Mount Elgon. First, the government-owned National Water and Sewerage Corporation (NWSC) treats and distributes water of several rivers, including rivers Manafwa and Sironko, to customers in urbanised areas. Second, there are two large irrigation schemes, the governmental Doho rice scheme and a private scheme, where rice is grown in the wetlands of river Manafwa. These enterprises depend on the water resources of Mount Elgon and their profits are influenced by the water quality.

Because of population pressure, farmers are increasingly cultivating unsuitable land, such as very steep slopes and unstable, flood prone riparian land. This causes severe runoff, erosion and even landslides (Mugagga et al. 2012). A substantial amount of sediment is transported into the river systems of Mount Elgon, which drastically reduces the water quality. Land users can reduce erosion in various ways, e.g. by applying terracing, contour trenches, grass strips, mulching, agroforestry and by stabilizing the riverbanks with buffer strips (UNDP 2013). Most farmers have already adopted at least one soil conserving technique but overall adoption and application rates are unsatisfactory. Previous studies reveal that limited adoption might be due to limitations in available farm equipment, labour and extension services (Barungi et al. 2013; Ministry of Water and Environment 2012).

### 2.3 Payment for watershed services

A PWS scheme could motivate farmers to conserve the soil and the compensations can help them overcome labour, capital and information constraints. The concept of payments for ecosystem services is not new in the study area. Several carbon credit programs existed in the past, and since five years, an organisation called ECOTRUST is engaging farmers to plant trees in exchange for payments derived from carbon credits (ECOTRUST 2016). Currently, there are no PES projects for conservation of water resources, but in the past five years, farmers received compensations for good soil and water management in two pilot projects under the framework Ecosystem Based Adaptations. The first project compensated farmers individually and monetary for creating contour trenches and hedgerows of Napier grass (UNDP 2013). In the second project, farmers were engaged in proper soil and water management at the community level, with access to credit from a community revolving fund as a reward (IUCN 2013). Funding for these projects was only short-term and both have ended. The interest of local beneficiaries of water quality services, such as the NWSC, for investments in water source protection is growing and the development of a PWS project in the future is likely. The results of this research can, therefore, contribute importantly to the development of future conservation projects in the Mount Elgon region specifically and in other similar regions in general.

## 3 Choice experiment

This study uses a discrete choice experiment (DCE) for the ex-ante assessment of farmers' preferences for PWS contracts. This survey-based, stated preference method is used to reveal which soil conservation practices and compensation amounts and methods are the most desirable from the viewpoint of the upstream land users. In a DCE, respondents are presented a series of choice cards containing several hypothetical alternatives; in our case PWS contracts. Each contract is characterised by a number of attributes with levels varying over the alternatives. For each choice card, the respondent has to indicate his or her most preferred alternative. The output of a DCE can be used to model respondents' utility in accordance with Lancaster's economic theory of value, which states that consumers' utility or satisfaction from a certain good is derived from the properties or attributes of the good (Lancaster 1966).

### 3.1 Attributes and levels

Potential attributes were derived from scientific literature on PES projects in general, from similar studies on preferences for PWS contracts in developing countries and expert insights in the local context. In order to minimize the complexity of the choice task, the number of attributes was limited to six (Table 1). Selection was informed by interviews with local beneficiaries of water related ecosystem services, namely the NWSC and the Doho rice irrigation scheme, and by three focus group discussions with farmers cultivating ecologically fragile plots in the study area.

**Table 1: Description of the attributes and levels used in the choice experiment**

| Attribute name | Explanation | Levels |
|---|---|---|
| **Distance to the river to be protected** | Distance between the river and the cultivated area that should be planted with grass and indigenous tree species and can no longer be used for agriculture. | 0 m<br>5 m<br>10 m<br>20 m |
| **Trenches and grass bunds** | Share of the land on which the farmer has to apply contour trenches and grass bunds. | None of the fields<br>Half of the fields<br>All fields |
| **Soil conserving agriculture** | Share of the land on which the farmer has to conserve the soil using mulching, minimal tillage and contour farming. | None of the fields<br>Half of the fields<br>All fields |
| **Compensation** | Amount of money that is paid to the farmer annually if (s)he adheres to the contract. | UGX 90,000<br>UGX 180,000<br>UGX 270,000<br>UGX 360,000 |
| **Mode of compensation** | To whom the payment is made; either directly to the farmer, to a fund that can be used for community projects or divided between the two. | Personal payment<br>50/50<br>Payment to communal fund |
| **Assistance** | Whether or not the farmer receives additional assistance in the form of the necessary tools, labour force or both. | No assistance<br>Provision of required tools<br>Provision of labour<br>Provision of tools and labour |

Of the six retained contract attributes, three refer to conservation practices. The first conservation technique is the creation of buffer strips along the river, with four levels ranging from 0 m to 20 m. This measure is highly relevant, as most riverbanks are currently degraded by crop cultivation and stakeholders indicated that creating buffer strips is the most important solution to river siltation. The second attribute concerns the application of a series of contour trenches followed by a grass bund while the third attribute concerns the implementation of good soil management practices, consisting of mulching, minimal tillage and contour farming. The levels of both attributes cover none, half or all of the farmer's fields. These techniques are well known by most farmers but application is limited due to the high workload and the requirement of specialized farm equipment (Barungi et al. 2013).

The other three attributes relate to compensation modes and amounts. The monetary compensation amount is specified as an annual payment, conditional on the implementation of the measures described by the contract. The levels are determined based on expert judgement on the investment and opportunity costs of the application of several bundles of measures and range from UGX 90,000 to UGX 360,000, which is equivalent to 21 to 84€ at the time of survey implementation.

