Working Paper

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Abstract

The forests of the East Usambara Mountains, Tanzania, are internationally recognized as one of the world's most biodiverse ecosystems. Despite past conservation efforts, these forests face an on-going threat from land clearing for smallholder agriculture and timber harvesting. As many remaining fragments of forest lie on farmers' properties, often in the form of modified agroforestry systems, a potential means to slow or halt forest loss is a 'payments for ecosystem services' (PES) programme, where farmers are paid to protect trees on their farms. For such a programme to achieve its goals, careful consideration of farmers' preferences for PES is required. Using a choice experiment, this study quantifies these preferences, and in addition, determines the approximate payment amount required to attract farmer support. Notable results are that payment for manure fertilizer (representing an investment in farm productivity) was highly effective at motivating farmer support, a group payment was highly ineffective, and that minimal programme conditionality was not always preferred. Required payment amounts were found to be highly variable between farmers. The paper concludes with a discussion of PES programme design practicalities as informed by the study findings.

Keywords

Payments for ecosystem services, agroforestry, Tanzania, choice experiment, biodiversity

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Contents

Introduction

Agricultural and environmental policies increasingly feature market incentives to promote environmentally beneficial land management actions. One such incentive-based policy is 'payment for ecosystem services' (PES), where landholders and/or land managers are given material incentives for undertaking conservation in an attempt to align individuals' economic interests with the wider social interests of environmental protection (Ferraro and Kiss, 2002; Engel, *et al.* 2008). Established PES programmes are relatively uncommon in developing countries but are growing in popularity. Increasing attention is now being paid to how they might be used in varied developing country contexts, and what design attributes are required for their success (Engel, *et al.* 2008; Pattanayak, *et al.* 2010).

For PES to be successful there is a strong need to consider the preferences of landholders and land managers targeted for participation. This paper reports on a choice experiment that quantifies such preferences for key design attributes of a proposed PES programme that aims to protect trees on farms in the East Usambara Mountains, Tanzania.

The East Usambara Mountains are located in North Eastern Tanzania and form part of the Eastern Arc Mountain range, an internationally recognized biodiversity hotspot (Myers, *et al.* 2000; Brooks, *et al* 2002). The forests of the East Usambaras have suffered from past clearing, logging and fragmentation, and remain threatened by environmentally detrimental agricultural practices and timber harvesting (Bjørndalen, 1992; Hall, *et al.* 2009). The majority of previous conservation efforts in this region have focused on the declaration and subsequent management of nature and forest reserves. While this approach has been at least partially successful in conserving the

forests that fall within reserve boundaries, it is considered insufficient to prevent biodiversity loss (see for instance, Newmark, 2008). In some instances it is thought that the declaration of reserves may have intensified pressure on non-reserve land, and furthermore, contributed to social dislocation (Conte, 2004, p. 157; Rantala and Vihemäki, 2011).

PES is an alternative conservation approach that may be better suited to balancing social and environmental goals than traditional conservation approaches. The potential held by this policy option has been recognized by international and Tanzanian conservation agencies and organizations. The Eastern Arc Mountains Conservation Endowment Fund, for one example, has a stated aim of exploring PES options for conservation efforts across the Eastern Arc (EAMCEF, 2006). This research aims to provide practical guidance for policy makers interested in using PES type programmes either in the East Usambara Mountains or in other, similar sites. We ask what type of PES programme is most likely to receive the support of East Usambara smallholder farmers and as a corollary, what kind of response can be expected from farmers under a number of different PES designs. We use a choice experiment approach to quantify the preferences and willingness to accept (WTA) values held by farmers for hypothetical PES programmes. Policy design attributes considered include the type of payment mechanism, the recipient of payments (a village fund or individual farmers), the amount of payment required (WTA values) and different conditionality regimes. The research aims to provide a strong empirical base for future PES programme implementation in the East Usambaras and, help guide robust PES design at other sites in Tanzania or internationally.

The Payment for Ecosystems Services (PES) concept

The Millennium Ecosystem Assessment (2005) defined ecosystem services as "the benefits people obtain from ecosystems." Such benefits include those from provisioning services (the products obtained from ecosystems such as food, water and fibres), regulating services (the regulation of biophysical cycles such as climate), cultural services (non material benefits such as aesthetics or spiritual values) and supporting services (services which allow for the provision of other services, such as nutrient cycles). Ecosystem services are often key factors in the production of economic value and hence material welfare. However, there is growing acknowledgment that many ecosystem services are undergoing rapid degradation due to overuse and misuse (The Millennium Ecosystem Assessment, 2005). A common reason for this is a lack of efficient institutions (including markets) that guide the supply and demand for ecosystem services (Costanza, *et al.* 1997; Arrow, *et al.* 2000; Balmford, *et al.* 2002).

The existence of market failure in the regulation and provision of ecosystem services means that the depletion of the environments that provide ecosystem services is often greater than socially optimal, and similarly, the production of ecosystem services (for instance, by land managers) is less than socially optimal (Ferraro and Kiss, 2002). Ecosystem services are often, although not exclusively, public goods, and their benefits may materialise at different scales, from local (for instance, pollination of crops) to global (carbon biosequestration). Particularly on larger scales, externalities, poorly defined property rights and limited information hamper efforts to optimise ecosystem service provision and protection between those who benefit from an ecosystem service, and those who affect its provision (Ferraro and Kiss, 2002; Engel, *et al.* 2008). Payments for ecosystem services (PES) programmes are one potential

solution to this problem, which work by using material incentives to encourage environmentally beneficial land management actions by individuals or groups. PES programmes seek to alleviate environmental externalities, strengthen property rights and improve information flow regarding the desired levels of ecosystem services. In doing so, PES programmes aim to internalize the benefits associated with enhancing or maintaining ecosystem services to ensure land managers (or other providers of ecosystem services) face incentives concordant with the interests of ecosystem service beneficiaries (Arrow, *et al.* 2000; Pagiola, *et al.* 2005; van Noordwijk and Leimona, 2010).

The term 'payment for ecosystem services' receives broad application to a range of market-based environmental policies (Engel *et al.* 2008). However, a stricter definition provided by Wunder (2005) is generally used in recent documentation of PES. Wunder (2005) defines PES by five characteristics:

(1) *It is voluntary:* PES is distinguished from command and control policies by being a negotiated framework between a purchaser and a provider of an ecosystem service. This assumes that providers have real land-use choice.

(2) *It is based on a well-defined environmental service:* The purchaser must be confident they receive the agreed quantity of the relevant ecosystem service, either through direct measure or through an appropriate proxy. A PES programme for a service that is difficult to monitor is unlikely to hold the confidence of purchasers.

(3) PES *involves payment from at least one purchaser,* and

(4) *To at least one provider:* A PES differs from some conservation and development policy instruments in that it is a commercial arrangement. Payment and monitoring of service provision often take place through an intermediary such as government acting on behalf of taxpayers or businesses.

(5) A working PES programme is contingent upon the ongoing provision of the ecosystem service in question, and hence payments are *conditional:* they are linked to provision with monitoring to ensure the contract is being upheld.

