Payment for Ecosystem Services (PES) program design in Tanzania: Famers' preferences for enforcement and payment options

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Selected Paper prepared for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26, 2011.

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This paper is currently in draft format only. Not for citation.

Abstract:

The forests of the East Usambara Mountains, Tanzania, are internationally recognized as one of the world's most biodiverse ecosystems. However, despite past conservation efforts they face an ongoing threat from clearing for smallholder agriculture. One potential solution is a 'payments for ecosystem services' (PES) program, where farmers are paid to protect forest that lies on their farms. To determine the design of PES program most likely to attract participation, careful documentation of farmer's policy preferences is required. We quantify these preferences and determine willingness to accept values using a choice experiment approach. 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 program conditionality was not always preferred.

Keywords:

choice experiments, payment for ecosystem services, conditionality, willingness to accept, Tanzania, biodiversity

1. Introduction

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 institutions that guide the supply and demand for ecosystem services (Balmford, *et al.* 2002; Arrow, *et al.* 2000; Costanza, *et al.* 1997).

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 by economic agents 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, considerable externalities, a lack of well 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 (Engel, *et al.* 2008; Ferraro and Kiss, 2002). Payments for ecosystem services (PES) programs are one potential solution to this problem, which work by using material incentives to encourage environmentally beneficial land management actions by individuals or communities. PES programs seek to alleviate environmental externalities, strengthen property rights and improve information flow regarding the desired levels of ecosystem services. In doing so, PES programs 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 users (Arrow, *et al.* 2000; Pagiola, *et al.* 2005; van Noordwijk and Leimona, 2010).

Although established programs are still rare in developing countries, increasing attention is being paid to how they might be used in such contexts and what kind of design attributes are required for their success (Engel, *et al.* 2008; Pattanayak, 2010). Many commonly used definitions of PES (for example, the widely used definition by Wunder, 2005) are theoretically strict, defining as PES only those instruments meeting a narrow set of criteria based on rigid Coasian principles of externalities, compensation and property rights. However, for PES to be widely successful there is a strong need to adapt PES principles to varied circumstances (Jack, *et al.* 2008; Swallow *et al.* 2009).

An important part of adapting policy to a particular circumstance is taking into account the preferences of those likely affected by the policy's imposition. This paper reports on a choice experiment that quantifies ES providers' preferences for key design attributes of PES, in the East Usambara Mountains, Tanzania. The East Usambaras are recognised as one of the world's most significant biodiversity hotspots, meaning that they support extremely high biodiversity levels yet face considerable threat from deforestation (Brooks, *et al.* 2002). PES may be a suitable policy instrument to alleviate this threat, and although there are not currently such market-based programs in place in the East Usambaras, conservation authorities and organisations are considering their suitability for this region (EAMCEF, 2006). This paper reports on farmer preferences for key elements of PES program design, including payment type, payment amount and conditionality levels. Willingness to accept (WTA) values for a variety of hypothetical PES programs are presented. In quantifying farmer preferences this paper reports on what kind of responses can be expected from farmers under different PES designs.

The selection of design elements for the choice experiment is informed by the nascent debate over different 'paradigms' of PES. We consider two paradigms recently proposed by van Noordwijk and Leimona (2010): 'compensation for opportunities skipped' (COS), where payment is given for avoided actions which would otherwise be environmentally detrimental, and 'co-investment in ecosystem stewardship' (CIS), where the beneficiary makes an investment in the land management actions of the ecosystem provider that have environmental benefits. We operationalize key distinguishing characteristics of COS and CIS, tailor them to the local context and incorporate them into the set of choice experiment attributes and options. This is intended to test whether a particular PES paradigm matches farmer preferences for this particular context, or whether a hybrid approach is needed.

The questionnaire incorporates several design features intended to reduce the likelihood of hypothetical biases that can otherwise be problematic in stated preference studies. These biases include the occasional tendency for respondents to answer in ways they believe will skew the results, and any subsequent policy, in their favor. Furthermore, there is a tendency for respondents to answer in ways which they believe will receive approval from those conducting the survey, or in ways that reinforce their own moral tendencies. Methods utilized to avoid these biases include cheap talk (Cummings and Taylor, 1999), and an indirect questioning technique ('inferred valuation') proposed by Lusk and Norwood (2009; 2009a). To the best of our knowledge, this represents the first published application of inferred valuation to WTA estimation in a developing country.

Section 2 describes different approaches to PES and section 3 describes the agri-environmental context of the East Usambara study site. Section 4 presents the methodological approach, including a description of the choice experiment model and explanation of the inferred valuation approach. Sections 8 and 10 present results and concluding remarks respectively.

2. Different Categories of Payment for Ecosystem Services

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 program for a service that is difficult to monitor is unlikely to hold the confidence of purchasers. Given the diffuse, indirect nature of many ecosystem services this can be a serious impediment. (3) PES *involves payment from at least one purchaser,* and (4) *to at least one provider:* A PES differs from other conservation and development policy instruments in that it is a commercial arrangement where both parties benefit from the transaction. Payment and monitoring of service provision often take place through an intermediary such as a government acting on behalf of taxpayers or businesses. (5) A working PES program 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 programs currently exist that satisfy all five 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. However, meeting the strict definition of PES given above is not an indication of program 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 (Kemkes, *et al.* 2010; Jack, *et al.* 2008). 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." While this definition captures the essence of the PES mechanism, more detailed terminology is needed to classify the variety of instruments that could meet such a description.

An attempt at that terminology is provided by van Noordwijk and Leimona (2010), who loosely identified three types of PES, differentiated primarily on the extent of their conditionality. They described 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 (increased tree cover), (3) improved actions (replanting in the runoff zone), (4) improved management plans (an intent to replant in the runoff zone), or (5) improved management objectives. These conditionality stages, from strongest (level 1) to weakest (level 5), are presented in Figure 1-1.

