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Analysis

Designing a payments for ecosystem services (PES) program to reduce deforestation in Tanzania: An assessment of payment approaches

David Kaczan *, Brent M. Swallow, W.L. (Vic) Adamowicz

Department of Resource Economics and Environmental Sociology, 515 General Services Building, The University of Alberta, Edmonton, AB T6G-2H1, Canada

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ABSTRACT

Payments for ecosystem services (PES) programs aim to improve environmental outcomes by providing direct incentives to land managers for the provision of ecosystem services. Participation in PES programs is voluntary, so effective program design requires careful consideration of farmers' preferences. This study quantifies such preferences using a choice experiment. The study site is the East Usambara Mountains, Tanzania, an internationally recognized 'biodiversity hotspot.' We assess preferences for four payment approaches: constant and variable annual cash payments to individual farmers, a constant annual cash payment to a village fund on behalf of farmers, and an upfront manure fertilizer payment. We find that the manure fertilizer payment was statistically significant in motivating farmer participation while the group payment was non-significant. In addition, the relationship between the likelihood of participation and the stringency of conditionality is surprisingly non-linear. In a test of external validity, average willingness to accept (WTA) values are found to be similar to the average opportunity cost of maintaining land uses consistent with conservation objectives.

1. Introduction

The fact that ecosystem services (ES) have economic value is well recognized. However, there is abundant evidence that many ecosystems have suffered from over-exploitation and mismanagement, to the point where their long-term viability, and thus their ability to provide services, is at risk (The Millennium Ecosystem Assessment, 2005). This is commonly explained by a lack of institutions, including markets, which could otherwise guide the supply and demand for ES (Arrow et al., 2000). Externalities, a lack of well-defined property rights and limited information hamper efforts to optimize ES provision between those who benefit from an ES and those who affect its provision (Engel et al., 2008; Ferraro and Kiss, 2002).

Payments for ecosystem services (PES) programs are one potential solution to this problem. PES programs use conditional payments to encourage individuals and communities to undertake environmentally beneficial land management actions. They help internalize the benefits associated with enhancing or maintaining ES to ensure that land managers face incentives concordant with the interests of ES users (Arrow et al., 2000; van Noordwijk and Leimona, 2010). To improve the likelihood of achieving intended environmental benefits, PES programs should be designed to suit local circumstances, both in regard to the environmental problem at hand and the social context (Jack et al., 2008; Swallow et al., 2009). An important part of adapting PES to a particular circumstance is taking into account the preferences of those targeted for participation (Petheram and Campbell, 2010).

This paper reports on a choice experiment that quantifies ES providers' preferences for key design attributes of a proposed PES program for the East Usambara Mountains, Tanzania. The East Usambara forests are recognized as one of the world's most significant biodiversity hotspots, meaning that they support extremely high biodiversity levels yet face considerable threats from deforestation (Brooks et al., 2002; Myers et al., 2000). Despite past conservation efforts, the threat from land clearing for smallholder agriculture and timber harvesting is ongoing. At the time of this study, authorities and non-governmental organizations were actively exploring the use of PES as an option to reduce further clearing in the area (Lopa, 2011; WWF, 2010). PES is attractive in this context because many of the remaining fragments of forest lie on farmers' properties, often in the form of modified agroforestry systems. Command and control conservation policies, such as reserve creation (based on compulsory land acquisition) or restrictive environmental laws would come at a high cost to farmers, some of whom are already skeptical of conservation projects due to past reserve creation (Rantala and Vihemäki, 2011). PES, which is voluntary and compensates farmers for their actions, may represent a more socially acceptable conservation approach in this case. Furthermore, the potential for applying a PES type mechanism in the East Usambara Mountains has been improved by the development of REDD+ (Reducing Emissions from Deforestation and forest Degradation) policy mechanisms and funds. The expansion of REDD + over time has elevated the status of co-benefits such as biodiversity protection and poverty alleviation (Campbell, 2009), which are of considerable relevance for

* Corresponding author at: Nicholas School of the Environment, Box 90328, Duke University, Durham, NC 27708, USA. Tel.: +1 919 613 8070.
E-mail address: david.kaczan@duke.edu (D. Kaczan).

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REDD + intervention in the East Usambaras due to the high biodiversity and high poverty levels found here. In 2009 the Government of Norway allocated USD 83 million to REDD + activities in Tanzania to be spent over the following five years (NORAD, 2011).

We use a choice experiment to quantify farmer preferences for PES program design. Choice experiments are often used to value environmental goods or services, but can also be used to value environmental programs represented as combinations of attributes. For instance, a PES program will combine a particular payment amount, a particular payment method and a particular set of land use requirements in order to create a functional program. Choice experiments can be used to quantify preferences for individual program attributes, as well as to quantify overall 'willingness to accept' (WTA) values: the amount of payment required to induce participation in the program. Valuably, choice experiments can test multiple, hypothetical versions of a program simultaneously. This makes them more versatile and often cheaper than revealed preference approaches (such as auctions) which are limited in how many program variants they can offer, and require real payments.

Despite these advantages, choice experiments have been used in only a small number of studies to inform PES program design to date, partially due to the difficulty of reducing hypothetical bias—inaccuracies that stem from the non-binding nature of participants' choices in the questionnaire. However, the use of techniques such as cheap talk (see Cummings and Taylor, 1999), inferred valuation (see Lusk and Norwood, 2009) and visual aids (see Whittington and Pagiola, 2012) can reduce this bias. These three techniques are used in this study, along with a comparison of results to land-use opportunity costs as a test of external validity. Surprisingly, past applications of stated preference techniques to PES in developing countries appear to have placed little emphasis on the use of these techniques (see Whittington and Pagiola, 2012 for a review).

A key focus of this study is on the impact that different payment approaches have on participation. Previous studies for the most part have used only one payment vehicle, preventing analysts from making comparisons of payment approach effectiveness in a controlled framework. In this study we compare four payment approaches: (1) a constant annual cash payment to individual farmers, (2) a varying annual cash payment to individual farmers based on conservation opportunity costs, (3) a constant annual cash payment to a village fund on behalf of farmers, and (4) an upfront payment to individual farmers specifically for manure fertilizer. We compare our WTA values to estimates of farmers' opportunity cost of forest conservation in this area as a test of external validity.

The remainder of this paper is structured as follows. Section 2 presents a synopsis of the PES concept. Section 3 describes the East Usambara study site. Section 4 presents a summary of relevant choice experiment literature and a description of the methods used. Sections 5 and 6 present results, including the opportunity cost comparison, and a concluding discussion.

2. The Payment for Ecosystem Services Concept

Recent literature makes extensive use of Wunder's (2005) five-point PES definition, which describes a 'best practice' PES model focused on economic efficiency. This definition states that PES is a (1) *voluntary* transaction regarding a (2) *well-defined* ES (or land use likely to secure that service), between (3) at least one ES provider and (4) at least one ES buyer, if and only if (5) ES provision is secured (conditionality).