Few programmes currently exist that satisfy all five of Wunder's (2005) conditions (Landell-Mills and Porras, 2002; Wunder, 2005). In particular, directly linking the payment to a particular environmental outcome can be difficult to achieve as natural variation, long time lags or complex ecological non-linearities can obscure the contribution of an individual's actions to the final ecosystem service outcome. Given this, Muradian *et al.* (2010) proposed a broader definition of PES as "a transfer of resources between social actors, which aims to create incentives to align individual and/or collective land use decisions with the social interest in the management of natural resources."

A key aspect of PES that warrants additional discussion is the extent of 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). However conditionality can be applied at different levels. Van Noordwijk and Leimona (2010) defined conditionality on a spectrum, 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. Choosing the extent of conditionality required to deliver fully the required ecosystem service at the least cost to farmers is an important component of PES design. It is thus a key focus of the choice experiment described in this paper.

In summary, meeting a strict definition of PES, such as that provided by Wunder (2005) is not an indication of programme design quality, or the likelihood of success. A successful PES must be tailored to the particular socio-economic, political, cultural and biophysical context of the environmental problem in question (Jack, *et al.* 2008; Kemkes, *et al.* 2010). This includes consideration of the preferences of those targeted for participation.

REDD+ and the potential for PES in the East Usambara Mountains

The potential for applying a PES type mechanism in the East Usambara Mountains is likely improved by the recent development of REDD+ (reducing emissions from deforestation and forest degradation) policy mechanisms and funds. PES is recognized as a key method of achieving REDD+ goals due to its emphasis on conditionality.

From a global perspective, the rationale for forest conservation in the East Usambaras is foremost for biodiversity conservation. Given the area's high biodiversity value, effective conservation would represent an environmental benefit of global significance. However, the area's forests also provide carbon sequestration benefits (to the global community) and water provision benefits (to the local and downstream communities). The benefits of carbon sequestration in particular provide conservation

policy administrators with the opportunity to derive biodiversity conservation financing from REDD+ sponsoring funds.

REDD+ is developed and promoted by the United Nations Framework Convention on Climate Change (UNFCCC, 2009; Cerbu, *et al.* 2011). The expansion of REDD+ over time has elevated the status of co-benefits such as poverty alleviation and biodiversity protection (Campbell, 2009). These co-benefits are of considerable importance in making the case for REDD+ intervention in the East Usambaras due to the high biodiversity of forests and relative economic disadvantage found in the area.

Several agencies have implemented programmes to prepare countries for the large-scale operation of REDD+ mechanisms, such as the United Nations' UN-REDD and the World Bank's Forest Carbon Partnership Facility. Tanzania is one of four countries that have reached the 'implementation' stage of the UN-REDD programme, via USD 4.2 million of investment in administrative and monitoring capacity (UN-REDD, 2011). In addition, there are a number of bilateral agreements between governments of industrialized nations and governments of tropical developing nations specifically for REDD+ programme preparation and implementation. Of particular note is the Government of Norway's International Climate and Forest Initiative, which has allocated USD 83 million to REDD+ activities in Tanzania over a five year period (NORAD, 2011). The potential availability of REDD+ resourcing is thus substantial.

REDD+ developments are highly relevant to PES based conservation efforts in the East Usambaras for three reasons. Firstly, the funds available for REDD+ activities are substantial and likely to be available in the near future. Secondly, the REDD+ emphasis on conditionality and incentive based policy means that PES is well suited

to achieving REDD+ aims. Thirdly, the inclusion of ‘co-benefits’ into the REDD+ framework means that the conservation opportunities in the East Usambaras closely match the priorities of funding agencies.

Despite this there are no existing PES programmes in the East Usambaras, although pilot projects are currently being considered. There are very few operational PES programmes in Tanzania. Two examples are a trial ‘payment for watershed services’ scheme, recently implemented in the Ruvu subcatchment, Uluguru Mountains (also part of the Eastern Arc) (see Yanda and Munishi, 2007; Lopa, 2008; Fisher, *et al.* 2010), and a wildlife management agreement between a group of wildlife tour operators and farmers in the rangelands adjacent to Tarangire National Park (see Nelson, *et al.* 2010). In addition there are a number of clean development mechanism (CDM) projects in operation or in planning, which use voluntary carbon credits to finance local greenhouse gas reducing projects (Econ Pöyry, 2009). However, at present there is no overall PES policy framework for natural resource management in Tanzania (Fisher, *et al.* 2010). The lack of PES policy experience is an impediment to successful programme implementation, and thus careful prior research into programme feasibility and design is required before benefits are likely to be realized.

Study site description

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. This range is comprised of thirteen ancient mountain blocks that stretch from southern Kenya to southern Tanzania. These mountains support rainforest cover in wetter areas and deciduous woodland in drier areas, with an elevation gradient contributing to a diverse array of forest ecosystems (Lovett,

et al. 2001; Burgess, *et al.* 2007). The range receives more precipitation and cooler temperatures than the surrounding plains. 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, and the East Usambaras in particular, have developed extremely high levels of species richness (Lovett, *et al.* 2001; Hall, *et al.* 2009).

Of the Eastern Arc Mountains, the East Usambaras are considered to be one of the most important regions biologically with the highest endemic species density (per $100km^2$) of any ecosystem known in the world (Myers, *et al.* 2000). The East Usambaras, as part of the Eastern Arc, are a recognised 'Global Biodiversity Hotspot', a grouping of the most valuable and vulnerable ecosystems worldwide (Myers, *et al.* 2000; Brooks, *et al.* 2002). The East Usambaras also form an important catchment supplying water for the nearby city of Tanga (with a population of approximately 240,000 in 2002).

The agro-ecological context

The forests across the Eastern Arc 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 (Newmark, 2002; Hall, *et al.* 2009). These direct causes of degradation have been facilitated by deeper structural causes, such as land ownership patterns, lack of environmental law enforcement and corruption (Milledge, *et al.* 2007; Vihemäki, 2009). Approximately only 30 percent of the original forested area in the Eastern Arc Mountains remains, and 71 endemic or near-endemic vertebrate species are considered endangered (Burgess, *et al.* 2007). In the case of the East Usambaras, 57 percent of the original forest cover has been lost, mostly in the past 35 years (Newmark, 2002).

One cause of deforestation, on-farm removal of trees by smallholder agriculturalists, continues due to the cultivation of cardamom *(Elettaria cardamomum),* as part of a series of

crop rotations, planted and removed in response to changing soil nutrient status. Cardamom is an important cash crop grown by an estimated 60 percent of farmers in the upland region. Income from this crop constitutes approximately 30 percent of the average household's income (Reyes, *et al.* 2009).

Cardamom is planted within the standing forest after the understory, midstory and parts of the overstory have been removed (selective thinning). Despite profitable initial yields, productivity decreases rapidly over a period of 3-7 years (after planting) due to nutrient depletion. Fertilizing with manure or replacing cardamom plants can allow for second and subsequent rotations, however in many cases, the remaining overstory is removed and the field is used for cropping. A common 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 rainforest regeneration (Reyes, *et al.* 2006).

Of the remaining forest in the East Usambaras, approximately 26 percent has already been planted with cardamom, meaning that the process of land conversion is underway (Reyes, *et al.* 2006). This process is exacerbated by a gradually increasing population, which in conjunction with the pattern of land distribution and management, has led to land scarcity (Mwanyoka, 2005).