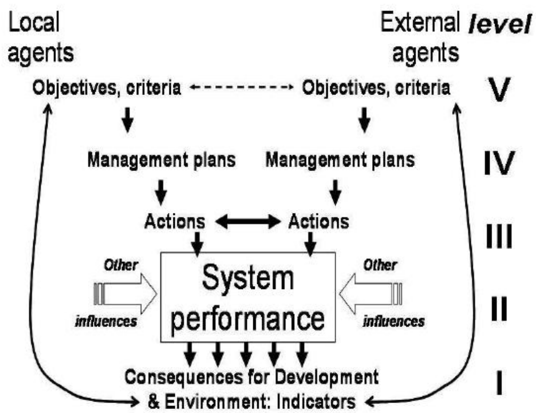

Figure 1-1: Five levels at which agreements on PES programs between local agents as 'ecosystem providers' and external actors as 'ecosystem beneficiaries' can be 'conditional' (Van Noordwijk and Leimona, 2010).

The three types of PES established by van Noordwijk and Leimona (2010) are 'commoditized ecosystem services' (CES), 'compensation for opportunities skipped' (COS) and 'co-investment in environmental stewardship' (CIS).

CES: The strictest form of PES, conditional on actual service delivery (level 1). Recurrent payments may be negotiated directly between beneficiaries and providers (for instance through an auction mechanism) with price set by supply and demand of the ecosystem service in question. CES has no explicit poverty target and is focused primarily on economic efficiency (quantity of environmental improvement per dollar spent). It presupposes well defined, individual property rights.

COS: Landholders are paid (compensated) to accept restrictions on the use of their land by beneficiaries via an intermediary (usually government). COS is conditional on system performance (level 2) or actions taken (level 3). Rationale for payment is to compensate landholders for giving up a legal and economically attractive land use option that otherwise would degrade ecosystem services. COS may involve poverty targeting via differentiations in payment, hence compensation is set externally rather than negotiated between beneficiaries and providers through a market or auction.

CIS: Beneficiaries (usually via an intermediary) invest in the environmentally beneficial land management actions of landholders. Payment may take the form of individual payments commensurate with the investment needed to undertake the desired land management option or may involve investment in the community such as improved public services. Payment is generally conditional on actions taken (level 3) but sometimes on management plans (level 4) or system performance (level 2). CIS may or may not target a collective of ES providers rather than individuals. This former approach makes it suitable in situations where property rights are not explicitly individualistic or well defined. It utilises community trust and bonds in conjunction with market rewards to achieve the desired environmental goals.

Clearly there is considerable overlap between the paradigms summarized above. It should be noted that van Noordwijk and Leimona (2010) do not so much 'classify' PES as 'typify' PES, in the sense that their groupings necessarily contain some overlap. Alongside the few strict PES programs that match Wunder's (2005) original definition, there are a burgeoning number of PES-like instruments that do not (Wunder, 2007). However, these can be loosely placed in one of the three categories proposed by Van Noordwijk and Leimona (2010). This conceptual exercise is likely to have little influence over the practical design of any particular scheme, but it may help direct the academic debate over what type of PES best suits a particular context, and furthermore, what exactly a PES program is.

The paradigms of PES are to some extent mirrored by the paradigms described by Farley and Costanza (2010). The latter authors place PES into two categories, an efficiency-focused 'environmental economics' approach and an equity-focused 'ecological economics' approach. Their 'environmental economics' approach is primarily based on the definition provided by Wunder (2005) (described above) which focuses on strictly defining property rights. Externalized benefits are internalized, bringing marginal costs into alignment with marginal benefits to society. The focus is on economic efficiency (greatest quantity of ecosystem services per dollar spent) and not on poverty alleviation (Wunder, 2008). This framework most closely matches the CES paradigm, however has parallels with COS also. The alternative type of PES described by Farley and Costanza (2010) - their 'ecological economics' approach – equally prioritizes environmental outcomes and poverty reduction. It advocates for a variety of payment mechanisms, both market and non-market, and places emphasis on collective institutions and payments. In doing so it is similar to the concept of CIS.

It should be noted that there are few examples of CES in operation in developing countries given the strictness of the conditionality and contractual arrangements required. Van Noordwijk and Leimona (2010) argued that CES is unsuitable in circumstances where property rights are weak or where communities have limited experience participating in services markets. The existence of multiple levels of land management institutions (legal pluralism) as well as unclear property rights can make the establishment of clear responsibilities and incentives problematic (van Noordwijk and Leimona, 2010; Swallow, *et al.* 2010). For this reason the discussion of PES paradigms in this paper is limited to COS and CIS.

In section 4 we operationalize some of the characteristics of the COS and CIS concepts in a series of hypothetical PES programs. These are presented to farmers in a choice experiment framework to ascertain farmer preferences for different program attributes. It should be noted that given the looseness of the currently existing definitions and the evolving nature of the PES debate, we do not attempt to capture the COS and CIS concepts in their entirety. However in assessing farmer preferences for some key components of PES - such as payment type and amount, conditionality levels (see section 6) – we are able to draw some conclusions as to the suitability of the COS and CIS categorization.

3. Study Site Description

3.1. The East Usambara Mountains

The 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 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). The ranges receive more precipitation and cooler temperatures than the surrounding plains and are under the direct climatic influence of the Indian Ocean. 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 very high levels of species richness (Hall, *et al.* 2009; Lovett, *et al.* 2001).

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 (Reyes, *et al.* 2006). 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 (Brooks, *et al.* 2002). The East Usambaras further form an important catchment supplying water for the nearby city of Tanga (with a population of approximately 240 000 in 2002).