Conditionality is the key differentiating feature between PES and other non-coercive conservation approaches (such as integrated conservation and development projects, and community-based natural resource management) (Ferraro and Kiss, 2002). Van Noordwijk and Leimona (2010) defined a variety of conditionality types, where payment can be linked to (1) the consequence of an improved ecosystem service (for example, cleaner water), (2) improved system performance (for example, increased tree cover), (3) improved actions (for example, replanting in the runoff zone), (4) improved management plans (for example, an intent to replant in the runoff zone), or (5) improved management objectives (for example, an intent to improve water quality). PES contracts are based on a relationship between land management actions and agro-ecosystem outcomes, a relationship that includes some degree of uncertainty (Muradian et al., 2010). Shifting conditionality type from improved actions to improved ES emphasizes respect for ES providers' land management ability and autonomy (Van Noordwijk and Leimona, 2010), but places the burden of risk of variation in agro-ecosystem performance onto ES providers. Alternatively, conditionality that emphasizes actions rather than outcomes places the burden of risk on the ES buyer. Given these varying levels of autonomy and uncertainty, it is likely that ES providers' preferences for particular PES programs will be heavily influenced by the type of conditionality proposed. In this study we assess farmers' responses to three different levels of conditionality of varying stringency, corresponding to conditionality types 2, 3 and 4 described above.

Few programs exist that satisfy all five of Wunder's (2005) conditions (Tacconi et al., 2009; Wunder, 2005). However, meeting the strict, conceptual definition of PES is not necessarily an indication of program design quality, or the likelihood of successfully achieving the desired environmental improvement. PES programs must be tailored to the particular socio-economic, political, cultural and biophysical context of the environmental problem at hand (Jack et al., 2008; Kemkes et al., 2010), which includes consideration of the preferences of those targeted for participation (Petheram and Campbell, 2010). A lack of knowledge regarding ES providers' preferences could lead to the implementation of PES programs that fail to attract sufficient participation, either overall, or from the most desirable subset of ES providers (those whose actions most strongly influence the environmental outcome). Such programs could risk falling short of their environmental goals, and/or could risk alienating communities of ES providers who feel their input was not adequately sought during program design.

3. Study Site Description

3.1. The East Usambara Mountains

The East Usambara Mountains are located in North Eastern Tanzania (4°48′–5°13′ S and 38°32′–38°48′ E) and form part of the Eastern Arc Mountain Range. These mountains support humid tropical forest in the wetter areas and deciduous woodland in drier areas, with an elevation gradient contributing to a diverse array of forest ecosystems (Burgess et al., 2007; Lovett et al., 2001). Due to relatively stable climatic conditions through recent prehistory (Holocene) as well as ecological isolation due to drier vegetation types on the coastal plain, the Eastern Arc mountains have developed what is thought to be the highest endemic species density (per 100 km^2) of any known ecosystem (Hall et al., 2009; Lovett et al., 2001; Myers et al., 2000). The Eastern Arc is a recognized 'Global Biodiversity Hotspot', a grouping of the most valuable and vulnerable ecosystems worldwide (Brooks et al., 2002; Myers et al., 2000). Of the Eastern Arc forests, the East Usambara site is recognized as being one of the most biologically important (Burgess et al., 2007).

The human population of the East Usambaras is growing rapidly due to high birth rates and local in-migration. Most household income is generated by smallholder agriculture (described below), which accounts for approximately 88% of employment (commercial estate farming accounts for a further 11%). Incomes are on average lower than those for the rest of the country, and the vast majority of the population in the area has primary level education only (Reyes, 2008).

3.2. The Agro-ecological Issue

The East Usambara forests and the high biodiversity they support have suffered from past land clearing, logging and fragmentation, and remain threatened by environmentally-detrimental agricultural practices and timber harvesting (Hall et al., 2009; Newmark, 2002). 57% of the original forest cover has been lost, mostly in the past 35 years (Newmark, 2002).

One type of deforestation, on-farm removal of trees by smallholder farmers, occurs due to the cultivation of cardamom (*Elettaria cardamomum*). Cardamom is an important cash crop grown by an estimated 60% of farmers in the region. It is planted in a cardamom agroforest: a modification of the original forest where understory and midstory vegetation is removed, the overstory is thinned, and cardamom is planted underneath. Despite high initial yields, cardamom agroforest productivity decreases rapidly over a period of 3–13 years (after planting) due to nutrient depletion. Fertilizing with manure or replacing cardamom plants can allow for subsequent rotations, however in many cases, the remaining overstory is removed and the field is instead used for cropping. A common land-use conversion is to sugarcane, although conversion to perennial spices (cloves, cinnamon) or annual food crops (cassava, bananas, yams) also occurs. Like cardamom, these second stage crops also suffer from nutrient deficiencies over time, and eventually many plots are abandoned to woody weeds (*Lantana camara*, *Clidemia hirta*, and *Psidium guajava*) which limit forest regeneration (Reyes et al., 2006). Of the remaining forest in the East Usambaras, approximately 26% has already been planted with cardamom, meaning that the process of land conversion is well underway (Reyes et al., 2006).

Alternative land management practices have recently been proposed that could maintain some degree of ecosystem functionality while allowing for ongoing cardamom production. Although original forest provides the highest biodiversity benefits, maintaining agroforests would be preferable to complete forest loss. Leonard et al. (2010) found that agroforests in the East Usambaras support a range of important flora species and threatened bird species. Of note, 'improved' agroforestry systems may be developed. Such systems are thought to have higher biodiversity benefits than either conventional cardamom agroforests or open field crops such as sugarcane, and do not suffer from the same rapid productivity declines (Bullock et al., 2011). Improved agroforestry uses manure fertilizer, and midstory and overstory species are allowed to regenerate around the cardamom, which is planted in lower density than in conventional cardamom agroforests.

Average yields and yearly profits are estimated to be lower under improved agroforestry than under conventional cardamom agroforestry. Similarly, yearly profit from conventional agroforestry is estimated to be lower than that from sugarcane, once productivity declines have occurred, after 3–13 years after the planting of cardamom (although the extent of these profit discrepancies varies considerably due to fluctuations in cardamom and sugarcane prices) (Bullock et al., 2011). In addition, the net present value of sustained, improved agroforestry is estimated to be lower than the net present value of temporary, conventional agroforestry followed by sugarcane, the typical pattern of land use in the East Usambaras (Bullock et al., 2011). This result holds over a large range plausible discount rates (0.03–0.4). These results are broadly concordant with the observed land use patterns in the East Usambaras, and suggest that the long-term maintenance of agroforestry may require providing farmers with additional incentives. The hypothetical PES programs developed for this study focus on this goal.