There are alternative land management practices recently proposed that could maintain some degree of ecosystem functionality while allowing for ongoing cardamom production. Although original forest provides the highest biodiversity values, maintaining the cardamom agroforests would be preferable to complete forest cover loss (for instance, due to conversion to sugarcane). Leonard, *et al.* (2010) found that agroforests in the East Usambaras support a

range of important flora species and threatened bird species. Of particular note, 'improved' agroforestry systems may be developed. Such systems are thought to have higher biodiversity and carbon sequestration 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 features the application of manure fertilizer. Midstory and overstory species are allowed to regenerate around the cardamom, which is planted in lower density than in conventional cardamom agroforests. Yields and subsequent profits are estimated to be lower than those from conventional cardamom agroforestry and sugarcane (Bullock, *et al.* 2011), although the extent of this discrepancy varies considerably due to fluctuations in cardamom and sugarcane prices. Regardless of the exact profit differences however, it is likely that long-term maintenance of improved agroforestry requires providing farmers with additional incentives above the profits that are already associated with this farming method. The hypothetical PES programmes developed for this study focus on this goal.

Experimental approach

This study uses a choice experiment to quantify farmers' preferences for different elements of PES programme design. Choice experiments are a stated preference valuation technique where respondents are asked to make choices between competing hypothetical goods or contracts in a questionnaire (see for instance, Adamowicz, *et al.* 1998). Each choice as presented in the questionnaire is called a 'scenario'. The hypothetical good or contract is described by a package of 'attributes' (for instance the environmental quality, the payment amount). Each attribute can take on a number of options (for instance, high or low environmental quality, high or low payment) and these options are varied between the scenarios presented to respondents. Respondents

are asked to choose between two competing hypothetical contracts, each which have different attribute options as chosen by the researcher.

Choice experiments can be used to determine the value of the individual attributes that make up the contract and so are suitable for the analysis of preferences for policies/programmes which have a number of components. The hypothetical nature of choice experiments means they are also one of the few means of predicting preferences for (and behaviour under) polices that have not yet been implemented. Choice experiments are similar to conjoint analysis (which involves ranking or rating hypothetical scenarios) but the use of discrete choice makes them consistent with random utility theory (Adamowicz, *et al.* 1998). A technical summary of the choice experiment conceptual framework is provided in appendix 1.

General concepts of conditionality, payment type and opportunity cost were adapted to tangible programme design attributes. Levels for each attribute were then chosen based on extensive pretesting in the East Usambara villages of Shambageda and Kwezitu. This process involved three pilot survey rounds with a total of 77 participants. Follow up questions about the questionnaire were also posed to respondents of the pilot study. Pilot survey rounds were conducted in September, 2010, by the first author of this paper.

A key attribute of the hypothetical programmes presented to respondents is the primary payment vehicle. This was a per acre[1] annual amount that would be paid directly to the farmer in return for their agreement to protect trees on farm. There were two versions of the primary payment vehicle tested: a static payment, where the

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

monetary amount paid would be constant from year to year, and a variable payment, where the monetary amount paid would fluctuate with the price of cardamom.

In addition, two alternative payment vehicles were included in the hypothetical programmes. The first alternative is a group payment, where a per-acre amount would be donated annually to a fund for investment in village communal infrastructure (roads, the school, the hall). The group payment represents 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. It was hypothesized that this might take advantage of existing social norms to encourage land holders/managers to make a contribution to their community by way of farm management.

The second alternative payment is a once-off, per-acre upfront payment specifically for the purchase of manure fertilizer. This latter approach represents a 'co-investment' between the sponsoring organization and the farmer to improve the productivity of his/her farm. Doing so can avoid the need to clear additional forest or to convert nutrient-depleted agroforest to sugarcane. This is based on the findings of Reyes (2008) in which manure applications were found to increase cardamom yields by approximately 50 percent. 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. The seemingly high cost of fertilization is due to costs of labour to transport manure to sometimes distant and scattered fields. This cost information was collected during structured interviews with landholders.

Three different levels of conditionality were incorporated into the experiment. At the least arduous level, farmers would be expected to simply fill out a logbook of their

farm activities, and hence farmers are simply trusted to abide by the spirit of the programme, with the possible chance of an audit of the logbook. This was based loosely on a logbook system used in the East Usambara Novella *Allanblackia* project, an ongoing effort to increase cultivation of fruit from *Allanblackia stuhlmannii* trees (UNDP, 2009). At the intermediate level, farmers' properties are inspected once per year by a local villager hired by the programme, but face no requirements for the health of tree cover or the quantity of understory. At the most arduous conditionality level, farmers face twice yearly inspections from a forestry officer who considers both tree density and species requirements. Table 1 shows the full schedule of attributes and levels.

Table 1: Attributes and levels presented in hypothetical contracts

Attribute	Description	Levels
Individual payment	Amount of money provided directly to farmer for maintenance of agroforest (per-acre payment, annually)	Approximate USD: 0, 21, 50, 176
Collective payment	Amount of money provided to a dedicated village development fund for maintenance of agroforest (per-acre payment, annually)	Approximate USD: 0, 21, 50, 176
Upfront fertilizer payment	Provision of a one off, upfront payment for the 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 farm.	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 farm. The officer will ensure that there are enough saplings for canopy replacement and that trees present are indigenous species.	Yes, No (binary variable)

The payment amounts were selected a priori based on the opportunity cost of maintaining an ‘improved agroforest’ over a sugarcane plantation. Costs and revenues of the different farming operations were sourced from Bullock *et al.* (2011). Payment amounts were then adjusted during three rounds of pilot surveys to achieve an appropriate distribution of bid acceptance levels. In other words, the initially selected payment amounts were adjusted so that the highest bid was generally accepted and the lowest bid generally rejected so to ensure a statistically robust outcome at the analysis stage.