3.2. The Agro-ecological Issue

The forests across the Eastern Arc and the high biodiversity they support have suffered from past clearing, logging and fragmentation, and remain threatened by environmentally detrimental agricultural practices (Hall, *et al.* 2009; Bjørndalen, 1992). These direct causes of degradation have been facilitated by deeper structural causes, such as land ownership patterns, lack of environmental law enforcement and corruption (Vihemäki, 2009). Approximately 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, 60 percent of the original forest cover has been lost, mostly in the past 35 years (Figure 1-2) with rapid deforestation ongoing (Reyes, *et al.* 2006). It should be noted that the term deforestation as used here means the conversion of original forest to open land (for cropping or grazing). In addition to deforestation, approximately half of what remains has been thinned (degraded), losing biodiversity value although maintaining some carbon benefits. For more on forest definitions for the purposes of PES policy see van Noordwijk and Minang, (2009).

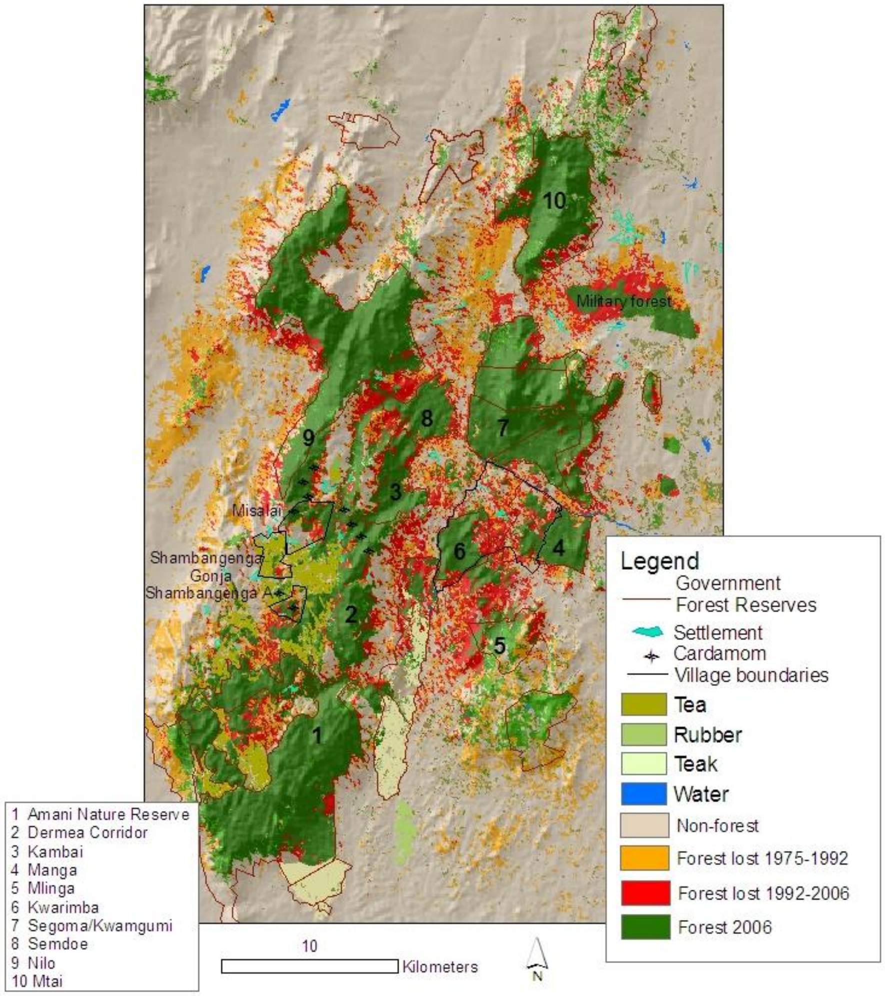

Figure 1-2: Land cover in the East Usambara Mountains as determined from satellite imagery (source: Hall, 2009).

Key to this deforestation process is the cultivation of cardamom *(Elettaria cardamomum),* as part of a series of crop rotations, planted and removed in response to changing soil nutrient status (Figures 1-3). Original forest is thinned in the first instance for the cultivation of this important cash crop grown by over 60 percent of farmers in the region. Cardamom's contribution to the average household budget is approximately 30 percent of income, and it accounts for more than half of total cash crop income (Reyes, *et al.* 2009). Despite the value of this crop, cardamom farmers in the East Usambaras have an average income far below the national average (Reyes, *et al.* 2006).

Cardamom is planted within the standing forest after the understory, mid story and parts of the overstory (selective thinning) have been removed. Productivity of the crop decreases rapidly over a period of 3-7 years due to nutrient depletion. Fertilizing with manure or replacing cardamom plants can allow for a 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 in many instances. 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.

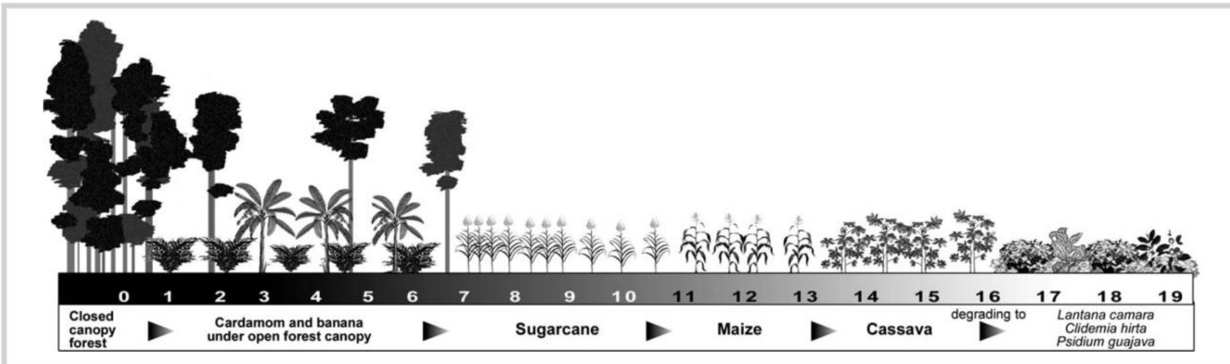

Figure 1-3: The typical sequence of land cover change following the planting of cardamom within the rainforest in the East Usambara Mountains (Reyes, *et al.* 2006).