4. Data and Methods

4.1. The Choice Experiment Approach

This study uses a choice experiment (CE) to quantify preferences for different elements of PES program design. In a choice experiment, participants are asked to choose between competing hypothetical goods/outcomes as described in a questionnaire. The hypothetical good/outcome is a package of attributes, each of which can take on a number of levels which are varied between scenarios. There are a small but growing number of studies which use CEs to explore landholders' environmental program preferences. The earliest of these studies used socio-demographic characteristics, program length and payment level to explain participant choices of hypothetical PES programs. For instance, Stevens et al. (1999) and Klosowski et al. (2001) investigated landholder preferences for forest management in New England. These related studies reported that tax incentives, an environmental amenities focus and shorter contract length, as well as higher landholder income, led to higher participation rates. Horne (2006) evaluated Finnish landholders' preferences for conservation contracts in non-industrial, privately owned forests using a CE. She showed that more stringent conservation requirements and a longer contract length would necessitate higher annual payments, as expected.

More recently, a number of choice experiment PES studies have also considered heterogeneity within the landholder population. These studies focused on the European experience with agri-environmental schemes, and were motivated in part by low participation rates in programs implemented over the past decade (Broch et al., 2013; Ducos et al., 2009). Ruto and Garrod (2009) surveyed farmers – both participants and non-participants in existing PES programs – in 10 European countries. Contract length, contract conditionality and administration costs were the most important determinants of farmer participation. The authors found that respondents could be classed as either 'high-' or 'low-resistance adopters', with the former requiring much higher payment amounts. Espinosa-Goded et al. (2010) surveyed landholders in two regions of Spain about their preferences for a PES program encouraging the planting of nitrogen-fixing crops. They found that a fixed, one-off payment (to offset start-up costs) could reduce the required annual payments. They also found substantial heterogeneity of preferences in their sample, with some farmers' indicating disutility from the proposed fixed payment. Christensen et al. (2011) used a CE to assess Danish farmers' preferences for pesticide-free buffer zone subsidies. They found that a flexible contract was better than reduced administrative costs for encouraging participation. They also found that certain attributes could elicit both positive and negative responses from different farmers within the sample. Beharry-Borg et al. (2013) estimated farmers' WTA amounts for land use changes that would improve water quality in Yorkshire, UK. They also found high heterogeneity, although average WTA concordant with existing PES payments. Finally, Broch et al. (2013) investigated farmer willingness to participate in afforestation contracts, also in Denmark. They found that landscape level factors such as population density, recreation levels and biodiversity levels affected farmers' program preferences. Broch and Vedel (2012) used the same data to demonstrate the high heterogeneity of farmer preferences.

Arifin et al. (2009) is the only study to our knowledge that has used a CE to advise PES program design in a developing country situation. Their study quantified landholders' preferences for community forest contracts in Sumber Jaya, Indonesia. They reported that landholders would be prepared to accept strict conditions on land use in exchange for the land rights certainty that the program provided.

There are a number of studies which used the related stated preference (SP) technique of contingent valuation (CV). Most of these examined preferences held by users of ES (for example, individuals or firms who benefit from biodiversity or improved water quality), although some considered the preferences of ES providers (see for instance, Cooper, 2003; Cooper and Osborne, 1998; Southgate et al., 2010). A common theme in the CV PES literature, at least as applied to developing countries, is a lack of procedures to reduce hypothetical bias (see Whittington and Pagiola (2012) for a review). This problem, common in SP studies, is also not addressed in the majority of CE studies reviewed here. Furthermore, few of the CE studies reviewed here compared their SP estimates of WTA to estimates made using other methods. Those that did made limited comparisons. For instance, Horne (2006) noted that her WTA estimates were greater than opportunity cost. Espinosa-Goded et al. (2010) and Beharry-Borg et al. (2013) noted that their WTA estimates were roughly comparable to the payments made in existing PES programs, which serve as a form of revealed preference. A comparison between farmers' opportunity cost and their stated WTA, as made in this study, is a test of external validity (provided the opportunity costs are accurately measured). Although some discrepancy is to be expected, large discrepancies may suggest the presence of hypothetical bias.

4.2. The Choice Experiment Model

It is assumed that farmers face a loss of utility due to the changes in management practice required by a PES contract, and a gain of utility from the associated payment. A farmer is assumed to choose a contract if the net utility from that choice is greater than either no contract or any competing choices. Based on random utility theory, the probability of a farmer making a particular choice is assumed to increase as the utility of that choice increases (Ben-Akiva and Lerman, 1985, pp. 59). The characteristics of the PES contract (attributes) are allowed to take on a range of levels, as described in Section 4.3. The overall utility derived from a contract is expressed as a utility function:

$$U_i(P_h) = U(Z_h; X_i) \tag{1}$$

where P_h is the hth PES program scenario, $U_i(P_h)$ is the utility derived from that scenario, Z_h is a vector of attributes (including the payment) that make up program P_h, and X_i is a vector of characteristics of the ith farmer. Utility is assumed to be a function of profit made by the farmer, which in turn is a function of the nature of the PES program, P_h. This utility function has a corresponding indirect utility function, $V_i(P_h)$, which has a systematic, observable component $v(P_h)$ and a random unobservable component ε_{ih}:

$$V_i(P_h) = v(P_h) + \varepsilon_{ih}. \tag{2}$$

The probability, π_{ih} that a particular program h will be chosen from the available set of programs C is:

$$\pi_{ih} = \Pr\left[v(P_h) + \varepsilon_{ih} \geq v\left(P_j\right) + \varepsilon_{ij}; \forall h \neq j \in C\right]. \tag{3}$$

And so

$$\pi_{ih} = \Pr\left[\varepsilon_{ij} - \varepsilon_{ih} \leq v\left(P_j\right) - v(P_h); \forall h \neq j \in C\right]. \tag{4}$$

If the unobservable components are identically, independently distributed as type 1 extreme values (Gumbel distributed), the conditional choice probability of selecting alternative h is:

$$\pi_i(P_h) = \frac{e^{\mu v(P_h)}}{\sum_{h \in C} e^{\mu v(P_h)}} \tag{5}$$

where μ is a scale parameter, inversely proportional to the standard deviation of the distribution of errors. Note that μ often cannot be separated from the utility function so is normalized to one. Note that this choice of error distribution implies that preferences exhibit the 'independence of irrelevant alternatives' property (Hanley et al., 2001). We assume that the utility function is linear:

$$v(P_h) = BZ_h \tag{6}$$

where B is a vector of marginal utilities for each program attribute, Z_h.

A limitation of the multinomial logit model is an assumption of homogenous preferences across respondents. This assumption can be relaxed by the use of a latent class model (LCM) or random parameters logit model (RPL). A RPL allows parameters to vary randomly over individuals, providing a continuous distribution of preferences (Boxall and Adamowicz, 2002). A LCM can be considered a semi-parametric version of the RPL where parameters are distributed discretely. This allows for the identification of distinct 'classes' of respondents, and does not require any assumption on the distribution of parameters, beyond the number of classes (Sagebiel, 2011). We present LCM results in this case because we judged that the identification of classes of respondents would be of greater practical use in policy design than would be the identification of a continuous distribution of preferences.