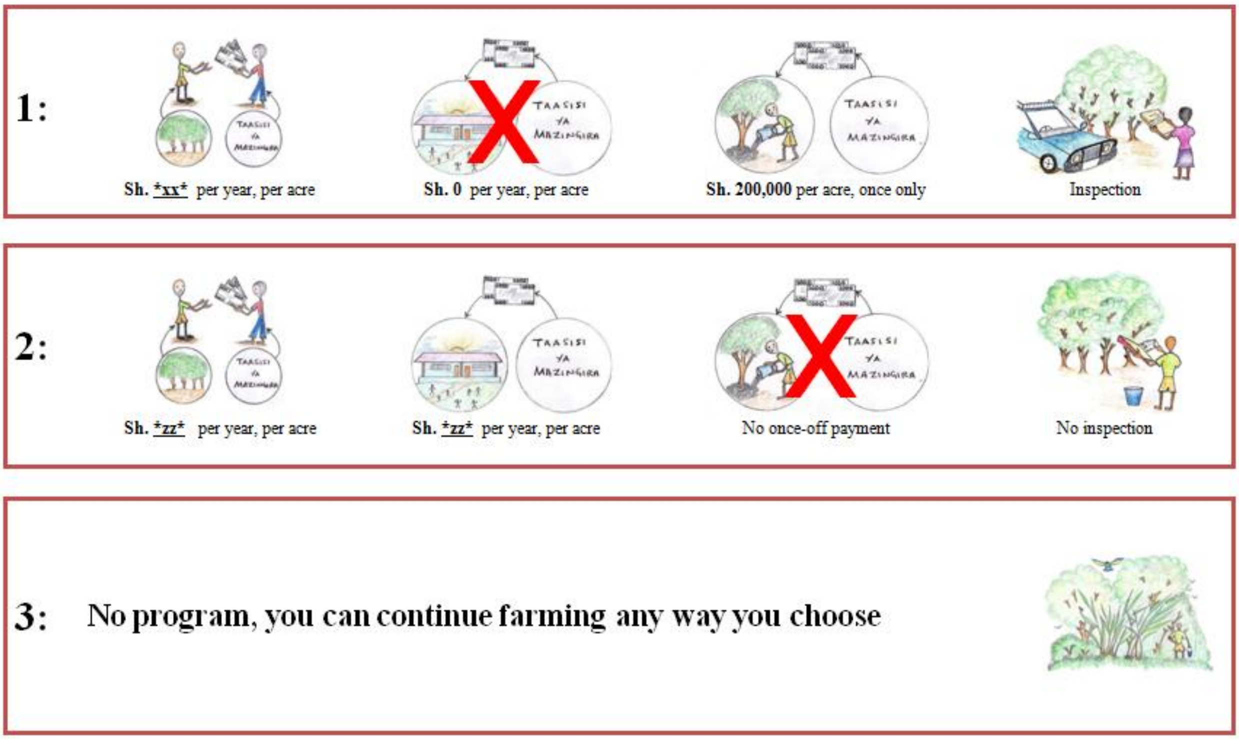
Contracts were stipulated as lasting for ten years. Premature departure from contracts (i.e. violation of contract conditions) would result in a fine of approximately USD 35 and the cessation of further payments. This amount was chosen so to approximately match the fine currently existing for the infraction of cutting a protected species of tree. Farmers were also told that they must enrol all of their owned/managed land into the programme if they were to take part. Permitting farmers to enrol only part of the landholdings could allow farmers to geographically shift forest cutting activities while still receiving income from PES, a problem known as ‘on-farm leakage’ (Engel, *et al.* 2008). Section 0 contains further discussion on this issue.

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 programme. Similarly, payment would be lower when

sugarcane prices were lower as the incentive to leave the programme would be diminished. Farmers were told that on average their annual payments would be equal to (approximately) USD 21, 50 or 176, matching the static payment described in Table 1.

The questionnaire was structured with an introductory section collecting information on the participant's farming practices upfront. This was followed by an information section explaining the deforestation problem, an explanation of the upcoming choice experiment procedure, and a cheap talk script (see appendix 2). The choice scenarios came next, presented in picture form (Figure 1) and accompanied by a verbal description. A series of socio-demographic questions concluded the questionnaire.

Farmers were questioned in Kiswahili (the national language of Tanzania) in face-to-face interviews with trained enumerators 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 - 88 farmers, Kisangani - 64, Kagare – 55, and Gonja - 44) with a small number from nearby Shambageda village (Shambangeda B - 11 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 numbers of households surveyed was approximately 50 percent of the total households in the case of Kwezitu. Participation rates were high with an estimated 90 percent of farmers approached prepared to take part. Surveys were undertaken in private and took an average of 42 minutes each. A small gift was provided for participation but no monetary compensation was given.



Note: A verbal description given by the enumerators accompanied each picture scenario, explaining each attribute and attribute option.

Figure 1: Example scenario as presented in pictures to respondents. The three blocks correspond with the three possible choices that respondents have: PES programme 1, PES programme 2, or no PES programme. Farmers were asked to choose one of the three, based on their preferences for the attributes associated with each. Attributes changed between scenarios.

Key findings

Table 2 presents summary socio-demographic statistics for the farmer sample. 75 percent of surveyed farmers were men, indicating the (self identified) prominence with which men act as primary decision makers with regards to farm decisions. Only one third were born in the village they were living in. Level of education was fairly homogenous across the sample, with 91 percent of participants having attended primary school only.

Table 2: Summary socio-demographic characteristics of sample (sample size: 220)

	Mean	St. Dev
Sex (proportion men)	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	-
Yams	90.6	-
Bananas	97.1	-
Other Spices	89.4	-
Cassava	79.6	-
Sugarcane	38.8	-

The conceptual treatment of choice experiment data is explained in appendix 2, and multinomial logit regression results are presented in appendix 3. The outcome of the analysis described in these appendices gives rise to a number of key findings. These are of relevance firstly to the designer of a potential East Usambara PES programme, but also demonstrate some broader principles with implications for PES scheme design at other sites.

Key finding 1: The nature of payment greatly influences likely participation rates

The choice experiment compared three hypothetical payment types, a direct payment to individual farmers, a group payment to a special village development fund, and a dedicated once-off payment for organic manure fertilizer. All payments were quoted in per acre terms and were to be paid annually for the life of the ten-year contract (with the exception of the once-off manure fertilizer payment).

Both the manure fertilizer payment and the individual, annual cash payment were found to be effective at motivating hypothetical participation in a PES programme. The group payment proved highly *ineffective* at promoting hypothetical participation. The manure fertilizer payment, worth USD 140 per acre, was enough to persuade the median farmer to accept a hypothetical programme without additional yearly PES payments for the life of the 10-year contract. This is likely due to two reasons. Firstly, the expected financial benefits from manure fertilizer due to improved agroforest productivity is likely greater than the upfront value of the manure fertilizer itself (Reyes, 2008; Bullock, *et al.* 2011). Secondly, manure is difficult to procure (due to supply and transportation limitations) and hence valuable.

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 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. It is conceivable that a modification of the proposal here would be suitable, for instance, periodic provision of the manure fertilizer payment throughout the life of the contract.

The group payment was highly *ineffective* at promoting hypothetical participation. Under this hypothetical payment type, farmers were told that the per-acre, annual amounts would be deposited into a dedicated village fund for use on communal infrastructure (roads, the school, the hall). Participants were told that this fund would be a new, special fund which would be overseen by the environmental organization administering the PES programme. The group payment represents a collectivist

approach to PES, where individuals make a contribution to the welfare of the village as a whole through actions on their own farm. It was hypothesized that this might take advantage of existing social norms to encourage land holders to make a contribution by way of farm management. However, this payment's effect was insignificantly different from zero in most model estimations. At most, this payment may have had a very small effect (as suggested by one aggregated data model), with an effect one-eighth the size of that of the standard individual payment, per dollar spent.

Key finding 2: The required amount of payment is highly variable between farmers

Willingness to accept (WTA) values – the payment amount required to convince the median farmer to participate – were calculated for different elements of programme design[2]. Without the manure fertilizer payment and with a moderate conditionality regime, a USD 28 per acre per year payment is required to convince the median farmer to enroll. If the payment from year to year varies in line with the opportunity cost of maintaining the forest (or at least part of it, the price of sugarcane), the required payment is USD 79, even if both payment regimes provide an equivalent amount when averaged out over time.

The impact of the manure fertilizer payment is dramatic, causing WTA to become negative. Hence the upfront manure fertilizer of value USD 140 per acre is in itself enough to convince the median farmer to enrol.

[2] 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 (Hanneman, 1984). This process can be extended to determine the overall WTA required to induce participation by subtracting the marginal utilities of programme attributes from the marginal utility of the status quo option. The status quo coefficient represents the marginal utility of not participating in a programme. To determine the median WTA value required to induce participation in a programme we used the variable treatment model and the combined model (see Table 5) as the static treatment model alone does not find a significant status quo coefficient.

Table 3: Willingness to accept amounts (per acre, per year for a 10 year contract).