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. This process is exacerbated by a gradually increasing population, which in conjunction with the pattern of land distribution and management found here, has led to land scarcity (Mwanyoka, 2005).

There are alternative land uses recently proposed that could maintain some degree of ecosystem functionality while allowing for ongoing cardamom production. Although inferior to original forest, maintaining agroforests would be preferable to complete forest cover loss. Leonard, *et al.* (2010) found that agroforests in the East Usambaras support a range of important vegetation species and threatened bird species. Of particular note, 'improved' agroforestry systems may be developed. Such improved systems are thought to have higher biodiversity and carbon sequestration benefits than either conventional cardamom agroforests or open field crops such as sugarcane, and can be maintained indefinitely (Bullock, *et al.* 2011). Improved agroforestry features a fallowing period of three years, followed by the application of fertilizer (manure). Mid storey and over storey species are allowed to regenerate around the cardamom, which is planted in lower density. 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 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 to quantify preferences for different elements of PES program design. Choice experiments are a stated preference valuation technique where subjects are asked to choose between competing hypothetical goods or outcomes. The hypothetical good/outcome is a package of attributes, each of which can take on a number of levels which are varied between hypothetical scenarios. Choice experiments can be used to determine the value of the individual attributes that make up the good/outcome and so are suitable for the analysis of preferences for policies 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 behavior 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 comprehensive overview of choice experiments is provided by Louviere *et al.* (2010).

Although choice experiments have been used extensively in the valuation of environmental amenities (see for instance Hoyos, 2010 for a review), there are only five published examples we are aware of that specifically use a choice experiment to explore policy preferences for land management programs amongst landholders. Ruto and Garrod (2009) used a choice experiment with a latent class model to evaluate farmer preferences for agri-environmental programs in 10 case studies across Europe. They quantified the additional payments required to overcome increased administrative load, longer contract length or more restrictions. Choice experiments were also used by two related studies (Klosowski, *et al.* 2001; Stevens, *et al.* 1999) that evaluated landholder preferences for coordinated forest management in New England. Both studies reported a reluctance to participate in land management programs even with financial payments, however they highlighted those policy attributes (tax incentives, an environmental amenities focus, shorter contract length) as well as landholder characteristics (income) that contributed to higher participation rates. Horne (2006) evaluated Finish landholder's preferences for conservation contracts in non-industrial, privately owned forests. Her choice experiment showed that more stringent conservation requirements and a longer contract length necessitate higher annual payments, as expected.

Arafin, *et al.* (2009) is the only study to our knowledge that has used a choice experiment to advise environmental policy development 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. In addition to these choice experiment studies, there are a small number of other studies into PES program preferences which use other stated choice methods such as contingent valuation (Layton and Siikamäki, 2009; Cooper, 2003; Cooper and Osborne, 1998).

These previous studies have demonstrated the utility of choice experiments to the design of PES policy. However it is evident that the potential for this technique is far from fully realized. Even considering a broader array of methodologies, there are only a few studies on the policy attributes of PES that determine participation levels in practice (Ruto and Garrod, 2009).

5. Conceptual 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. 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). The characteristics of the PES contract (attributes) are allowed to take on a variety of levels (Table 1-1). The overall utility derived from a contract is expressed as a utility function:

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

Where P_h is the h^{th} PES program scenario, $U_i(P_h)$ is the utility derived from that scenario, Z_h is a vector of attributes that make up program 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 program, 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}:

$$V_i(P_h) = v(P_h) + \varepsilon_{ih} \qquad \text{Equation 1-2}$$

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

$$\pi_{ih} = \Pr\left\lfloor v(P_h) + \varepsilon_{ih} \geq v(P_j) + \varepsilon_{ij};\ \forall\, h \neq j \in C \right\rfloor \qquad \text{Equation 1-3}$$

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 1-4

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

$$\pi_i(P_h) = \frac{e^{\mu v(P_h)}}{\sum_{h \in C} e^{\mu v(P_h)}} \qquad \text{Equation 1-5}$$

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 implies that the choice set is assumed to adhere to the 'independence of irrelevant alternatives' property, which means that the relative probabilities of selection of two options is unrelated to the presence of an irrelevant third option (Hanley, *et al.* 2001). We assume that the utility function is linear:

$$v(P_h) = BZ_h \qquad \text{Equation 1-6}$$

Where B is a vector of marginal utilities for each program attribute, Z_h. The above formulation can be solved using a multinomial logit model (assuming a logistic distribution of errors) using maximum likelihood.

A major limitation of the multinomial logit model is an assumption of homogenous preferences across respondents. This assumption can be relaxed by the use of a random parameters model (or mixed logit model) where utility parameters are estimated along a continuous distribution across individuals. This approach requires a large sample size and varied responses (Boxall and Adamowicz, 2002) and was thus considered less well suited to this exercise. We apply an alternative, latent class analysis. This 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). In equation 1-6, the vector of marginal utilities B, is not specific to an individual. In a latent class approach we assume that individual *i* belongs to a particular segment, *s* of the population:

$$\pi_{i|s}(P_h) = \frac{e^{\mu_s B_s Z_h}}{\sum_{h \in C} e^{\mu_s B_s Z_h}} \qquad \text{Equation 1-7}$$

Where B_s and μ_s are segment specific utility and scale parameters respectively. 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 1-2, the latent membership function (M_{is}^*) has both an observed ($A_s X_i$) and unobserved component (ϵ_{is}):

$$M_{is}^* = A_s X_i + \epsilon_{is} \qquad \text{Equation 1-8}$$

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 above. However this function is dependent on the characteristics of the individual i, not on the characteristics of the program's attributes:

$$\pi_{is}(X) = \frac{e^{\mu_s A_s X_i}}{\sum_{s \in S} e^{\mu_s A_s X_i}} \qquad \text{Equation 1-9}$$

The product of equations 1-9 and 1-7, over the sum of all segments, gives the joint probability that individual *i* belongs to segment *s* and chooses alternative P_h.