In a LCM we assume that individual i belongs to a particular segment, s of the population:

$$\pi_{i|s}(P_h) = \frac{e^{\mu_s B_s Z_h}}{\sum_{h \in C} e^{\mu_s B_s Z_h}} \tag{7}$$

where B_s and μ_s are segment-specific utility and scale parameters respectively. Membership in a particular segment is based on a latent membership likelihood function based on socio-demographic characteristics. Like the utility function in Eq. (2), the latent membership function ($M_{is}{}^*$) has both an observed (A_sX_i) and unobserved component (ε_{is}):

$$M^*_{is} = A_s X_i + \varepsilon_{is} \tag{8}$$

where A_s is a coefficient vector specific to segment s that is associated with the observable socio-demographic and psychometric determinants (X_i) of individual i's membership. The conditional choice probability function mirrors the multinomial logit model from above. However, this function is dependent on the characteristics of the individual i, not on the characteristics of the program's attributes:

$$\pi_{is}(X) = \frac{e^{\mu_s A_s X_i}}{\sum_{s \in S} e^{\mu_s A_s X_i}}. \tag{9}$$

The product of Eqs. (9) and (7), over the sum of all segments, gives the joint probability that individual i belongs to segment s and chooses alternative P_h.

$$\pi_i(P_h) = \sum_{s=1}^{S} \left[\frac{e^{\mu_s A_s X_i}}{\sum_{s \in S} e^{\mu_s A_s X_i}}\right] \left[\frac{e^{\mu_s B_s Z_h}}{\sum_{h \in C} e^{\mu_s B_s Z_h}}\right]. \tag{10}$$

4.3. Experimental Design and Data

General concepts of conditionality and payment type were adapted into tangible program attributes, and the options were refined to meaningful levels based on extensive pretesting in the East Usambara villages of Shambageda and Kwezitu. This process involved 7 structured interviews and 3 pilot survey rounds with a total of 77 participants. Interviews and pilot survey rounds were conducted in September of 2010.

Three payment attributes were used. The primary payment vehicle was a per-acre[1] annual cash payment, either constant or varying over time, made directly to the farmer for his/her on-farm forest conservation. The second was a group payment, where the per-acre annual amount would be donated to a village fund for use on communal infrastructure (the village school, roads and dispensary). This group payment represented a collectivist approach to PES, where individuals make a contribution to the welfare of the village as a whole through actions on his/her own farm. We hypothesize that such a group payment could harness pre-existing social incentives. Contributions to communal goals often provide social benefits such as respect. A group payment could allow farmers to contribute (and thus receive recognition and social benefits for doing so) via on-farm conservation. This hypothesis was motivated by Leimona et al. (2009) who reviewed farmer preferences at five PES sites in Indonesia, the Philippines and Nepal. They found in some cases that collective, non-monetary rewards were specifically

[1] Acres are the standard unit of land measurement familiar to Tanzanian farmers in the study district and thus are used throughout this paper.

requested by potential program participants. The third payment attribute was a once-off, per-acre upfront payment specifically for the purchase of manure fertilizer. Field experiments show that application of adequate amounts of manure fertilizer can improve cardamom yields by approximately 50% (Reyes, 2008). By increasing farm productivity, such a payment would aim to ameliorate the need to clear additional forest or convert nutrient-depleted agroforest to sugarcane. The value of the manure fertilizer payment, approximately USD 140 per acre, was based on the average expected cost of generously fertilizing one acre of cardamom agroforest using livestock manure.

Three different levels of contract conditionality (and associated enforcement intensity) were used. At the least stringent level, farmers would be expected to simply fill out a logbook of their farm activities. Farmers would be trusted to abide by the spirit of the program, with a possible chance of a logbook audit. This was based on a logbook system used in the East Usambara Novella *Allanblackia* project, an ongoing effort to increase cultivation of fruit from *Allanblackia* trees in the area (UNDP, 2009). At the moderate level of conditionality, farmers would have their property inspected once per year by a local village resident hired by the program (to ensure no large trees had been removed), but would face no requirements for the quality and quantity of the understory vegetation. At the high conditionality level, farmers would face twice yearly inspections from a forestry officer who would consider both tree density and species requirements. The high conditionality level would allow for improved agroforest only (as discussed in Section 3.2) while the low and intermediate conditionality levels would also allow continued conventional agroforest (but no further tree removal). Table 1 shows the full schedule of attributes and levels.

Contracts were stipulated as lasting for ten years. Premature departure from contracts (i.e. violation of contract conditions) would result in a fine of approximately USD 35 and the cessation of further payments. This amount was chosen to approximately match the fine currently existing for the infraction of cutting a protected tree species. Farmers were also told that they must enroll all of their owned/managed land into the program if they were to take part. Permitting farmers to enroll only part of their land could allow them the possibility to geographically shift forest cutting activities while still receiving income from PES, also known as 'on-farm leakage' (Engel et al., 2008).

A split-sample treatment was applied to test farmers' responses to a varying payment mechanism. Half of the sample was told that their individual payments would vary from year to year depending on the price of sugarcane, a key opportunity cost for maintaining forest or agroforest. Although this does not perfectly represent the opportunity cost of the land-use restriction (which depends on both the price of sugarcane and cardamom) it provides an approximate representation. This 'variable' payment would be higher in years of high sugarcane prices in order to encourage farmers to stay in the program. Similarly, payment would be lower when sugarcane prices were lower as the incentive to leave the program would be diminished. Famers were told that on average (over the life of the contract) their payments would be equal to (approximately) USD 21, 50 or 176, matching the constant payment.

A large number of potential PES scenarios can be constructed from the attributes and options in Table 1 ($[4^2 * 2 * 3]^2 = 9216$) so the full set of possible combinations was reduced to a set of 32 using an orthogonal fractional factorial design using the Ngene software package (ChoiceMetrics, 2011). These were arranged in blocks of 4 scenarios consisting of two hypothetical PES programs each and a status quo option ("none of the above"). Inclusion of the status quo reduces the likelihood of forced, spurious choices, and ensures consistency with standard welfare theory (Hanley et al., 2001). Each survey respondent considered one block (four scenarios).

Farmers were questioned in the Kiswahili language in face-to-face interviews in September and November, 2010. Enumerators were experienced research assistants, who were also local community members familiar with the culture and farming practices found in the study area. Interviews were requested with the 'head of household' from households randomly selected from village registries. Surveying took place in the subvillages of Kwezitu village (Antekae—83 farmers, Kisangani—60, Kagare—39 and Gonja—29) with a small number from nearby Shambageda village (Shambangeda B—9 farmers). These villages were selected for surveying due to the high proportion of resident farmers engaged in agroforestry, some of the highest proportions of any villages in the East Usambaras. The number of households surveyed was approximately 50% of the total households in the case of Kwezitu. Participation rates were high, with an estimated 90% of farmers solicited prepared to take part. Surveys were undertaken in private and took an average of 42 min each. A token gift only was presented for participation.