	Conditionality	Median WTA (USD)	Std. Error (USD)
No upfront manure fertilizer payment	Moderate	28.3	14.9
	High	59.6	14.0
Upfront manure fertilizer payment	Moderate	-55.5	16.9
	High	-24.2	15.5

Note: Data from both the static and variable payment treatments are used in calculating these figures (See Table 5 in appendix 3).

These WTA estimates are broadly comparable to existing estimates of the profit discrepancies (opportunity costs) estimated between competing land uses (Bullock, 2011). However, these estimates represent the median preferences of participants as a whole, and hence assume that programme preferences are homogenous. It is probable that there exists a range of preferences amongst participants which may be categorized into discrete classes representing the main 'types' of participant. Latent class analysis, a post hoc statistical classification process, is used for this (see appendix 1 for details of this analytical approach, and Table 6 in appendix 3 for regression results).

We found a high degree of variation in WTA values between farmers. We found evidence of two classes of farmer in the sample: those who appear prepared to enter into a conservation contract without payment (class 1), and those who require high levels of compensation to participate, and are on the whole reluctant to take part (class 2). The latter class is smaller, with 21 percent of respondents. The average of these two classes' WTA values, weighted by the class probabilities, gives rise to the overall WTA figures reported in Table 3.

Class 1 is defined by preferences similar to those reported in the whole model (see Table 4 in appendix 3). However, in addition to the individual payment, group payment is shown to have a significant effect (although it provides only 23 percent of the utility of the individual payment per dollar). The manure fertilizer payment coefficient remains strongly positive and a preference for either a low or moderate level of conditionality (compared to a high level of conditionality) remains. Class 2 on the other hand is defined simply by strong resistance to PES.

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

The strong discrepancy between the preferences of members of the two classes means that the reader should be cautious in the use of the WTA results. The apparent willingness of class 1 members to participate without payment suggests that 'hypothetical bias' may be an issue (see Appendix 2 for details). These farmers may be overly enthusiastic in their questionnaire responses and be failing to consider fully their financial position before responding. We believe that robust conclusions may still be drawn in regard to preferences for particular programme elements (for example, levels of conditionality). However, further investigation of WTA values for the overall programme may require the use of a mechanism like a reverse auction.

Key finding 3: There is a trade-off between the conditionality level and payment required to encourage participation

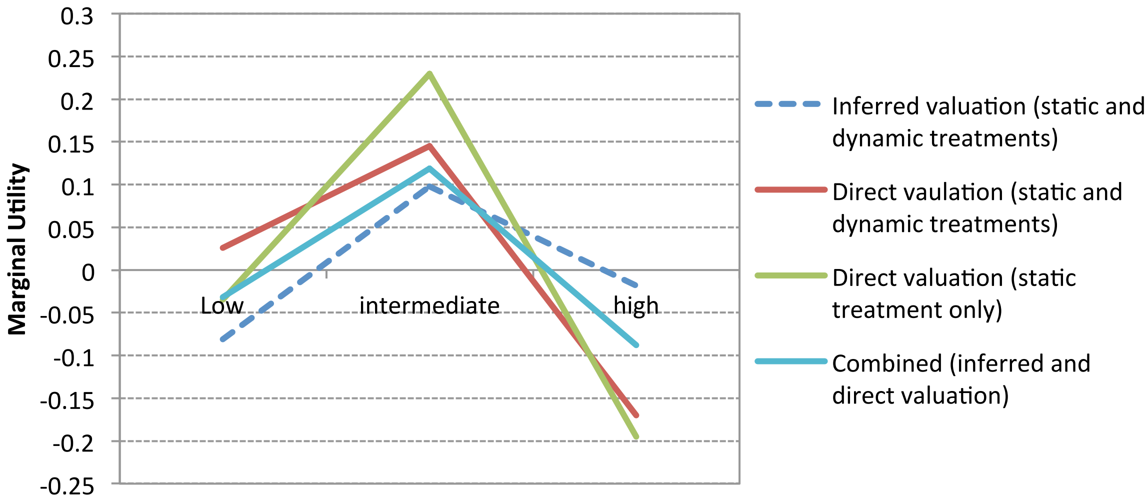
Table 1 above contains a description of conditionality levels, and the associated enforcement regimes, tested in the choice experiment. To attract farmer participation, a programme with moderate conditionality requires lower payment than a programme with high conditionality. This difference is unsurprising: the conditions associated with the high conditionality requirement (for instance the need to protect some understory) inhibit the ability of farmers to maximize profits from their agroforest, and is a more onerous responsibility in general (for instance, two inspections per year). However, the environmental benefits of a programme with these restrictions are likely to be higher than the benefits of a programme with fewer restrictions. A comparative study on plant species richness by Hall *et al.* (2010) 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 programme expense and biological benefits.

Key finding 4: Preferred levels of conditionality may be non-linear

Conditionality is a defining characteristic of PES: payment is conditional on some defined performance criteria that must be met by the ecosystem service providers (Wunder, 2007). The choice experiment presented farmers with one of three levels of conditionality: low, moderate and high (see Table 1 above).

We find evidence for a non-linear response to the extent of conditionality. Farmers were most likely to participate in a programme which held them to account with regard to their actions (conditionality - moderate) and less likely to participate in a

programme which held them to account with regard to environmental outcomes (conditionality – high). The latter is a more stringent standard and hence costlier for the farmer to comply with. Surprisingly however, participants also showed a preference against the lowest level of conditionality which was based simply on trust and intentions rather than a physical inspection for compliance.



Note: Dash line indicates statistical insignificance. The four lines represent different models based on different treatments and/or questioning approaches (described in appendices 2 and 3). They are found to be approximately equivalent in regards to this finding.

Figure 2: Marginal utilities associated with different conditionality regimes. A higher marginal utility represents greater preference for that conditionality option.

It is likely that although the lowest level of conditionality is easiest for farmers to comply with, they do not believe such a regime is plausible or represents good policy. It is possible that farmers who support the goals of a policy (for instance, to prevent deforestation) will base their preferences not only on what the policy can do for them (the payment) but also in terms of whether it is likely to meet its wider social goals.

Key finding 5: A constant annual payment is preferred to a variable payment

We tested a payment version where the payment amount tracked a key opportunity cost of the desirable land management action, the price of sugarcane (a common land use alternative to forest and agroforest, see Figure 2). Half of the sample was told that their individual payments would vary from year to year, following the price of sugarcane. The envisaged purpose of such a fluctuating price was to prevent farmers from dropping out during periods of high opportunity cost, and to reduce programme expenditures during times of low opportunity cost. Farmers were told that on average their payments would be equal to (approximately) USD 21, 50 or 176, matching the static payment.

Despite the supposed equity of payment amount over time, the static payment was strongly preferred. It is likely that the complexity and the additional risk (unsteady income) associated with such a payment mechanism is a deterrent to many farmers.

Key finding 6: The institution used to manage collective funds shapes farmer attitudes

Early pilot versions of the questionnaire referred to the 'Village Development Fund' (VDF) as the recipient of the group payments. This existing fund receives payments from higher levels of government and is supposed to fund village infrastructure. However interviews undertaken during preliminary stages of data collection suggested that its management is viewed sceptically. Versions of the questionnaire that mentioned the VDF gave model estimations with significant negative coefficients for the group payment, meaning that payment actually *decreased* the likelihood of farmer participation. This effect reversed in later questionnaire versions when the VDF was replaced by a hypothetical fund described as a "new, special fund [which

would] utilize the money on things like the school, the road or the dispensary." Participants were told that this fund would be audited by the programme administrators to ensure that this money was correctly spent. Insights gained through structured interviews supported the hypothesis that mistrust of the existing VDF's management was influencing the response to the group payment proposal.