A second compensation attribute describes the mode of payment and has three qualitative levels, namely compensation to individual farmers, compensation to a community fund and an equal division between the two. Money transferred to a community fund can be accessed for community projects, e.g. improving school and road infrastructure. Through communal payments, landholders can contribute to the welfare of the entire village through actions on their own farm, which can result in additional social benefits for the farmer, such as increased respect. Furthermore, communal payments might be more desirable from a pro-poor perspective, because even the poorest and landless people that do not qualify for the PES contract can still benefit. These arguments are supported by research on the RUPES projects in South-East Asia by Leimona et al. (2009). Community funds are already used by other conservation projects in the study area, for instance ECOTRUST's "Trees for Global Benefit" program (ECOTRUST 2016) and are also favoured by the beneficiaries of water related ecosystem services.

The final compensation attribute describes additional assistance provided to farmers who adhere to the contract and can be considered as an in-kind reward. Assistance can be in the form of provision of farm equipment, provision of farm labour or both. The former is supported by the research of Barungi et al. (2013), who find that adoption of soil conservation can be raised by increasing the variety of farm equipment owned by the farmer. The latter is supported by the high workload that is associated to the techniques. The base level is specified as no assistance at all.

### 3.2 Design and implementation

Based on the attributes and levels, twelve choice cards were designed, each consisting of two unlabelled contracts and an opt-out option, in which the farmer does not enter any PWS contract and remains in the same situation (i.e. status quo) (Figure 2). Ngene software was used to create a $D_b$-efficient design ($D_b$-error = 0.1729) based on small priors (-0.001, 0.001) of the parameters, of which the sign was derived from the focus group discussions. The choice cards were shown to the respondents in a random order, after a careful explanation of the goal of the experiment and a thorough description of the attributes. The choice experiment was first tested among ten farmers and fine-tuned before implementation.

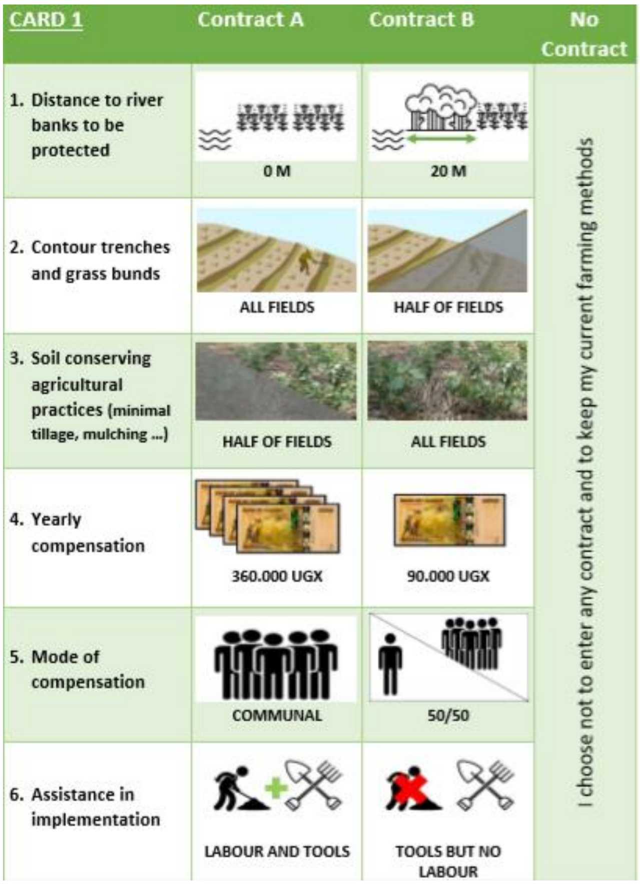

**Figure 2: Example of a choice card**

Respondents were selected from three catchments in the study area, Manafwa, Sironko and Cheseber, which can be considered as important water sources with a high level of degradation. In each of the catchments 50 respondents were selected based on a three-stage stratified sampling strategy. First, five parishes bordering the main river or a large side branch were selected through systematic sampling from a list of parishes that was sorted from highest to lowest elevation, in order to capture the whole course of the river. Second, within each parish, two villages were selected at random, and third, within each village five respondents were randomly chosen from a list of all households cultivating at least one plot bordering the river. This resulted in a sample of 150 farmers in 30 villages, which are depicted in Figure 1. Along with the choice experiment, household survey data were collected using a quantitative, structured questionnaire, which included modules on household demographics, land and non-land assets, agricultural production and experience with soil conservation. All data was collected in September - October 2017.

## 3.3 Econometric analysis

Analysis of the results from DCEs is based on random utility theory. This means that the utility associated with a PWS contract for a respondent can be decomposed into a deterministic component, depending on the contract attributes, and an unobservable stochastic component, or:

$$U_{in} = \sum_{k=1}^{6} \beta_{ik} x_{ik} + \varepsilon_{in}$$

Where $U_{in}$ is the utility associated with contract *i* for respondent *n*. The deterministic component is determined by the sum of the levels of the six attributes $x_k$ multiplied by a coefficient $\beta$ and $\varepsilon_{in}$ is the stochastic component of utility. These utility functions can be estimated based on the likelihood of individual *n* selecting alternative *i*, assuming that each respondent selects the alternative that delivers the highest utility. Different econometric models exist to estimate the coefficients. Which model is used depends on the distributional assumptions of the choice probabilities (Train 2009).