Table 1
Attributes and levels presented in hypothetical contracts.

Attribute	Description	Levels
Individual payment	A payment provided directly to the farmer for maintenance of agroforest (per acre payment, annually)	Approximate USD: 0, 21, 50, 176[a]
Collective payment	A payment provided to a dedicated village development fund for maintenance of agroforest (per acre payment, annually)	Approximate USD: 0, 21, 50, 176[a]
Upfront fertilizer payment	A payment provided for a once-off, upfront procurement of fertilizer (value approximately USD 140 per acre)	Approximate USD: 0, 140 (binary variable)
Conditionality low	No inspections—farmers are required to keep a log book documenting farm activities which may be audited	Yes, No (binary variable)
Conditionality moderate	A local villager will be hired by the administrating organization to inspect farmers' farms once per year to ensure no large trees have been removed from forest and agroforest.	Yes, No (binary variable)
Conditionality high	A forestry officer from the administrating organization will inspect farmers' farms twice per year to ensure that no large trees have been removed from forest and agroforest. Also will ensure that there are enough saplings for canopy replacement and that trees present are indigenous species.	Yes, No (binary variable)

[a] The payment amounts were selected a priori based on the expected cost of maintaining agroforest instead of a sugarcane plantation. Payment amounts were adjusted during three rounds of pilot surveys to achieve an appropriate distribution of bid acceptance levels.

4.4. Mitigating Hypothetical and Social Desirability Biases

A well-known disadvantage of SP techniques is the potential for hypothetical bias. Hypothetical bias is the discrepancy between preferences expressed in a hypothetical survey situation and those expressed in a real choice situation (Little and Berrens, 2004). For example, participants may respond strategically, giving a biased response in an effort to skew results and consequently, any program influenced by the survey's findings. Careful survey design can reduce hypothetical bias. For instance, the use of cheap talk scripts, first proposed by Cummings and Taylor (1999), have been shown to be effective (Carlsson et al., 2005). A cheap talk script simply encourages respondents to provide realistic answers. We used the following script immediately before the choice experiment questions: "*Even though the set of conditions described to you are not real and do not commit you to any actions, it's really important that you answer as if this was a real choice with real consequences. Sometimes people say one thing in a survey but when they face the same situation for real, they do something else. Please think really carefully about whether you really would do what you say.*"

Another type of hypothetical bias is 'social desirability bias,' the influence of social norms and the immediate social context on the resulting responses. There is a tendency for some respondents to answer in ways which they believe will receive approval from those conducting the survey (Maguire, 2009), or to answer in ways that reinforce their own moral tendencies (Nunes and Schokkaert, 2003).

Inferred valuation is a questioning approach that aims to avoid social desirability bias by asking respondents to predict other people's choices, rather than asking for their own. It is hypothesized that this curtails the motivation to overstate for the purposes of appearing charitable to the interviewer. Lusk and Norwood (2009) provided evidence that inferred values are approximately equal to conventional self-provided values, but adjusted for social desirability bias. All respondents were presented with their block of 4 hypothetical choice scenarios twice, firstly framed as direct valuation and secondly as inferred valuation.

5. Results

5.1. Descriptive Statistics

75% of the sample (220 usable responses) was male, indicating the (self-identified) prominence with which men act as primary decision makers with regards to the farm (Table 2). Only one third of participants were born in the village they were living in. Self-reported income averaged USD 690 per household per year, lower than the Tanzania national average (CIA, 2010). 26.9% of the sample had in addition an off-farm source of income, which for these households provided an average of USD 455 per year. We are cautious in the use of self-reported income given the high variation in responses. Average land size owned or managed was 6.27 acres, with an average of 2.82 acres of cardamom agroforestry and 0.30 acres of original forest. These varied considerably over the sample. Level of education was relatively homogenous, with 91% of participants having completed primary schooling only.

Table 2
Summary socio-demographic characteristics of sample ($n = 220$).

	Mean	St. dev
Gender (proportion male)	0.75	–
Born in village (proportion)	0.33	–
Age (years)	45	14
No. adults in household	2.64	2.47
No. children in household	2.89	1.92
Self reported annual income (USD)	690	1017
Proportion with off-farm income source	26.9	–
Off farm income (for those with off farm income) (USD)	455	502
Proportion planting:		
Cardamom agroforestry	81.6	–
Other spices	89.4	–
Sugarcane	38.8	–

5.2. Payment Type Preferences and WTA

Table 3 presents separate multinomial logit (MNL) models for the inferred valuation scenarios and the direct valuation scenarios, as well as for the amalgamated data set. Conditionality variables are represented by effects codes.[2]

A likelihood ratio test found no significant difference between models ($\chi^2_{d.f = 5} = 5.21$, p-value = 0.39) suggesting that respondents expect little difference between their own responses and the responses of their peers. Assuming that the Lusk and Norwood (2009) inferred valuation technique is effective in such a context, social desirability bias appears to be not significant.[3]

We find evidence that the nature of payment greatly influences the required amount of payment, as expected. Both the manure fertilizer payment and the individual, annual cash payment significantly motivated hypothetical participation in a PES program ($p < 0.01$). The group payment had a non-significant effect on hypothetical participation ($p > 0.1$).

The constant annual payment is preferred to the variable payment. Table 4 presents choice models of the constant and variable payment treatments separately. The status quo and conditionality variables are only significant in one treatment each, possibly due to the smaller size of subsamples used here. The coefficient for individual payment is lower under the variable payment treatment than under the constant payment treatment indicating that the same quantity of money provides less incentive when the payment amount fluctuates year to year (assuming no scale differences between models).

Group payment is not significant under either treatment, and the status quo is only significant under the variable payment treatment. There is a small difference in the marginal utility of the upfront manure fertilizer payment between treatments, with a higher marginal utility under the variable payment regime. This may represent a substitution effect: a less reliable payment year to year makes the upfront offer relatively more attractive. This effect is interesting given that the model overall suggests that the constant payment is preferred over the variable payment. It would appear that preferences are to some extent context dependent: an upfront investment within a variable payment framework is more attractive than the same upfront investment in a constant payment framework.

Willingness to accept (WTA) values were calculated for different elements of program design[4] (Table 5). Without the manure fertilizer payment and with a moderate conditionality regime, a payment of approximately USD 28 per acre per year is required to convince the median farmer to enroll. If the payment varies from year to year in line with the price of sugarcane, the required payment is USD 79, even though both payment regimes provide an equivalent amount over time. The presence of a manure fertilizer payment caused WTA to become negative, meaning that this payment was in itself enough to motivate participation.