A note on the generalization of results

It should be noted that the results summarized here, particularly the WTA values, are a product of the hypothetical programme design. Departure from this particular PES model towards alternative PES models would reduce the extent to which these results predict behaviour.

It is thus important to keep in mind the key elements of the hypothetical programmes presented to respondents in this study. The choice experiment was intended to realistically mimic a programme that could incentivize the maintenance of improved agroforestry. Farmers were told that they had an option of entering a ten year contract which required the preservation of large trees and, depending on the conditionality level, a certain amount of understory vegetation. Premature departure from the contract (i.e. a violation of conditions) would result in a fine of approximately USD 35 and the cessation of further payments. Farmers were also told that they would have to enrol all of their owned/managed land into the programme.

Results found in this study are most likely to be applicable to other PES proposals and situations when the programme design is broadly similar to that used here. Attitudinal differences (for instance trust in institutions such as government and environmental agencies, desire to conserve forests for intrinsic reasons) and socio demographic differences (income, education levels, farming activities) will further reduce the

extent to which these results can be generalized to other situations. Agronomic differences would change the costs and revenues faced by famers and thus change the amount of compensation likely required to achieve a given enrolment level amongst farmers.

However, many of the qualitative conclusions are likely to be relevant across a wide range of PES models, and furthermore, across a range of locations. General principles such as the trade-off between conditionality and compensation (key finding 3), the considerable preference discrepancy arising from the form of payment (key finding 1), the importance of institutions (key finding 6), the preference for static payments rather than variable payments (key finding 5) and the existence of substantial preference heterogeneity within a population (key finding 2) are likely to remain relevant.

The way forward for conservation in the East Usambara Mountains

In concert, the key findings presented in this chapter indicate the possibilities open to policy makers attempting to halt deforestation while respecting the economic needs and aspirations of East Usambara farmers. These findings complement previous research efforts undertaken in this region, and *relative* to other sites in sub Saharan Africa, the knowledge base required for policy implementation is well progressed here. Although substantial uncertainties remain, a pilot PES programme is likely feasible from a microeconomic perspective. The following points propose key design elements for a pilot PES based on the key findings presented above, complemented with insights from the literature.

Quantification of environmental benefits

A first step towards establishing PES is quantification of the ecosystems services that would flow from such a programme. There has been considerable documentation of these benefits in the East Usambaras. For instance, Munishi and Shear (2004) estimated the carbon value of forests in the East Usambara region (approximately 517 tonnes of carbon per hectare in tree biomass, and 418 tonnes of carbon per hectare in soils), data important for the accurate accounting of REDD+ type funding. Leonard *et al.* (2010) and Hall *et al.* (2010) reported on the biodiversity values of different land use types, including forests, agroforests and open fields. Bullock *et al.* (2011) reported on the opportunity costs of forest conservation in their calculations of profitability of different agricultural activities. These data can be used to assess the quantity of 'ecosystem services' that can be expected from a particular PES programme configuration. A detailed knowledge of such information allows policy makers to assess the (financial) costs and (environmental) benefits of competing PES designs.

Payment mechanisms

It is likely that a combination of individual payment and manure fertilizer payment would be most successful at attracting participation. Although the fertilizer payment was sufficient in itself to encourage participation, an additional cash payment may be required to keep farmers within the programme if cardamom prices fall. It should be noted that cardamom prices were very high at the time of this study – approximately TZS 30,000 (USD 20) per bucket of green cardamom at the farm level. It may also be more appropriate to supply the manure fertilizer payment at regular intervals

throughout the contract length, so as to maintain productivity over time and to maintain the strength of the incentive to honour the conservation contract.

Support for the manure fertilizer payment approach is provided by Fisher, *et al.* (2011), who reported that REDD+ in Tanzania is likely to fail unless agricultural intensification policies (such as fertilizer provision) are pursued in addition to straight payments. They reported that although this adds to the expense of a PES programme, it could reduce leakage and deliver poverty alleviation benefits.

An additional consideration for policy designers is the way in which cash payments are distributed. A positive social outcome depends not only on the amount of payment (the primary question considered in this research) but also on whom the cash is paid to within the household. Past experiences with monetary compensation for conservation activities in the East Usambara area have highlighted this. During creation of the Derema corridor (a conservation area) for instance, payments were made to households who lost their farms, however these payments typically were to men. This left many women lacking access both to land and the compensation, and thus unable to participate effectively in household financial decisions (Rantala and Vihemäki, 2011).

Conditionality and enforcement

From a farmer-preference perspective, we find support for the use of an intermediate or strong conditionality requirement (with a corresponding intermediate or strong enforcement regime). A lower level of stringency was not found to always improve participation. Given that illicit environmental activity (illegal logging and clearing) still occurs, the monitoring regime will be important to ensure the goals of the programme are met.

Policy designers will need to consider the treatment of original forest in a PES programme. Payment for agroforest could see farmers increase cultivation in previously untouched forest areas in order to earn payments for those areas also. To prevent this, payment will need to be supplied both for original forest and for agroforest. Given that even under such a regime, a profit discrepancy will still exist between the cultivated agroforest and the uncultivated original forest, either regulations or a payment differential will need to be utilized. This is unlikely to have a large effect on the overall PES budget given that original forest is already fairly rare on farms.

Some form of ground inspection will be required in addition to satellite imagery monitoring. Satellite imagery has difficulties distinguishing between agroforest and original forest, and also is limited by the high levels of cloud cover over the East Usambaras (Hall, 2006). The ground inspections could also play an outreach role in addition to simply policing the programme, informing farmers of their contract responsibilities, collecting feedback and promoting improved farming techniques.

It will likely be necessary to insist that farmers enrol the totality of their landholdings in the region when joining the PES programme. Permitting part enrolment could allow farmers to geographically shift forest cutting activities while still receive income from PES, an occurrence known as 'on-farm leakage' (Engel, *et al.* 2008). It is acknowledged, however, that this restriction may increase the risk of subsequent 'off-farm leakage'. If farmers are restricted from cutting their own trees they may turn to unprotected reserve areas to source building materials and firewood. This risk could be moderated by allowing farmers to cut trees planted for timber purposes, or to cut certain tree species that are considered less environmentally valuable. Further

consultation with local communities and forest managers may be required to find an approach that best balances the risks of on- and off-farm leakage.

Group payments and bonus payments

The attraction of a group payment is the possibility of harnessing both financial incentives and social incentives to conserve simultaneously. By linking compensation to the activities of the collective, pro-social behaviour may operate to encourage participation in and compliance with PES contracts. The group payment used in this hypothetical study however, a group payment for village infrastructure was highly ineffective in motivating hypothetical participation.