Not every respondent reasons the same and random variations in taste might influence their decision making process. Therefore, a mixed logit (MXL) model is used, which is able to account for preference heterogeneity by allowing the coefficients $\beta$ to vary according to a distribution around their mean value (Train 2009). Apart from the compensation attribute, all attributes are assumed to have a random coefficient with a normal distribution. One additional parameter is added to the model, an alternative specific constant (ASC). The ASC is specified to be 0 when one of the contracts is chosen and 1 when the respondent opted out. In this way the ASC reflects the utility associated to the status quo and a negative estimate indicates that respondents are willing to enter PWS contracts. For ease of interpretation, the categorical variables are dummy coded.

In order to explain sources of preference heterogeneity, a latent class model (LC) is used. LC models assume that the population consists of different segments, each with a distinct preference pattern. Within the groups, preferences are assumed to be homogenous. Individuals are assigned to classes with a certain probability, based on a membership likelihood function, which consists of variables related to latent general attitudes and perceptions (Boxall and Adamowicz 2002). The number of classes was established by comparing the Akaike's and Bayesian information criterion of models with two and three classes. Models with more than three classes were not considered, because class sizes would be too small. Differences in socio-demographic and farm characteristics, and experience with soil conservation between the classes can be interpreted as potential sources of preference heterogeneity.

Finally, the results are converted into more tangible monetary quantities by calculating the willingness to accept (WTA) the PWS contract attributes. They are derived as the marginal rate of substitution between the compensation attribute and another attribute, holding all else constant, and they can be calculated as the ratio between the two parameters (Louviere et al. 2000). We derive WTA values in WTA space, placing distributional assumptions directly on the WTA and price coefficients (Train and Weeks 2005). We also calculate WTA for the different latent classes based on the estimates of the LC model. The WTA of a PWS contract is calculated by summing the WTAs of the included attributes. This is done for nine hypothetical contracts with the aim of comparing three different compensation scenarios (monetary and individual compensation, monetary and individual compensation with supply of labour for 20 days, and monetary compensation to a communal fund) and three different conservation scenarios (trenches and soil conservation on all fields with buffers of 5, 10 and 20 m). Furthermore, the calculated contract WTAs are extrapolated to the catchment of river Manafwa to gain insight in the total budget requirements for a large-scale conservation program.

### 3.4 Limiting potential bias

One of the most important limitations of the choice experiment method is hypothetical bias. Hypothetical bias arises when the respondents' choices in the experiment deviate from the choices they would make in real life. This could be a concern in this choice experiment, because farmers in the sample have no experience with incentives for soil conservation and some respondents are inexperienced with the application of the techniques included in the contracts. However, a cheap-talk script was used to explain the importance of making realistic decisions and to ask respondents to consider all the costs and benefits associated with the presented contracts.

Another type of bias, so called attribute non-attendance (AN-A), arises when respondents do not consider all attributes when making a decision. Stated non-attendance data was collected for each respondent after the choice experiment. Stated AN-A was accounted for in the MXL model by constraining the coefficients for the self-reported ignored attributes to zero during the estimation. A second MXL model, in which parameters are estimated separately for respondents that considered and respondents that ignored the attributes, is used to validate the respondents' AN-A statements, following Scarpa et al. (2013).

# 4 Results

## 4.1 Preferences for PWS contracts

Table 2 presents the results of three different models: the basic MXL model, the MXL corrected for AN-A and the LC model. AN-A for one attribute was reported by 10% of the respondents for four out of six attributes, namely inclusion of trenches and grass bunds, payment, payment mode and assistance. The MXL model corrected for AN-A takes this into account. The results are mostly similar to those of the basic MXL model, except for the significant (but with a similar magnitude) coefficient for distance to the river. This indicates that AN-A, as it was stated by the respondents, does not influence the outcomes of the model considerably. As the reliability of stated AN-A can be questioned, we include an AN-A validation model in Annex (Table A1). The results of this validation model indicate that, even for respondents who stated to have ignored the payment attribute, utility is still significantly influenced by it. We can conclude that results are robust to AN-A, and we base the discussion and further analysis on models that do not account for AN-A.

In the basic MXL model, all coefficients are significant, except for the distance to the river. Eight out of ten standard deviations are significant, indicating preference heterogeneity. The ASC is negative, which implies that farmers prefer to enter a PWS contract. Payment has a positive effect on farmers' utility as expected. The inclusion of both trenches and soil conserving agriculture into PWS contracts has a positive effect on farmers' utility. The respondents dislike communal payments, even if half of the payment is still made to the individual farmer. Finally, inclusion of additional assistance increases the likelihood of participation in the hypothetical PWS contract.