5.3. Comparison of WTA and Opportunity Cost

One way of determining the external validity of the CE WTA results is to compare the estimated average WTA amount with the estimated average profit discrepancies between competing land uses (the opportunity cost). We use a financial assessment of East Usambara farming practices, published by Bullock et al. (2011).[5] Their assessment is based on interviews with East Usambara farmers and observations of prices at local markets in 2009. At a cardamom price of 20 USD per bucket (green, at village) there is an average yearly profit discrepancy between improved cardamom agroforesty and sugarcane of approximately 77 dollars per acre.[6] The discrepancy decreases as the price of cardamom increases (assuming all else constant). At prices higher than 7 USD per bucket, conventional agroforestry is competitive with

[2] Conditionality variables (which represent mutually exclusive, discrete, policy states) are represented in the model by effects codes rather than dummy variables, to avoid confounding the status quo coefficient (the status quo situation has no contract by definition and thus no conditionality). Note that this is not required for the payment dummy variable because a payment of zero is compatible with the status quo situation. A discussion of this issue is provided by Bech and Gyrd-Hansen (2005).

[3] We note that the similarity between the inferred and direct treatments may have been influenced by the order the questions were presented in (direct, then inferred), and recommend that this result is read with this in mind. A preferable study design would have randomly assigned the order, and would be a worthwhile topic for further research. We were limited by the burden on enumerators to make this randomization in addition to the other split treatments and randomizations contained in the survey. Nevertheless, 63% of respondents deviated from their direct responses when answering the inferred responses, indicating that they recognized the differences between the questions and felt comfortable answering differently.

[4] WTA is determined by taking the ratio of an attribute's marginal utility to the marginal utility of money (the primary payment vehicle) to determine the marginal rate of substitution between the attribute and money (Hanemann, 1984). This process can be extended to determine the overall WTA required to induce participation by subtracting the marginal utilities of program attributes from the marginal utility of the status quo option. The status quo coefficient represents the marginal utility of not participating in a program.

[5] Thanks are given to Renee Bullock (University of Florida) for making her data available for this comparison.

[6] Average profit discrepancy was calculated by averaging expected yearly profit over 12 years (ten years of production). Establishment costs were excluded for agroforestry (which are assumed to be pre-existing) but included for sugarcane (which would be established on land currently under agroforestry).

Table 3
Multinomial logit models of preferences for a hypothetical PES program, based on subsamples of questioning method.

	Inferred valuation		Direct valuation		All data combined	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Individual	0.064	0.006***	0.067	0.006***	0.065	0.004***
Group	0.009	0.006	0.007	0.006	0.008	0.005*
Status quo	0.218	0.137	0.429	0.139***	0.319	0.097***
Upfront payment	0.836	0.107***	0.842	0.112***	0.837	0.077***
Conditionality moderate	0.098	0.072	0.145	0.076*	0.119	0.052**
Conditionality high	−0.018	0.070	−0.170	0.075**	−0.088	0.051*
Conditionality low[a]	*−0.081*		*0.026*		*−0.032*	
No. obs.	220		200		220	
d.f.	6		6		6	
LLF	−826.878		−761.988		−1591.471	
AIC	1665.757		1535.976		3194.941	

[a] Implicit coefficient, β_1 which is calculated from effects codes coefficients for conditionality moderate (β_2) and conditionality high (β_3). $\beta_1 = -(\beta_2 + \beta_3)$.
* Significant difference between treatment and control at α = 0.1 level.
** Significant at α = 0.05 level.
*** Significant at α = 0.01 level.

sugarcane (Fig. 1). At prices above 23 USD, improved agroforestry is competitive also. It is likely that at prices substantially below these thresholds, PES type payments would likely be necessary to maintain these less profitable land uses.

The observed opportunity costs match the WTA calculations relatively well. Cardamom prices at the village level at the time of the choice experiment were between 17 and 24 USD, leading to a calculated profit discrepancy of 0–155 USD. A high conditionality PES program (requiring improved agroforestry) was found to require individual payment of 59.6–78.6 USD, close to the midpoint of the profit discrepancy. It is important to note that other elements of the program such as administrative burden are likely to increase WTA. Similarly, associated non-monetary benefits of the program, such as social recognition, are likely to decrease WTA. However, there is clear similarity between the estimated WTA amounts and the observed profit discrepancy.

5.4. Other Preferences

The manure fertilizer payment, worth about USD 140 per acre, was enough to persuade the median farmer to accept a hypothetical program without additional annual PES payments for the life of the 10 year contract. To elicit an equivalent willingness to participate using standard cash payments only, a program would have to pay approximately USD 84 per acre annually over the life of the ten-year contract. Reasons for the high value placed on this payment type could include high discount rates, credit constraints, or a poorly functioning manure fertilizer market. High discount rates would lead farmers to prefer the manure fertilizer payment, which is upfront, more than the annual payments. Second, credit constraints could prevent farmers from investing in fertilizer at the beginning of a season (or at the initial planting of cardamom) before profits have been realized. The possibility of receiving a sizeable upfront manure fertilizer payment, allowing for a multi-year improvement in farm productivity, could thus be highly attractive. Third, manure fertilizer supply is subject to shortages and high transport costs in the East Usambaras (Reyes, 2008). Respondents may have been attracted to this payment as an answer to these problems. This result has some precedent in the study by Espinosa-Goded et al. (2010), who also found a large decrease in WTA as a result of offering farmers a one-off upfront payment, in their case, intended to offset upfront costs. In their study total program expenditure (taking into account the cost of the upfront payment and discounted over time) was 23% less when such a payment was made.

It should be noted that large upfront payments and other irreversible benefits (such as land tenure provision) are generally not considered incentive compatible due to the loss of leverage once benefits are handed over (Wunder, 2007). The manure fertilizer payment used in this instance may avoid this problem by providing an ongoing incentive (a more productive agroforest for a number of years after fertilization) that is to some extent 'locked' into a particular land use choice, agroforestry. However, the risk of upfront payments should be considered by the PES designer. For instance, periodic provision of the manure fertilizer payment throughout the life of the contract may be more suitable.

There is a clear trade-off between the conditionality level and payment required to encourage participation. The choice experiment

Table 4
Multinomial logit models of preferences for a hypothetical PES program, based on payment treatment subsamples. Direct valuation questions used only.

	Constant treatment		Variable treatment		Combined treatments[a]	
	Coef.	Std. error	Coef.	Std. error	Coef.	Std. error
Individual	0.075	0.009***	0.059	0.009***	0.067	0.006***
Group	0.006	0.009	0.009	0.010	0.007	0.006
Status quo	0.214	0.191	0.696	0.205***	0.429	0.139***
Upfront payment	0.769	0.155***	0.956	0.166***	0.842	0.112***
Conditionality moderate	0.230	0.101**	0.029	0.116	0.145	0.076*
Conditionality high	−0.195	0.103*	−0.139	0.112	−0.170	0.075**
Conditionality low[b]	*−0.035*		*0.110*		*0.026*	
No. obs.	111		89		200	
d.f.	6		6		6	
LLF	−406.326		−349.164		−761.988	
AIC	824.653		710.328		1535.976	

[a] A likelihood ratio test finds a significant difference between the variable and constant treatments ($\chi^2_{d.f=6} = 12.996$, p-value = 0.043).
[b] Implicit coefficient, β_1 which is calculated from effects codes coefficients for conditionality moderate (β_2) and conditionality high (β_3). $\beta_1 = -(\beta_2 + \beta_3)$.
* Significant difference between treatment and control at α = 0.1 level.
** Significant at α = 0.05 level.
*** Significant at α = 0.01 level.