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

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).

6. Experimental Design and Data

The objective of the choice experiment design was to test farmer preferences for key PES components. The initial set of attributes and options was selected to represent the principle elements of the COS and CIS paradigms (as summarized in section 0), however, the chosen attributes are those that are central to the practical task of constructing a PES program of any variety regardless of theoretical constructs and classification schemes. General concepts of conditionality, payment type and opportunity cost were adapted to tangible policy design elements, 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. Follow up questions about the questionnaire were also posed to respondents of the pilot study. Interviews and pilot survey rounds were conducted in September of 2010.

The primary payment vehicle is a per acre annual amount paid directly to the farmer for his/her on-farm forest conservation. Although land in Tanzania is formally owned by the state, individual farmers hold title and thus management rights over specific farm plots. Two payment alternatives were also included. The first alternative is a group payment, where the per acre annual amount would be donated to a village fund for use on 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 to make a contribution by way of farm management.

The second payment alternative 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) experimental study in which manure application 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 labor 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 included. At the least arduous level, farmers are expected to simply fill out a logbook of their farm activities, and hence farmers are simply trusted to abide by the spirit of the program, with the possible chance of an audit of the log book. 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* trees (UNDP, 2009). At the intermediate level, farmers’ properties are inspected once per year by a local villager hired by the program, 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 1-1 shows the full schedule of attributes and levels.

Table 1-1: 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	Whether the program provides a one off, upfront payment for the procurement of fertilizer (value	Approximate USD: 0, 140

	approximately USD 140 per acre)	(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)

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 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 the landholdings could allow farmers 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 'dynamic' 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 their payments would be equal to (approximately) USD 21, 50 or 176, matching the static payment described in Table 1-1.

Although these attributes are similar to those used in existing PES schemes, their selection was partially informed by the recently proposed COS and CIS paradigms, described in section 2. In doing it was hoped that the results would inform not only practical PES program design in the East Usambara context, but also further the discussion over the suitability of this classification system. The primary payment vehicle, a financial incentive targeted directly at the ES provider is more commonly associated with COS type PES programs. The two payment alternatives meanwhile – the manure fertilizer investment and the group payment - are more typically associated with the CIS concept. The manure fertilizer investment aims to encourage agroforest conservation by improving the returns associated with its practice, while the group payment aims to harness farmers' desire, if present, to contribute to the collective village welfare.

A second key difference between CIS and COS is the extent of conditionality (van Noordwijk and Leimona, 2010). COS has a higher burden of conditionality: providers are expected to actually provide the ecological service being paid for, or undertake an action known to reliably provide it. CIS however is not usually conditional on ecological outcomes, but instead on land management actions that are generally concordant with the desired ecological outcomes or even the intention to undertake certain actions. There is also a higher dependency on trust in the latter paradigm and so strong inspection and enforcement regimes are not included.

Finally, the split sample treatment was applied to assess farmer responses to a price that fluctuates with the (partial) opportunity cost of the land management action (profit from sugarcane), rather than remaining constant year to year. This was a direct test of a literal interpretation of the COS paradigm, that payment is 'compensation for opportunity skipped.' These design elements are simply a selection of characteristics that distinguish between COS and CIS. Further distinction is difficult at present given that these paradigms are only loosely defined, and to some extent overlap. They represent 'typifications', rather than strict 'classifications' of PES programs.

A large number of potential PES scenarios can be constructed from the attributes and options in Table 1-1 ($[4^2*2*3]^2 = 9216$) 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, 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). Efficient type designs were precluded from use due to a lack of prior marginal utility estimates (ChoiceMetrics, 2011a), 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.

The questionnaire was structured with an introductory section collecting information on the participant's farming practices. 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 section 7). The choice scenarios came next with a series of socio-demographic questions to conclude.

Farmers were questioned in Kiswahili (the national language of Tanzania) in face to face interviews with trained enumerators in September and November, 2010. 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 present prepared to take part. Surveys were undertaken in private and took an average of 42 minutes each.

7. Mitigating 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 behavior, 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).

However, 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. My 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 program 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 a not uncommon experience 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, 2009; 2009a). 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 (2009) 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 neighbors' eligibility to participate in any future programs, 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). Unlike the dynamic payment treatment, all respondents received both the standard valuation approach and the inferred valuation approach.

8. Results

8.1. Sample Profile

75 percent of the sample was male, indicating the (self identified) prominence with which men act as primary decision makers with regards to farm decisions (Table 1-2). Only one third of participants were born in the village they were living in, possibly a result of past government 'villagization' programmes (*Vijiji*, a policy of rural resettlement as part of Tanzanian socialism, or *Ujamaa*) (Lal, 2010) or due to resource and population driven local migration (Yanda and Shishira, 2009). Self reported income averaged USD 690 per household per year, lower than the Tanzania national average (CIA 2010). 26.9 percent of the sample had in addition an off farm source of income, which for these households averaged an additional USD 455 per year. We are cautious in the use of self reported income given the high variation in responses, and rely instead on a possessions index as a proxy for income. Also, land size serves as a proxy indicator of wealth. Morgan-Brown, *et al.* (2010) found that land size explains 74 percent of variation in annual income in their study of environmental attitudes in the same region. 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 primary forest. These varied considerably over the sample (Figure 1-4). Level of education is not included as a variable for analysis due to limited variation across the sample (91 percent of participants have primary schooling only).