**Table 2: Estimates of the mixed logit model (with and without AN-A correction) and the latent class model**

| | **Mixed Logit model** | | | | **Latent Class Model** | |
|---|---|---|---|---|---|---|
| | Basic model | | Corrected for stated AN-A | | | |
| **Log likelihood** | -1444 | | -1441 | | -1444 | |
| **Pseudo-r²** | 0.27 | | 0.27 | | 0.27 | |
| | *coefficient (se)* | *Standard deviation (se)* | *coefficient (se)* | *Standard deviation (se)* | *Class 1 Probability = 70.2%* | *Class 2 Probability = 29.8%* |
| ASC | -0.727*** | Fixed | -0.764*** | Fixed | -0.871*** | -1.357*** |
| | (0.176) | | (0.173) | | (0.227) | (0.347) |
| Payment | 0.002*** | Fixed | 0.002*** | Fixed | 0.002*** | 0.002 |
| | (0.000) | | (0.000) | | (0.000) | (0.000) * |
| Distance to river | -0.015 | 0.111*** | -0.017** | 0.112*** | 0.033*** | -0.147*** |
| | (0.010) | (0.009) | (0.009) | ( 0.009) | (0.004) | (0.013) |
| Trenches, half | 0.550*** | 0.461** | 0.549*** | 0.319* | 0.526*** | -0.074 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | (0.115) | (0.197) | (0.110) | (0.187) | (0.108) | (0.267) |
| Trenches, all | 0.466*** | 0.551*** | 0.467*** | 0.426*** | 0.492*** | -0.029 |
| | (0.103) | (0.144) | (0.099) | (0.137) | (0.092) | (0.236) |
| Soil conservation, half | 0.411*** | 0.062 | 0.420*** | 0.277** | 0.350*** | 0.266 |
| | (0.099) | (0.187) | (0.101) | (0.122) | (0.096) | (0.241) |
| Soil conservation, all | 0.525*** | 0.392** | 0.513*** | 0.390*** | 0.447*** | 0.077 |
| | (0.104) | (0.172) | (0.103) | (0.144) | (0.447) | (0.218) |
| Divided payment | -0.667*** | 0.479** | -0.683*** | 0.500*** | -0.385*** | -0.965*** |
| | (0.105) | (0.146) | (0.108) | (0.127) | (0.092) | (0.207) |
| Communal payment | -1.041*** | 0.569*** | -1.024*** | 0.602*** | -0.718*** | -1.074*** |
| | (0.120) | (0.146) | (0.118) | (0.137) | (0.101) | (0.238) |
| Labour | 0.546*** | 0.271 | 0.556*** | 0.372** | 0.462*** | 0.459* |
| | (0.121) | (0.259) | (0.122) | (0.155) | (0.117) | (0.269) |
| Tools | 0.372*** | 0.489** | 0.392*** | 0.680*** | 0.443*** | 0.050 |
| | (0.120) | (0.189) | (0.127) | (0.150) | (0.113) | (0.259) |
| Tools and labour | 0.806*** | 0.499** | 0.795*** | 0.471*** | 0.689*** | 0.485* |
| | (0.129) | (0.194) | (0.127) | (0.181) | (0.120) | (0.271) |

*Source: authors' estimation from choice experiment data*

** p < 0.1; ** p < 0.05; *** p < 0.01*

A latent class model with two classes is reported[2]. The first class is the largest class, with each respondent having a 70% chance of belonging to it. The preference pattern is similar to the mixed logit model, apart from the significant, positive preference for all conservation techniques, including the buffer strips along the river. Because of the preferences in favour of conservation, we will refer to this group as the "adopter-farmers". On the other hand, 30% of the respondents is more likely to belong to class two, which has a deviating preference pattern. This group is strongly averse to creating a conservation buffer along the river, and their utility is not influenced by the other two conservation attributes. These farmers will therefore be called "reluctant farmers". Like the adopter-farmers, they dislike communal payments and they are attracted to additional assistance, but only in form of labour or a combination of labour and tools.

### 4.2 Description of the latent classes

In order to explain preference heterogeneity, we compare socio-demographic and farming characteristics of the two classes in Table 3. Adopter-farmers are significantly less likely to be poor and food insecure than reluctant farmers. They have more children and are more likely to belong to the Bagishu tribe. This also entails a geographical difference: adopters are more likely to live in the southern districts, while reluctant farmers are more likely to live in Kapchorwa district. Adopter-farmers live in more remote areas, further away from main roads and urban

[2] The model with three classes sometimes failed to converge depending on the starting point of the algorithm. Due to instability of this model, a two-segment model is preferred.

centres. Landholdings are typically very small with an average of 1.3 ha in the research area, but adopter-farmers have larger farms with a higher share of fertile land.

**Table 3: Farmer and farm characteristics across latent classes, compared using one sided t-tests**

| | Sample mean (se) | Adopter-farmers mean (se) | Reluctant farmers mean (se) | t-value |
|---|---|---|---|---|
| Gender of HH (% male) | 84.00 (3.00) | 85.85 (3.40) | 79.55 (6.15) | 0.96 |
| Age of HH | 47.83 (1.17) | 47.46 (1.39) | 48.70 (2.22) | -0.48 |
| Household members | 7.59 (0.32) | 7.84 (0.41) | 7.00 (0.41) | 1.21 |
| Number of children | 3.80 (0.18) | 4.07 (0.22) | 3.16 (0.30) | 2.31** |
| Primary school certificate (%) | 57.33 (4.05) | 58.49 (4.81) | 54.55 (7.59) | 0.44 |
| Bagishu tribe (%) | 66.00 (3.88) | 69.81 (4.48) | 56.82 (7.55) | 1.53* |
| Sabyni tribe (%) | 33.33 (3.86) | 29.25 (4.44) | 43.18 (7.55) | -1.65* |
| Poor household[a] (%) | 88.00 (2.66) | 84.91 (3.49) | 95.45 (3.18) | -1.82** |
| Food insecure household[b] (%) | 74.00 (3.59) | 69.81 (4.48) | 84.09 (5.58) | -1.82** |
| Has off-farm income (%) | 61.33 (3.99) | 60.38 (4.77) | 63.64 (7.34) | -0.37 |
| Elevation | 1,475 (22.04) | 1,468 (25.71) | 1,492 (42.93) | -0.48 |
| Distance to town (km) | 5.87 (0.35) | 6.42 (0.44) | 4.54 (0.49) | 2.50*** |
| Distance to main road (km) | 1.75 (0.15) | 1.96 (0.21) | 1.22 (0.12) | 2.23** |
| Total farm size (ha) | 1.31 (0.96) | 1.46 (0.13) | 0.95 (0.11) | 2.48*** |
| Share owned | 0.89 (0.02) | 0.88 (0.02) | 0.92 (0.03) | -0.89 |
| Share of land next to river | 0.49 (0.03) | 0.49 (0.03) | 0.48 (0.05) | 0.19 |
| Share of land with erosion[c] | 0.38 (0.03) | 0.40 (0.04) | 0.32 (0.07) | 1.11 |
| Share of land with high soil fertility[c] | 0.25 (0.03) | 0.29 (0.03) | 0.14 (0.04) | 2.30*** |
| TLU[d] | 2.34 (0.18) | 2.32 (0.20) | 2.37 (0.20) | -0.12 |