Table 5
Willingness to accept amounts (USD), per acre, per year for a 10 year contract.

		Variable treatment		Combined treatments[b]	
	Conditionality	Median	Std. error	Median	Std. error
No upfront payment	Moderate	78.6	19.5	28.3	14.9
	High	78.6[a]	19.5[a]	59.6	14.0
Upfront payment	Moderate	−29.4	22.9	−55.5	16.9
	High	−29.4[a]	22.9[a]	−24.2	15.5

[a] No significant difference between high and moderate conditionality regimes for this model.
[b] The combined variable and constant payment treatment model (see Table 4) was used in the calculation of WTA as the constant treatment model alone does not find a significant status quo coefficient (necessary for WTA calculations). The combined treatment calculations provide an upper bound on WTA based on the constant treatment.

presented farmers with one of the three levels of conditionality: low, moderate and high (see Table 1 above). To attract participation from 50% of farmers, a program with moderate conditionality (one based on land manager actions, but not environmental outcomes) would require payment of approximately USD 28 per acre per year, while a program with high conditionality would require approximately USD 60. This difference is unsurprising: the requirements associated with high conditionality (for instance, protection of some understory) inhibit the ability of farmers to maximize profits from their agroforest. The associated enforcement procedure, two inspections per year, is similarly more onerous. However, the environmental benefits of a program with these restrictions are likely to be higher than the benefits of a program with fewer restrictions. A comparative study on plant species richness by Hall et al. (2011) demonstrated the biological value of a less intensively managed agroforest, and also the biodiversity benefits of protection from invasion by non-native species (in particular *Maesopsis eminii*). The policy designer must thus make a trade-off between program expense and biological benefits.

A more surprising result is that the relationship between predicted participation and level of conditionality is non-linear. The constant payment treatment model (Table 3) has a significant *positive* coefficient for the intermediate level of conditionality, while the high conditionality coefficient is significant and *negative*. The coefficient on the low conditionality level lies between these two extremes. A similar pattern is exhibited by the other models presented here (Fig. 2). This suggests that farmers are most likely to participate in a program which holds them to account with regard to their actions (moderate conditionality) and less likely to participate in a program which holds them to account with regard to environmental outcomes (high conditionality), or a program based simply on trust and intentions (low conditionality). Although the lowest level of conditionality is easiest for farmers to comply with, it is possible that they do not believe that such a regime represents good policy: Non-compliant participants could avoid consequences of their actions and thus undermine the program. The moderate and high conditionality regimes, which involve physical inspections, would not be so easily compromised. Farmers who support the goals of a policy (for instance, to prevent deforestation) will possibly base their preferences not only on what the policy can do for them (the payment) but also on whether they believe it is likely to meet its environmental goals. It should be noted that this is a hypothesis only, and further research is required to better understand this non-linear relationship. This could take the form of follow-up interviews or a choice experiment focused specifically on conditionality.

5.5. Heterogeneity of Preferences

The results presented up to this point represent the mean preferences of the participant sample as a whole. However, differences between farmers and farming operations (for example, quality of land, use of technology and access to roads) mean that individual farmers could have preferences and opportunity costs (and thus WTA amounts) that differ greatly from the averages presented in the preceding sections. We use a latent class model (LCM) with two classes to quantify such heterogeneity (Table 6). Selection of the number of classes is not guided by formal criteria; instead a number of authors (for instance, Boxall and Adamowicz, 2002; Scarpa and Thiene, 2005) recommend class selection based on log likelihood statistics and information criteria, and plausibility of results given the size of membership classes and the size of standard errors. Some analyst judgment is required.

Immediately apparent is a strong bifurcation of the status quo coefficient. Class 1 displays a negative coefficient, indicating that members of this class are prepared to enter into the contract without payment. Class 2 has a large positive status quo coefficient, indicating that members of this class require high levels of payment to join, and are on the whole reluctant to take part. Class 2 is the smaller of the two classes with 21% of respondents. The average of these two models, weighted by the class probabilities, gives the whole model reported upon in Sections 5.1 to 5.3.

Class 1 is defined by preferences similar to those reported in the whole model. However, in addition to the individual payment, group payment is shown to have a significant effect (although it provides only 23% of the utility of the individual payment per dollar received). The manure fertilizer investment coefficient remains strongly positive and a preference for a moderate level of conditionality (compared to a high or low level of conditionality) remains. Class 2 on the other hand is defined simply by a requirement for high payment. This manifests due to both a strong preference for the status quo and reduced marginal utility from individual payment. Application of a random parameters model (not shown here due to space constraints) gave similar results.

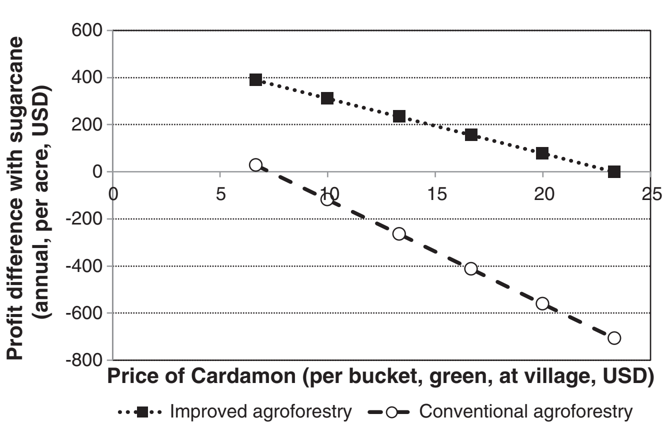

Fig. 1. Opportunity cost (per acre annually) of conventional and improved agroforestry, relative to sugarcane, at different cardamom prices. Negative numbers indicate that agroforestry is more profitable than sugarcane.
Figure compiled from data from Bullock et al. (2011).

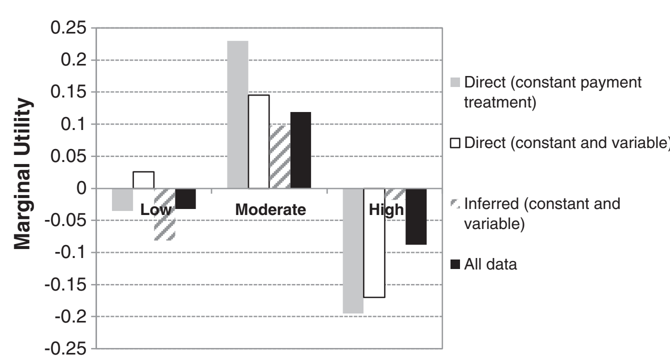

Fig. 2. Marginal utilities associated with different conditionality regimes. A higher marginal utility represents greater preference for that conditionality option. Note: Dash fill indicates statistical non-significance. The four series represent different treatments (constant versus variable payments) and questioning approaches (inferred versus direct valuation).