Table 1-2: Summary socio-demographic characteristics of sample

	Mean	St. Dev
Sex (proportion male)	0.75	
Age (years)	45	14
Born in village (proportion	0.33	
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	

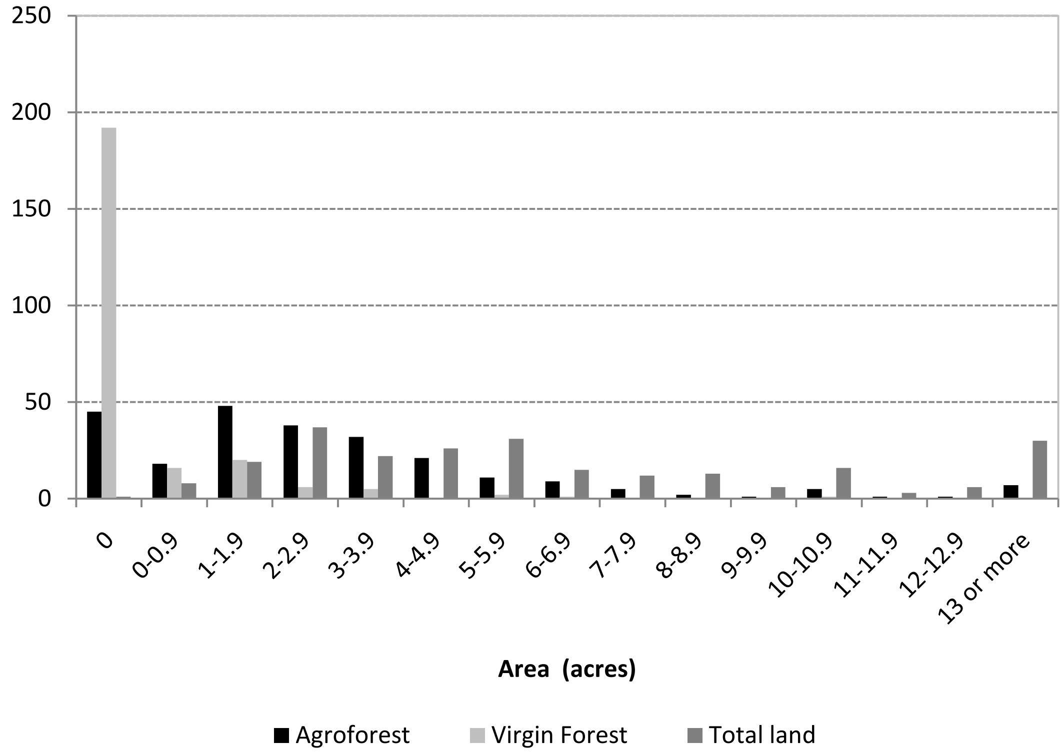

Figure 1-4: histogram of land characteristics amongst farmer sample: area of total land owned or managed, area of land with agroforest and area of land with original forest.

9. PES Policy Preferences

Table 1-3 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 1-3: Multinomial logit models of preferences for a hypothetical PES program, based on subsamples of questioning method. * = significant difference between treatment and control at α=0.1 level, * = significant at α=0.01 level.**

	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	0.120	0.159	0.284	0.160 *	0.200	0.113 *
Upfront payment	0.836	0.107 ***	0.842	0.112 ***	0.837	0.077 ***
Conditionality 1	-0.179	0.127	-0.119	0.133	-0.151	0.092 *
Conditionality 3	-0.116	0.121	-0.315	0.130 **	-0.207	0.088 **
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 likelihood ratio test is used to check for statistically significant differences between models (this test takes the form $LR = -2(LLF_R - LLF_{UR})$ and is compared to a chi-square distribution with degrees of freedom equal to the number of variables. The unrestricted model LLF is the sum of the two part models' LLF, whilst the restricted model LLF is provided by a combined model). The two sub groups are not significantly different ($\chi^2_{d.f=5}$ = 5.21, p-value = 0.39) suggesting that respondents expect little difference between their responses and the responses of their colleagues. Assuming that the Lusk and Norwood (2009; 2009a) inferred valuation technique is effective in such a context, this result also suggests that any social desirability bias is minimal. Aggregating the data across these two questioning approaches gives a model with similar coefficients but with additional significant variables. Aggregation does not provide additional data given that the direct and inferred valuation questions were based on the same scenarios, and so 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 program, as expected. The amount of payment required differs based on the type of payment mechanism. Of interest is the discrepancy between the marginal utility of individual and group payments. The individual payment provides positive utility in models of both direct and inferred valuation data. However, both data sets suggest group payment has no effect ($p > 0.1$). While this discrepancy between these two payment types was expected, it was not expected to this extent, given the tight community bonds that are often assumed to exist within small villages. If it was to be assumed that the group payment would be significant with a larger sample (a strong assumption), and had a coefficient comparable to that found here, eight dollars spent motivating farmers through a collective payment would be expected to elicit the same response as one dollar spent motivating farmers through an individual payment. Given the lack of significance of this variable in the direct valuation model however, this result is speculative.

The upfront payment for manure fertilizer has a strong effect on likely participation rates. The one off investment payment, which is approximately USD 140 per acre (dedicated to manure fertilizer), has the same predicted effect on participation as an annual cash payment of USD 84 per acre. This suggests either (or likely both) that farmers have a high discount rate and so prefer resources at the beginning of the contract rather than in installments at the end of each year, and/or that manure fertilizer commands a premium over cash due to difficulties in its procurement. This issue was raised a number of number of times by farmers during pretesting and interviews. But most importantly, the high value placed on the manure fertilizer investment probably represents the expected increase in income due to additional productivity of farmers' agroforests.