*Source: Authors' estimation from household survey data*

*One sided t-test with * p < 0.1; ** p < 0.05; *** p< 0.01*

[a]*Following the 3.00 threshold of the multi-dimensional poverty index* (Alkire and Santos 2010)

[b]*Moderately to severely food insecure following the Household Food Insecurity Access Scale* (Coates et al. 2007)

[c]*Self-reported*

[d]*Tropical Livestock Unit: Bull = 1; Cow = 0.8; Pig = 0.4; Sheep/Goat = 0.3; Chicken = 0.1*

Experience with soil conservation is compared across classes in Table 4 and Figure 3. Overall, riverbank protection is mentioned as the most popular technique, implemented by 61% of the farmers. Note that no information was gathered on the width of the protection buffer, so these might be very narrow. Contouring is applied least frequently, by 41% of the respondents. Interestingly, reluctant farmers know and apply more techniques on their farm than adopter-farmers. Adoption rates of most techniques are, however, similar, apart from contouring which is applied more among reluctant farmers and trenches which is applied more among adopter-farmers. For all techniques besides minimal tillage, nearly all farmers report reduced soil erosion. Increased fertility is reported less often. Adopter-farmers mention benefits of minimal tillage and riverbank protection more often than reluctant farmers, but they also mention more often costs in terms of labour and land requirements of minimal tillage, mulching, agroforestry and riverbank protection.

**Table 4: Soil erosion experience across classes, compared using one-sided t-tests**

| | Sample mean (SE) | Adopter-farmers mean (SE) | Reluctant farmers mean (SE) | t-value |
|---|---|---|---|---|
| Received extension (%) | 31.33 (3.80) | 32.08 (3.83) | 29.55 (3.77) | 0.30 |
| Number of techniques known | 6.29 (0.18) | 6.04 (0.17) | 6.85 (0.19) | -2.07** |
| Number of techniques applied | 3.92 (0.17) | 3.74 (0.17) | 4.33 (0.18) | -1.59* |
| Applies minimal tillage (%) | 46.67 (4.09) | 43.40 (4.07) | 54.55 (4.11) | -1.24 |
| Applies mulching (%) | 59.33 (4.02) | 59.43 (4.03) | 59.09 (4.06) | 0.04 |
| Applies contouring (%) | 41.33 (4.03) | 34.91 (3.91) | 56.82 (4.09) | -2.52*** |
| Applies trenches (%) | 56.67 (4.06) | 60.38 (4.01) | 47.73 (4.13) | 1.42* |
| Applies grass bunds (%) | 60.00 (4.01) | 58.49 (4.04) | 63.64 (3.97) | -0.58 |
| Applies agro forestry (%) | 57.33 (4.05) | 55.66 (4.08) | 61.36 (4.02) | -0.64 |
| Protects the riverbank (%) | 61.33 (3.99) | 61.32 (4.00) | 61.36 (4.02) | 0.00 |

*Source: Authors' estimation from household survey data*
*One sided t-test with * p < 0.1; ** p < 0.05; *** p< 0.01*

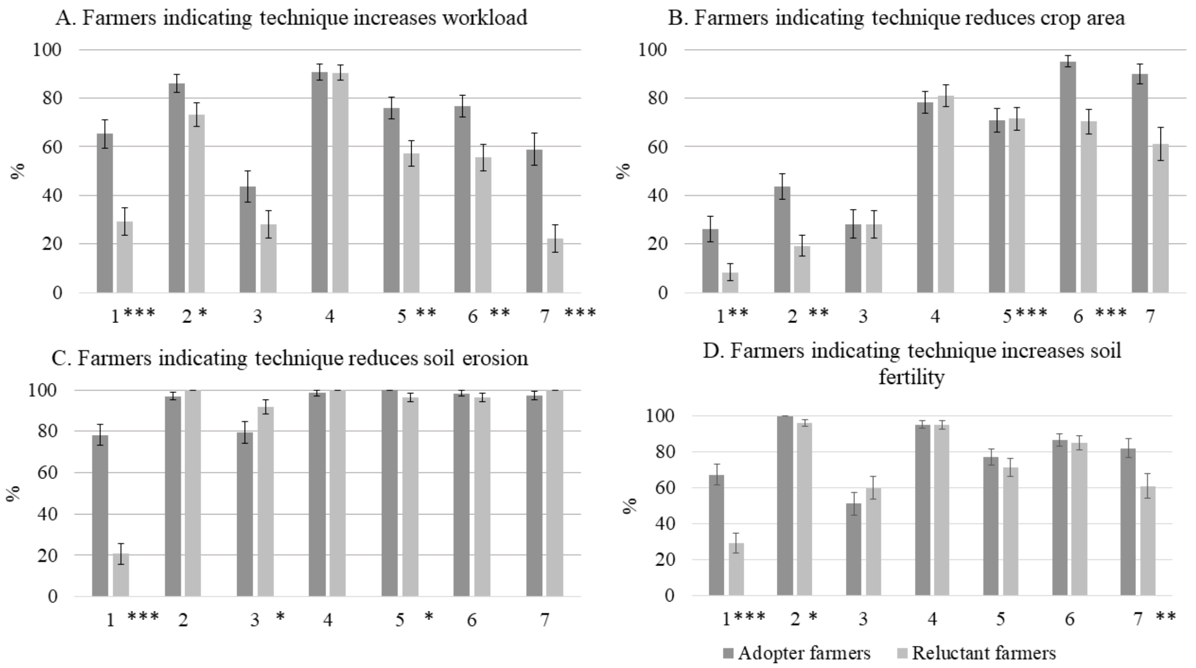


**Figure 3: Experience of costs and benefits of soil conservation measures among adopting farmers in the latent classes. 1 = Minimal tillage; 2 = Mulching; 3 = Contouring; 4 = Trenches; 5 = Grass strips; 6 = Agroforestry; 7 = Riverbank protection. One-sided t-test: * p < 0.1; ** p < 0.05; *** p < 0.01. Source: Authors' estimation from household survey data.**