However, there are alternative types of group payments that may be worth incorporating into a pilot scheme, such as a 'collectively conditional' group payment. For instance, a group payment to a village fund could be conditional on a certain proportion of the enrolled farmers meeting the terms of their contract. Or, a bonus payment could be made to individuals based on the performance of the group. Such a mechanism was trialed in an Australian pilot scheme where farmers could buy and sell 'salinity credits' in order to meet salinity reduction targets (Connor, *et al.* 2008). Farmers received a 'community performance bonus' when the group as a whole met an overall target, and thus harnessed social incentives in parallel to financial incentives. The scale on which such an incentive would apply (for instance, sub-village, village, district etc.) would require careful consideration.

In addition, achieving environmental benefits such as species conservation often depends on the spatial pattern on protected land, requiring coordinated effort across multiple farms (Nelson, *et al.* 2008). Collective bonus payments, or 'agglomeration bonuses' could be used to achieve this, where landholders receive an additional

payment or increased payment if adjacent farms enter into the PES programme (see for instance, Parkhurst, *et al.* 2002). Although such collective bonus payments are not the focus of this research due to the normal limitations of time and finances (and hence are not reviewed in depth here), they may merit consideration as part of a pilot PES for the East Usambaras.

Conclusion

There is a clear need to prevent further deforestation and forest degradation in the East Usambara Mountains given the array of environmental services produced there. Previous conservation attempts via the declaration of new forest and nature reserves have successfully conserved some areas of forest, but there is a danger that deforestation has simply been displaced elsewhere. In addition, there is recent evidence that some of these conservation efforts have caused social and economic disadvantage in already poor communities.

However, several years of detailed research and the increased funding being made available to promote REDD+ type activities means that opportunities to implement effective conservation programmes are growing. PES offers one potential means to achieve conservation while minimizing social tension and economic disadvantage.

This research has aimed to quantitatively document the preferences of farmers targeted for participation in a future PES programme, and in doing so, predict their likely behavioural response to different PES configurations. Notable results included: a high hypothetical response to a manure fertilizer payment; a minimal or zero hypothetical response to a group payment; conditionality preferences that were surprisingly non-linear; a preference against payment fluctuating in line with opportunity costs, a high level of preference heterogeneity within the sample of

farmers; and, the importance of selecting and/or creating trusted institutions to administer conservation funds. We have also calculated willingness to accept values, which give an approximate indication of the per acre costs of agroforest conservation. Stated preference research such as this cannot predict farmer responses perfectly or completely, and is limited by the number of design elements that can be incorporated in the hypothetical scenarios, and hence a pilot programme is likely necessary to investigate outstanding uncertainties.

Appendices

Appendix 1: The Choice Experiment Model

It is assumed that farmers face a loss of utility due to the conditionalities of a PES contract, and a gain of utility from the associated payment(s). A farmer is assumed to choose a contract if the net utility from that choice is greater than either no choice 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).

Each hypothetical contract presented to questionnaire respondents features a different combination of attributes and levels. The overall utility derived from a contract is expressed as a utility function:

$$U_i(P_h) = U(Z_h; X_i) \quad \text{Equation 1}$$

Where P_h is the h^{th} PES programme scenario, $U_i(P_h)$ is the utility derived from that scenario, Z_h is a vector of attribute levels that make up programme P_h, and X_i is a vector of characteristics of the i^{th} farmer. Utility is assumed to be partially a function of profits made by the farmer, which in turn are partially a function of the nature of the PES programme, P_h.

The utility function above 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}:

$$V_i(P_h) = v(P_h) + \varepsilon_{ih} \quad \text{Equation 2}$$

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

$$\pi_{ih} = \Pr\left\lfloor v(P_h) + \varepsilon_{ih} \geq v(P_j) + \varepsilon_{ij};\ \forall\, h \neq j\ \in C \right\rfloor \qquad \text{Equation 3}$$

And so $\pi_{ih} = \Pr\left\lfloor \varepsilon_{ij} - \varepsilon_{ih} \leq v(P_j) - v(P_h);\ \forall\, h \neq j\ \in C \right\rfloor$ Equation 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:

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

We represent indirect utility as a linear function of a vector of marginal utilities (B) for each programme attribute (Z_h), so that:

$$v(P_h) = BZ_h \qquad \text{Equation 6}$$

Equation 5 can then be solved using a multinomial logit model (assuming a logistic distribution of errors) using maximum likelihood.

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 analysis. Latent class analysis proposes that there exists a discrete number of preference classes into which individuals have a certain probability of falling into based on socio-demographic or other respondent characteristics (Grafton, *et al.* 2004, p. 270). Hence we assume that individual *i* belongs to a particular segment, *s* of the population, so that:

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

Where B_s is a segment specific utility parameter. Membership to a particular segment is based on a latent membership likelihood function based on attitudes, perceptions and socio-demographic characteristics. Like the utility function in equation 2, the latent membership function (M_{is}^*) has both an observed $(A_s X_i)$ and unobserved component (ϵ_{is}):

$$M_{is}^* = A_s X_i + \epsilon_{is} \quad \text{Equation 8}$$

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. If the errors are assumed to be are identically, independently distributed as type 1 extreme values (Gumbel distributed), the conditional choice probability function mirrors the multinomial logit model in equation 5. However this function is dependent on the characteristics of the individual *i,* not on the characteristics of the programme's attributes:

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

The product of equations 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.

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

It should be noted that a latent class model is not based on a predetermined behavioural relationship between an individual's characteristics and their choices, but

is a statistical classification process (Boxall and Adamowicz, 2002). Selection of the number of classes is not guided by formal criteria, however 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[3], and plausibility of results given the size of membership classes and the size of standard errors. Some analyst judgement is required. We selected a 2-class model: higher class models had very high standard errors, likely due to the over parameterization of a small dataset. Table 6 shows results for a latent class analysis of the direct valuation data.

Appendix 2: Further details regarding choice experiment design

This appendix contains a brief explanation of two further choice experiment design considerations: firstly, the need to reduce the number of possible scenarios to manageable levels using a statistical process, and secondly, the need to avoid hypothetical biases using survey design techniques.

Generating a compact experimental design

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 experimental design using the Ngene experimental design software package (ChoiceMetrics, 2011a). These were arranged in blocks of 4 scenarios consisting of two hypothetical PES programmes each and a status quo option ("none of the above"). Inclusion of the status quo

[3] Information criteria are log likelihood scores with an adjustment for degrees of freedom. The AIC (Akaike information criterion takes the form $AIC = -2\ln(L) + 2q$, where L is the log likelihood and q is the number of parameters. A variant is the BIC (Bayesian information criterion) which takes the form $BIC = -2\ln(L) + \ln(N)q$ where N is sample size. Smaller information criteria are preferred (Cameron and Trivedi, 2005).

reduces the likelihood of forced, spurious choices, and ensures consistency with standard welfare theory (Hanley, *et al.* 2001). Efficient type designs were precluded from use due to a lack of prior marginal utility estimates (ChoiceMetrics, 2011b), unavailable due to time and budget considerations (these would require a comprehensive choice experiment pre-study). Each farmer received one block – four scenarios – and was asked to make a decision on each scenario.

Avoiding hypothetical and social desirability biases

A well known disadvantage of stated preference valuation techniques is the potential for hypothetical and social desirability biases. Hypothetical bias can be defined as the discrepancy between the preferences expressed in a hypothetical survey situation and those expressed in a real market scenario (Little and Berrens, 2004). One type of hypothetical bias is strategic behaviour, where respondents give a biased response in an effort to skew results and consequently, any policy influenced by the survey's findings. This is a problem that faces stated preference techniques due to a lack of consequentiality: respondents are not bound by their response in any way, unlike agents participating in a real market (Bennett and Blamey, 2001; pp. 181).