The above assessment lumps two treatments together, the dynamic and static payment regimes. In the dynamic payment regime respondents were told that payment would vary year to year, proportional to the market price of sugarcane (which as described in section 6 is a key opportunity cost for farmers participating in a PES program). Table 1-4 presents choice models of subsamples of the data based on static, dynamic and combined models respectively. A likelihood ratio test finds a significant difference between the dynamic and static treatments ($\chi^2_{d.f=6}$ = 12.996, p-value = 0.043). The status quo and inspection 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 dynamic 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, and the status quo is only significant under the dynamic payment treatment. There is a small but statistically significant ($p < 0.1$) difference in the marginal utility of the upfront manure fertilizer investment between treatments, with a higher marginal utility under the dynamic 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 puzzling given that the model overall suggests that the static payment approach is preferred over the dynamic payment approach. It would appear that preferences are to some extent context dependent: an upfront investment within a dynamic payment framework is more attractive than the same upfront investment in a static payment framework.

Table 1-4: Multinomial logit models of preferences for a hypothetical PES program, based on treatment subsamples. Direct valuation questions used only. * = significant difference between treatment and control at α=0.1 level, * = significant at α=0.01 level.**

	Static payment			Dynamic 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	-0.016	0.217		0.667	0.243	***	0.284	0.160	*
Upfront payment	0.769	0.155	***	0.956	0.166	***	0.842	0.112	***
Conditionality 1	-0.265	0.178		0.082	0.203		-0.119	0.133	
Conditionality 3	-0.424	0.175	**	-0.168	0.195		-0.315	0.130	**
No. obs.	111			89			200		
d.f.	6			6			6		
LLF	-406.326			-349.164			-761.988		
AIC	824.653			710.328			1535.976		

The models presented above provide tentative evidence for a non linear response to the extent of conditionality. The static, direct model has a negative coefficient for the highest level of conditionality (with the intermediate level the baseline). When the high and low conditionality levels are combined (model not shown), the intermediate level of conditionality has significantly positive marginal utility (0.348, $p < 0.01$) whilst the remaining levels are not different to zero. Similarly, the joint model in Table 1-3 clearly shows an inverted U shape relationship between the level of conditionality and marginal utility (Figure 1-5). While results from this model are not robust given the conflation of direct and inferred questioning, it is likely that a similar pattern exists in the subsamples (with significance obscured by the small sample size). At the least, a lack of difference between the low level of conditionality and the intermediate level of conditionality (both not different to zero) supports this surprising finding of a non linear response.

The lowest level of conditionality relies on self reporting, which while being easiest for farmers is clearly open to abuse. It is likely that the negative response to this approach is due to preferences for policies that cannot be unfairly exploited. The highest level of conditionality, in which payments are tied to specific environmental outcomes (the number and density of indigenous species in the forest) also causes negative marginal utility relative to the intermediate level. This is expected given the additional burden on farmers who must comply with a tougher inspection regime by a forestry officer. The preferred conditionality level is between these extremes.

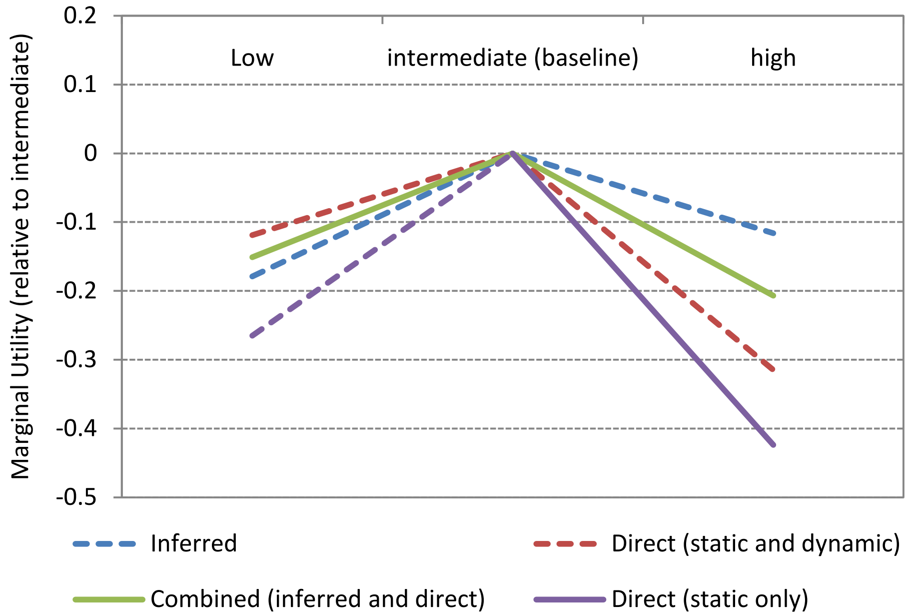

Figure 1-5: Marginal utilities associated with low and high conditionality regimes relative to the intermediate conditionality regime under different treatments (inferred versus direct questioning, static versus dynamic payment treatment). Dash line indicates statistical insignificance.

Willingness to accept (WTA) values can be calculated for different elements of program design 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 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 and is required for WTA calculations in scenarios where non-participation is an option (all voluntary programs). For determining the median WTA value required to induce participation in a program we use the dynamic treatment model and the combined model (Table 1-3) as the static treatment model alone does not find a significant status quo coefficient.

There is a considerable discrepancy in WTA amounts between the dynamic treatment and the combined treatment model (Table 1-5). Without a manure fertilizer investment and with a moderate conditionality regime, a USD 28 per acre per year payment is required to convince the median farmer to enrol. 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 75, even if both payment regimes provide the same amount on average. While we are unable to calculate the WTA amount for a static payment amount alone due to an insignificant status quo coefficient, the mixed treatment model amount (USD 28) provides a likely upper bound amount for this treatment.

The impact of the manure fertilizer investment 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 enroll. Again the effect of more stringent conditionality is evident. The highest level of conditionality raises WTA from USD 28 for the moderate conditionality level to USD 60 per acre per year, in the case of the combined treatment model.