## 4.3 Monetary contract valuation

Table 5 presents the WTA in 1,000 UGX per attribute for farmers in the two classes, calculated directly from the coefficients, and for all respondents aggregated, calculated with the WTA space model. The WTA is set to zero for insignificant coefficients in the LC model. Adopter-farmers have a negative WTA for all three conservation attributes, indicating that they do not require compensation for implementing the techniques. We do find that farmers in the research area in general and reluctant farmers specifically need compensations of UGX 9,300 and 73,500 per m per year, respectively, to conserve the riverbank. The WTA values for both communal payment dummies are substantial, indicating that the amount of compensation must be higher when it is (partly) given in a communal form. If assistance is provided, the amount of monetary compensation can be lowered. Finally, the WTA for the ASC is quite large and positive. Farmers would like to be compensated if the status quo remains or, reversely, the monetary compensation can be lowered if farmers enter a contract to move away from the status quo.

**Table 5: Estimates of the WTA contract attributes based on a WTA space model and the LC model in UGX 1,000**

| | WTA space model | Adopter-farmers WTA | Reluctant farmers WTA |
|---|---|---|---|
| ASC | 682,8 (129.1) *** | 435.5 | 678.5 |
| Distance to river | 9.3 (2.41) *** | - 16.50 | 73.50 |
| Trenches, half | - 225.4 (43.41) *** | - 263.0 | 0.00 |
| Trenches, all | - 163.7 (33.46) *** | - 246.0 | 0.00 |
| Soil conservation, half | - 74.40 (40.35) * | - 175.0 | 0.00 |
| Soil conservation, all | - 122.4 (36.95) *** | - 223.5 | 0.00 |
| Divided payment | 296.3 (34.92) *** | 192.5 | 482.5 |
| Communal payment | 444.3 (49.13) *** | 359.0 | 537.0 |
| Labour | - 246.7 (35.57) *** | - 231.0 | -229.5 |
| Tools | - 212.9 (38.24) *** | - 221.5 | 0.00 |
| Tools and labour | - 341.4 (44.94) *** | - 344.5 | -242.5 |

*Source: authors' estimation from choice experiment data*

As explained in section 3.4, hypothetical bias might lower the reliability of the WTA values. In our study, however, the WTA for provision of tools closely resembles the actual market price for tools. A bundle of tools consisting of a panga, a hoe, a spade, a wheel barrow and a pick axe can be bought at the market for UGX 196,000, which is comparable to the WTA of UGX 212,900 for provision of tools. The WTA estimates are thus highly realistic, which indicates that respondents understood the choice experiment well and made reliable choices.

The WTA values per attribute are aggregated to determine the WTA for several possible PWS contracts in Table 6. We calculate this for reluctant farmers only, because adopter-farmers, and even farmers in general when considering the WTA space model, have negative WTA for any contract combination and, thereby, do not require compensation. Reluctant farmers, on the other hand, do require a compensation for most of the contract combinations. The total WTA for a contract is negative when payments are individual and the buffer strips are 5 m, or when the buffer strips are 10 m and labour assistance is provided. Only in these cases, farmers are willing to enter the agreement without monetary compensation. Note that the WTA of entering a contract (ASC) is included in these calculations, so this does not necessarily mean that farmers are willing to adopt soil conservation in absence of a project. For all other contracts, farmers do need a monetary compensation. The required compensation obviously increases with increasing buffer strip width and is substantially larger when payments are communal.

**Table 6: WTA of nine hypothetical contracts for members of class two, calculated as the sum of the WTA per attribute, and estimates of compensation costs of a project that targets reluctant farmers (targeting) and that provides equal compensations to all (equality), for the river Manafwa catchment in UGX 1,000 per year**

| **Hypothetical contract** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** |
|---|---|---|---|---|---|---|---|---|---|
| Distance to river | 5 m | 5 m | 5 m | 10 m | 10 m | 10 m | 20 m | 20 m | 20 m |
| Trenches | All | All | All | All | All | All | All | All | All |
| Soil conservation | All | All | All | All | All | All | All | All | All |
| Payment mode[a] | I | I | C | I | I | C | I | I | C |
| 20 days labour assistance | No | Yes | No | No | Yes | No | No | Yes | No |
| **Total WTA (LC 2)** | -311 | -540.5 | 226 | 56.5 | -173 | 593.5 | 791.5 | 562 | 1,328.5 |
| **Estimated project cost (Targeting)[b]** | - | 106,469 | 150,388 | 37,597 | 106,469 | 394,935 | 526,691 | 480,443 | 884,029 |
| **Estimated project cost (Equality)** | - | 357,280 | 504,658 | 126,165 | 357,280 | 1,325,286 | 1,767,419 | 1,612,226 | 2,966,541 |

*Source: authors' calculation from choice experiment data*

[a]*I = Individual, C = Communal*

[b]*The Manafwa catchment has an approximate 2,233 farmers cultivating riparian land, of which 30% require compensation*