It is likely that these results occur due to the difference in farming operations between farmers (leading to different opportunity costs), as well as different attitudes towards environmental policy intervention. The analysis presented in Section 5.2 shows how the price of cardamom likely influenced land use. Similarly, farming costs and productivity levels could be similarly influential, but to different extents on different farms, leading to strong preference heterogeneity. This result has precedent in the literature. Espinosa-Goded et al. (2010) found that 15–27% of their sample of Spanish farmers reported negative marginal utility for a fixed payment. Similarly, Christensen et al. (2011) found strong heterogeneity in their status quo coefficient estimate when modeled using a random parameters logit. They found that a substantial minority of their Danish farmer sample held negative WTA values for PES. Ruto and Garrod (2009) found two distinct classes in their sample of respondents questioned on preferences for agri-environmental payment programs at ten sites across Europe. Their omission of the status quo coefficient means their results are not directly comparable to ours; however the large difference in the coefficient on the payment bid suggests that they likewise found one sample segment far more prepared to participate than the other. Our results, in conjunction with these earlier papers, highlight the importance of considering heterogeneity within a target population, even if that population is relatively homogenous in terms of farming activities and socio-demographic status.

With regard to specific socio-demographic characteristics, this study finds only gender and village of birth to have significant impacts on class membership. Males are more likely to fall into class 2, requiring high payment to participate. Those born in their current village of residence (lifelong inhabitants) were more likely to fall into class 1, showing stronger acceptance of PES. It is likely that a larger dataset would present greater insights into the impact of particular variables.

6. Conclusion

In this paper we set out three objectives. First, we aimed to demonstrate the suitability of the choice experiment approach to informing the design of PES programs. Few previous studies to our knowledge have done so in a developing country context. The similarity between the calculated WTA figures and the known opportunity costs of conservation land uses – along with the similarity between inferred and direct valuation results – gives us some confidence that our WTA figures are within a realistic range and that the biases that can affect stated preference valuation have been reduced.

Second, we aimed to provide information regarding farmer preferences for PES specifically for the East Usambara Mountains, Tanzania. The high biodiversity values in this area make it a priority for conservation research, and a number of conservation authorities and organizations are currently considering the suitability of PES for this region. This information is particularly valuable given that a number of East Usambara farming communities have been alienated by past environmental projects (Rantala and Vihemäki, 2011). Incorporating the preferences of farmers into future programs is essential for any chance of gaining local support.

With regard to this aim, we found a number of notable results. Firstly, the group payment was ineffective at promoting participation in the hypothetical program. Although we do not have data to explain this result, one hypothesis is offered by Kerr et al. (2012), who found that a group payment was ineffective in their litter collection field experiment in Mexico when trust levels in village administration were low. This may suggest that farmers in the study site have low trust in village level funds administration, a suggestion supported by our informal discussions in the field. Kerr et al. (2012) also tested the impact of a group payment (made to the local school) on participation in communal garden work in Tanzania. As is the case in this study, their choice experiment found that the group payment had no significant impact. Our results did show that individuals were effectively motivated by relatively small annual cash payments, paid directly to the individual farmer. A consistent rate of payment was preferred to a rate that fluctuates with the opportunity cost of the land management action. This is despite the supposed equity of payment amount over time. Apparently, the uncertainty of a fluctuating price necessitated a larger premium to encourage participation.

A non-monetary payment in the form of manure fertilizer appeared to be highly desirable amongst farmers. The fertilizer was intended as a multi-year investment in farmer operations. By improving the productivity of agroforest operations, it was intended that the incentive to replace agroforest with open field crops would be reduced. Policy makers and researchers could consider other variations on this payment approach (for instance, yearly fertilizer payments) to ensure that the incentive to remain in the program is ongoing.

Preferences for conditionality (and associated enforcement intensity) appeared to be surprisingly non-linear. Farmers were most likely to participate in a program which held them to account with regard to their actions, but not with regard to environmental outcomes (which is costlier for farmers to comply with). Counter-intuitively, participants showed preference against the lowest level of conditionality—that based simply on trust and intentions rather than a physical inspection for compliance. It is possible that although the lowest level of conditionality is the easiest for farmers to comply with, they do not believe such a regime represents good policy.

A third aim was to determine the extent of, and explanatory factors behind, preference heterogeneity within the study sample. Substantial heterogeneity was observed through the use of a latent class model. Consistent with previous studies, we found that the range of preferences extended from farmers who would participate without payment through to those who refused to participate without high compensation. Gender and village of birth were found to explain part of this split, however it is likely that a number of other explanatory factors remain hidden—most pertinently, those related to farm characteristics of production cost and revenues under different land uses. The observed heterogeneity points to the possibility of targeting PES programs at 'low-cost' farmers, and/or the possibility of targeting non-compensatory,

Table 6
Multinomial logit models of preferences for a hypothetical PES program with two latent classes (based on direct questioning data).

	Parameters for class 1		Parameters for class 2	
	Coef.	Std. error	Coef.	Std. error
Individual	0.113	0.113***	0.085	0.026***
Group	0.026	0.009***	−0.005	0.038
Status quo	−0.686	0.257***	4.056	0.908***
Upfront payment	1.518	0.182***	0.845	0.559
Conditionality moderate	0.207	0.088**	0.421	0.654
Conditionality high	−0.231	0.088***	−0.153	0.707
Conditionality low[a]	*0.025*		*0.332*	
Average class probabilities	0.787		0.213	
Class probability model (class 1)				
Constant	2.086	0.729***		
Treatment	−0.559	0.427		
Land area (acres)	0.048	0.044		
Gender (male = 1)	−1.156	0.568**		
Age (years)	−0.003	0.007		
Born in village	0.737	0.427*		
No. children	0.001	0.002		
LLF	−589.119			
McFadden Pseudo R^2	0.329702			
AIC	1216.237			
No. obs.	200			
d.f.	19			

[a] Implicit coefficient, β_1 which is calculated from effects codes coefficients for conditionality moderate (β_2) and conditionality high (β_3). $\beta_1 = -(\beta_2 + \beta_3)$.
* Significant difference between treatment and control at $\alpha = 0.1$ level.
** Significant at $\alpha = 0.05$ level.
*** Significant at $\alpha = 0.01$ level.

altruism-based environmental programs at those farmers who do not require payment. This is a possibility raised previously (Broch and Vedel, 2012), however the relatively weak explanatory results differentiating farmers between categories means further research is required. In addition, further consideration would need to be given to the potentially detrimental effects of such discrimination. It is possible that farmers' distribution across preference categories is at least partially influenced by the policy environment itself and is thus endogenous.

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