Careful survey design can mitigate such biases. For instance, the use of cheap talk scripts, first proposed by Cummings and Taylor (1999) have been shown to reduce the extent of hypothetical bias in stated preference studies (Carlsson, *et al.* 2005). A cheap talk script simply encourages respondents to provide realistic answers. Our questionnaire makes use of the following script immediately preceding 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."

A second and related type of hypothetical bias is 'yea saying,' the tendency to express support for a programme without fully considering the trade offs (Bennett and Blamey, 2001; pp. 181). Although choice experiments are less susceptible to 'yea saying' than the other major stated preference technique, contingent valuation (Hanley, *et al.* 1998), it was considered potentially problematic in this context given the enthusiasm for environmental protection expressed during preliminary interviews and pilot surveys. Yea saying is not uncommon in developing country stated preference research (Whittington, 2010).

Yea saying is closely related to 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 these latter two types of bias by asking respondents to state how much they believe other people would pay (Lusk and Norwood, 2009a; 2009b). The basis for using inferred valuation is that an individual does not usually possess specific knowledge of the preferences of the wider population. In the absence of such information, the respondent who is asked to make an inferred valuation must use his/her own value. However, because the question concerns other people's values, and not that of the respondent, there should be no

motivation to overstate for the purposes of appearing pro-environmental to the interviewer. Lusk and Norwood (2009a) hypothesized (and provided supporting evidence) that inferred values are approximately equal to conventional self-provided values, but adjusted for social desirability bias. The resulting value is more appropriate for policy development.

All respondents were presented with their block of 4 hypothetical choice scenarios twice, firstly framed as direct valuation and secondly as inferred valuation. After answering the 4 choice scenarios for the first time, farmers were told:

> *"Now we want to know what you think the other farmers in this area would choose. You might think they would make different decisions to you, or you might think they would make the same decisions. Your answers will not affect you or your neighbours' eligibility to participate in any future programmes, and like before, will not be linked to your or their identity".*

The wording in the inferred valuation questions was identical except referred to 'they' (other farmers in the area), instead of 'you' (the farmer answering the question). All respondents received both the standard valuation approach and the inferred valuation approach.

Appendix 3: Regression results

Table 4 presents separate multinomial logit models for the inferred choice experiment scenarios and the direct choice experiment scenarios, as well as for the amalgamated data set.

Table 4: Multinomial logit models of preferences for a hypothetical PES programme, 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 2	0.098	0.072		0.145	0.076	*	0.119	0.052	**
Conditionality 3	-0.018	0.070		-0.170	0.075	**	-0.088	0.051	*
Conditionality 1[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, $\beta_1$which is calculated from effects codes coefficients for conditionality 2 (β_2) and conditionality 3 (β_3). $\beta_1 = -(\beta_2 + \beta_3)$.

Note: * = significant difference between treatment and control at α=0.1 level, ** = significant at α=0.05 level, *** = significant at α=0.01 level.

The inferred valuation data and direct valuation data models are not significantly different based on a likelihood ratio test ($\chi^2_{d.f=5}$ = 5.21, p-value = 0.39). Respondents thus expect little difference between their responses and the responses of their colleagues. Assuming that the Lusk and Norwood (2009a; 2009b) inferred valuation technique is effective in such a context, this suggests that any social desirability bias is minimal. Only models based on the direct valuation questions are used for WTA calculations.

The status quo coefficient for the direct valuation is positive, indicating that the average farmer would require payment to take part in the programme, as expected. The amount of payment required differs based on the type of payment mechanism. The upfront manure fertilizer payment has a strong effect on likely participation rates, while the group payment is ineffective

The above assessment lumps two treatments together, the variable and static payment regimes. Table 5 presents choice models of subsamples of the data based on static, variable and combined models respectively. A likelihood ratio test finds a significant difference between these treatments ($\chi^2_{d.f=6}$ = 12.996, p-value = 0.043). The status quo and conditionality variables are only significant in one treatment each, however it is likely that the smaller size of subsamples contributes to this. The coefficient for individual payment is lower under the variable payment treatment (0.059) than under the static payment treatment (0.075), indicating that the same quantity of money provides less incentive when the payment amount fluctuates year to year. Group payment is not significant under either treatment.

Table 5: Multinomial logit models of preferences for a hypothetical PES programme, based on treatment subsamples

	Static payment			**Variable payment**			**Combined treatments**		
	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 2	0.230	0.101	**	0.029	0.116		0.145	0.076	*
Conditionality 3	-0.195	0.103	*	-0.139	0.112		-0.170	0.075	**
Conditionality 1[a]	*-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]: Implicit coefficient, β_1 which is calculated from effects codes coefficients for conditionality 2 (β_2) and conditionality 3 (β_3). $\beta_1 = -(\beta_2 + \beta_3)$.

Note: * = significant difference between treatment and control at α=0.1 level, ** = significant at α=0.05 level, *** = significant at α=0.01 level.

Direct valuation data used only.

The models presented above provide evidence for a non-linear response to the extent of conditionality[4]. The static, direct model 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 in between these two extremes. A similar pattern is exhibited by the other models presented here. Hence there is evidence suggesting that there exists a non-linear relationship between utility and the extent of conditionality. An intermediate conditionality level is preferred over both a low conditionality and a high conditionality programme, giving an inverted U shape relationship between the level of conditionality and marginal utility (see Figure 2) It should be noted that these marginal utilities are relevant only under a policy scenario (i.e. when the status quo is zero), and hence are relative to each other.

Table 6 shows results for a latent class analysis of the direct valuation data. A strong bifurcation of the status quo coefficient can be seen. Members of class 1 appear prepared to hypothetically enter into the PES programme without payment. Members of class 2 however require high levels of compensation to join, and are on the whole reluctant to take part.

[4] Conditionality variables (which represent mutually exclusive, discrete, policy states) are represented in the model by effects codes. While effects codes are statistically identical to more commonly used dummy variables, dummy variables cannot be correctly interpreted in discrete choice models which include a status quo coefficient. This is because when considering *N* discrete states, *N*-1 representative dummy variables are entered into the model. The N^{th} variable is dropped to prevent perfect colinearity, known as the 'dummy variable trap'. However this makes it impossible to separate out the impact of the N^{th} discrete state and the status quo coefficient, which are confounded. Effects codes avoid this problem by using a coding specification where the omitted variable is uncorrelated with the status quo. A discussion of this issue is provided by Bech and Gyrd-Hansen (2005).

Table 6: Multinomial logit models of preferences for a hypothetical PES programme with two latent classes

	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 2	0.207	0.088	**	0.421	0.654	
Conditionality 3	-0.231	0.088	***	-0.153	0.707	
Conditionality 1[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				
Sex (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 R2	0.329702					
AIC	1216.237					
No. obs.	800					
d.f.	19					

[a]: Implicit coefficient, β_1 which is calculated from effects codes coefficients for conditionality 2 (β_2) and conditionality 3 (β_3).

$\beta_1 = -(\beta_2 + \beta_3)$.

Note: * = significant difference between treatment and control at α=0.1 level, ** = significant at α=0.05 level, *** = significant at α=0.01 level. Direct valuation data used only.

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