To calculate the cost of a project that aims at protecting the whole river Manafwa catchment, the WTA per contract is extrapolated. Based on our survey data and GIS information on the catchment, approximately 2,233 farmers should be involved, of which 30% requires compensation. For contracts including labour assistance, a period of 20 days is considered as reasonable, as this is about half of the time required to establish or maintain trenches on an average farm. Hired farm labour costs approximately UGX 8,000 per day in the Mount Elgon region. The project designer can now use two payment allocation methods: targeting only the farmers requiring compensation, while assuming the others will carry out the measures without compensation, or provide equal payments to all farmers. The former is most cost-efficient, while the latter can be considered as fairer, because an adopter-farmer might not accept to receive a lower compensation than his reluctant neighbour. Note that for hypothetical contracts 2, 5, and 8 the cost of providing the labour is included in the total cost calculation and farmers are not expected to actually pay their negative WTA to the project implementer, which explains why there is still a cost even if the contract WTA is below zero. These results indicate that providing labour assistance is only cost efficient with buffer strips of at least 12 m wide and that communal payments drastically increase the total project costs. Depending on the level of soil and water conservation, the selected compensation methods and targeting strategy, projects can be established with an estimated annual cost ranging up to UGX 2,966,541,000, depending on budget availabilities. These costs are, of course, rough estimates and no transaction costs are included in the calculations.

# 5 Discussion

The DCE results show a general aversion to the status quo, indicating that farmers are willing to participate in a PES contract. This is a common finding in studies on preferences for PES in developing countries (Kassahun and Jacobsen 2015; Mulatu et al. 2014; Tarfasa et al. 2018; Tesfaye and Brouwer 2012; Balderas Torres et al. 2013; Vorlaufer et al. 2017). The strong negative ASC can point to utility that farmers derive from being part of a project, stemming from a belief that development projects are always beneficial or from pride farmers take in being member of a project and/or protecting nature. In addition, the ASC could represent utility associated to factors that are not included in the choice experiment. Farmers might, for instance, assume that they will receive training on the implementation of the techniques in the contract. The contracts in the choice experiment did not include a penalty for non-compliance, which may end in respondents feeling they have nothing to lose when joining the project.

Yet, the high willingness to participate in a PES contract is most likely explained by farmers' awareness of the problems of soil loss, reduced fertility and landslide disasters associated to their current farming practices and their willingness to move away from these practices. This is further corroborated by the estimated strong positive preferences for specific soil conservation measures among the large majority of farmers. There is a strong indication from the DCE results as well as from the questionnaire (Figure 3) that farmers perceive these techniques as beneficial. Similar preferences are found in other African case studies (Kassahun and Jacobsen 2015; Ward et al. 2016). These results imply that in our research area, about 70% of the farmers are willing to adopt conservation practices even without compensation. This is a promising finding for the future of the adoption of soil conservation in the study area.

The aversion to communal payments is understandable considering the prevalence of bureaucracy and corruption in Uganda (GAN 2017), which can create distrust in the local authorities. Farmers might fear that a communal PES compensation will not reach or benefit them. Besides, the preference for individual compensation might stem from farmers considering the possibility of free-riders when compensation is granted to the entire community instead of only to the individuals taking action. This result is consistent with several other studies in developing countries that investigated preferences for communal payments (Costedoat et al. 2016; Kaczan et al. 2013; Zabel and Engel 2010) but contradicts a study by Leimona et al. (2009) who claim collective rewards to be a better payment strategy than individual rewards in the light of poverty reduction and rural development. Collective payments are favoured by several stakeholders in the study area, including beneficiaries of water related ecosystem services, because they believe more farmers can be reached at the community level. Based on our results, however, we advise against communal rewards in PES contracts, as this is highly unwanted by farmers and drastically increases the required compensation, and thereby the cost of the program.

Respondents report a high preference for additional in-kind compensation in the form of farm equipment and labour assistance. This result is in line with findings from choice experiments in Zambia and Tanzania that also report strong preferences for agricultural inputs as compensation (Kaczan et al. 2013; Vorlaufer et al. 2017), and with the claim that PES programs in developing countries should favour in-kind rewards because of a more long-term effect on participants' livelihood (Asquith et al. 2008). Furthermore, by hiring labour as a compensation, one of the main limitations of PES in terms of equity, namely that landless people do not benefit, can be overcome. The preference for tools and labour can be an indication that these are important factors that currently limit farmers in implementing soil conservation practices – and high workload is indeed often mentioned as a cost of conservation practices such as mulching, trenches and grass strips (Figure 3). Hiring in labour might be expensive for farmers, and the direct return to labour from conservation practices might be low. Even though in-kind compensations are desired by farmers, they also come at a certain cost for PES programs. The results of the cost analysis indicate that providing labour assistance is not always cost efficient or competitive to pure monetary compensation (Table 6).

Especially for the conservation attributes, farmers' preferences are not homogenous. We distinguish between adopter-farmers (70% of the sample), willing to adopt SC under a contract even in absence of compensation, and reluctant farmers (30% of the sample), who dislike riverbank conservation. A similar preference heterogeneity was found for the adoption of conservation agriculture in Zambia by Ward et al. (2016). Based on characteristics listed in Table 3, several explanations for the observed preference heterogeneity can be hypothesized. First, reluctant farmers are more land constrained, which explains why they are unwilling to forsake land for conservation purposes. Second, they are more likely to be poor and food insecure – and thus more likely to have high time preferences – and, therefore, their priorities might not be on implementing conservation techniques with a return in the long run. Third, consistent with Barungi et al. (2013) reluctant farmers live closer to towns and main roads, in areas where population pressure tends to be more serious and where off-farm employment opportunities might increase the opportunity cost of farm work. Closeness to markets also lowers the opportunity cost of buying agricultural inputs, which explains why reluctant farmers cannot be persuaded with tools as compensation. Finally, reluctant farmers perceive their soils to be less fertile, which might reduce their willingness to invest in their land, as indicated by Barungi et al. (2013) and Turinawe et al. (2015).

Overall, the observed strong willingness to accept a PES contract with compensation, indicates a potential for PWS to increase the adoption of soil and water conservation techniques in the study area. However, the co-existence of adopter and reluctant farmers has important consequences for PWS design, especially for selecting payment levels and allocation methods. In this regard, a 'one-size-fits-all' payment approach, which is the standard approach in most PES programs today, seems unsuitable. Providing payments to adopter-farmers, who do not require them, is unnecessary and increases project costs drastically (see Table 6). An allocation strategy that takes into account the needs of individual communities and households can be more cost-effective. This would entail compensation only to farmers who actually require them, thereby assuring additionality and increasing cost-efficiency. A spatial targeting of communities can be useful in the study area, as the analysis shows that compensation demanding farmers are more likely to live in urbanised areas and in Kapchorwa district. We find that compensation-requiring farmers are more likely to be poor and land constrained, which implies that a PES scheme specifically targeting these farmers for compensation would be in line with equity considerations. The drawback of targeting specific groups for compensation is that it can lead to jealousy and perverse incentives for people who belong to groups who stated not to require compensation, as indicated by Leimona et al. (2015).

## 6 Conclusion

This study uses a choice experiment to reveal preferences of land users for soil and water conservation practices and compensation methods within a PWS framework in the Mount Elgon region. We find that farmers are averse to the current soil management situation and are highly willing to move away from this by adopting soil and water conservation techniques. The large majority of farmers (70% of the sampled farmers) are willing to adopt riverbank demarcation, trenches and soil conserving agriculture in absence of a compensation. A minority of farmers

(30% of the sampled farmers) who are poorer, have less land and live in more urbanised areas, are strongly averse to creating buffer strips along the river and require a significant compensation. In terms of compensation methods, we find that farmers are less likely to accept a communal compensation or expect a larger compensation when it is communal. In addition, we find that in-kind rewards significantly increase the willingness to accept a PES contract, which indicates that farmers lack resources, tools and labour, for implementing conservation measures.

The results hold interesting information for the design of future PWS projects in the Mount Elgon region, and for projects encouraging watershed management in general. Above all, the findings imply that PWS is a promising avenue for improved watershed conservation in the study area. Most farmers are clearly aware of the benefits of soil conservation and are willing to enter a conservation project. Our results specifically imply that in the interest of a cost-effective design, governmental and non-governmental organizations active in designing and implementing PES programs, should consider individual payment systems rather than hinging on an unsubstantiated belief that a communal payment creates broader or more inclusive benefits. In addition, our results imply that there is scope for differentiating and targeting PES programs in such a way that programs become more cost and environmentally effective as well as poverty and inequality reducing.

Finally, it is important to stress some limitations of our study. With a sample size of 150 farmers in a delineated study area, and with preferences for conservation and compensation methods generally being context specific, our results cannot be generalised. Yet, our study adds evidence to the literature on PES and contributes to understanding the potential of PES from a farmer perspective as well as to informing programs about the design and cost-effectiveness of PES schemes. In addition, even though we explicitly accounted for it, our results might still be subject to hypothetical bias. This is a general drawback of ex-ante preference studies. Yet, we do find that DCEs are a valuable tool to elicit farmers' preferences for PWS contracts in a developing country. The realistic estimates of land users' willingness to accept different contract attributes that we obtain in our study, allow to estimate project costs under different scenarios ex-ante. As such, DCEs can contribute importantly to the design of PWS programs that seek to conciliate cost-effectiveness, environmental effectiveness and land users' preferences.

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## Annex

**Table A1: Attribute non-attendance validation model**

| | Coefficient (se) | Standard deviation (se) |
|---|---|---|
| **Considered** | | |
| ASC | - 0.725 (0.176) *** | N.A. |
| Payment | 0.002 (0.000) *** | N.A. |
| Distance to river | - 0.008 (0.009) | 0.107 (0.009) *** |
| Trenches, half | 0.558 (0.113) *** | 0.428 (0.156) *** |
| Trenches, all | 0.492 (0.101) *** | 0.528 (0.130) *** |
| Soil conservation, half | 0.405 (0.099) *** | 0.142 (0.160) |
| Soil conservation, all | 0.528 (0.101) *** | 0.315 (0.164) * |
| Divided payment | - 0.715 (0.110) *** | 0.590 (0.129) *** |
| Communal payment | - 1.025 (0.115) *** | 0.508 (0.156) *** |
| Labour | 0.569 (0.121) *** | 0.306 (0.188) |
| Tools | 0.364 (0.120) *** | 0.469 (0.161) *** |
| Tools and labour | 0.808 (0.126) *** | 0.422 (0.177) ** |
| **Ignored** | | |
| Payment | 0.002 (0.001) * | N.A. |
| Distance to river | No stated AN-A | N.A. |
| Trenches, half | 0.410 (1.100) | 0.022 (0.906) |
| Trenches, all | 0.682 (0.972) | 0.029 (0.809) |
| Soil conservation, half | No stated AN-A | No stated AN-A |
| Soil conservation, all | No stated AN-A | No stated AN-A |
| Divided payment | - 0.582 (0.525) | 0.120 (0.672) |
| Communal payment | - 0.847 (0.620) | 0.622 (0.836) |
| Labour | - 0.380 (0.675) | 0.086 (0.797) |
| Tools | - 0.111 (0.703) | 0.001 (0.731) |
| Tools and labour | 0.841 (0.791) | 0.174 (0.968) |