Table 1-5: Willingness to accept amounts (per acre, per year for a 10 year contract) based on the direct questioning method, using dynamic treatment and combined treatment models respectively (Table 1-4) (n/s: WTA could not be calculated due to insignificance of attribute coefficient).

	Conditionality	Dynamic treatment	Combined treatments
No upfront payment	Moderate	75	28
	High	n/s	60
Upfront payment	Moderate	-33	-56
	High	n/s	-24

9.1. Heterogeneity of Preferences

These WTA results represent the median preferences of participants as a whole, and hence assume that preferences are homogenous. However, it is possible that there exists a range of preferences amongst participants for which it may be possible to categorize into discrete classes representing the main 'types' of participant. Latent class analysis, a post hoc statistical classification process, is used for this (see section 5). A latent class analysis is not based on a predetermined behavioural relationship between an individual's characteristics and their choices, but identifies such relationships from their choices.

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[4], and plausibility of results given the size of membership

[4] 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

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 1-6 shows results for a latent class analysis of the direct valuation data.

Table 1-6: Multinomial logit models of preferences for a hypothetical PES program with two latent classes (based on direct questioning data). * = significant difference between treatment and control at α=0.1 level, * = significant at α=0.01 level.**

	Parameters for class 1			Parameters for class 2		
	Coef.	Std. Error		Coef.	Std. Error	
Individual	0.113	0.011	***	0.085	0.026	***
Group	0.026	0.009	***	-0.005	0.038	
Status Quo	-0.893	0.27	***	4.056	0.908	***
Upfront payment	1.518	0.182	***	0.845	0.559	
Conditionality 1	-0.182	0.159		0.421	0.654	
Conditionality 3	-0.438	0.148	***	-0.153	0.707	
Average Class Probabilities	0.787			0.213		
Probabilities for class membership (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					

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).

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 very strongly positive status quo coefficient, indicating that members of this class require high levels of compensation to join, and are on the whole reluctant to take part. Class 2 is the smaller of the two classes with 21 percent of respondents. The average of these two models, weighted by the class probabilities, is the whole model reported upon above. Hence the skepticism shown by members of class 2 is responsible for the overall result of a negative status quo coefficient.

The treatment variable was included as an explanatory variable in the latent class analysis, however was not found to be significant ($p > 0.1$). Although a randomly assigned treatment obviously cannot impact the socio-demographic characteristics of a respondent, it can elicit behavior that appears similar to that associated with a particular set of socio-demographic characteristics (that associated with a particular class). This highlights an important feature of latent class analysis - the classes are probabilistic, meaning that a particular socio-demographic characteristic increases the probability of belonging to a certain class, but does not determine it absolutely. This sets latent class analysis apart from simple interaction terms entered directly into the standard MNL model.

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 provides only 23 percent of the utility of the individual payment per dollar). The manure fertilizer investment 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. In addition to the strong preference for the status quo, the marginal utility of the individual payment is reduced meaning that additional payment would be required to induce participation by members of this class.

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 the 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 dataset would present greater insights into the impact of particular variables.

10. Discussion and Conclusions

Six notable results arise from analysis of the choice experiment: (1) the surprisingly high value of the manure fertilizer investment, (2) the ineffectiveness of the group payment, (3) non-linear preferences for conditionality, (4) the preference against a dynamic payment, (5) the strong preference heterogeneity found in the sample, and (6) the lack of discrepancy between the direct valuation and inferred valuation.

A one-off co-investment in a farm input (manure fertilizer in this case) elicited surprisingly large support for the hypothetical PES programs. The investment, worth USD 140 per acre, was enough to persuade the median farmer to accept a hypothetical program without additional yearly PES payments for the life of the 10 year contract. With regard to WTA, the per acre upfront investment was equivalent to approximately USD 84 per acre per year, which if considered purely in financial terms indicates a discount rate of over 50 percent. However the majority of the value of the upfront payment should stem from the expected productivity increases of the investment, not from the market value of the input itself. Secondly, it is plausible that there exists an appreciation of the investment as a partnership, a value over and above its purely financial worth.

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). In this case however, the manure fertilizer investment attempts to 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). The 'reward' for agroforest maintenance is via additional productivity, not via the market value of the input itself.

The group payment was highly ineffective at promoting hypothetical participation. Making land management changes for the sake of collective welfare does not appear to represent an appealing prospect to farmers. On the contrary, individuals were effectively motivated by relatively small annual cash payments, direct to the individual farmer. We conclude that the group payment was eight times less effective than the individual payment (and possibly not effective at all), however this number is speculative given the lack of statistical significance of this variable in most models.

Preferred levels of conditionality may be 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 their environmental outcomes (a more stringent standard and costlier for the farmer 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 likely that although the lowest level of conditionality is the 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, 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 goals.

A static payment rate is preferred to a dynamic payment that fluctuates with the (partial) opportunity cost of the land management action. This is despite the supposed equity of payment amount over time. The uncertainty of a fluctuating price necessitated a large premium to encourage participation. The envisaged purpose of a fluctuating price was to prevent farmers from dropping out during periods of high opportunity cost, and to reduce program expenditures during times of low opportunity cost. However, the complexity and the additional risk associated with such a payment mechanism means that its implementation would require additional compensation.

This study shows mixed farmer support for elements of both a 'compensation for opportunities skipped' (COS) type PES paradigm, and for a 'co-investment in ecosystem stewardship' (CIS) type PES paradigm. There was no standout preferred approach, demonstrating that the design of PES should be tailored closely to local preferences quantified in advance of policy implementation. The varied response to the different payment types indicates that both COS and CIS type schemes could be successful in motivating farmer support in this instance. The unsurprising effectiveness of a direct financial incentive targeted directly at the farmer supports a COS type program, which typically utilize individual pecuniary incentives such as this. However, the one-off manure fertilizer investment elicited surprisingly large support for the hypothetical PES programs also, suggesting that such a CIS type program would be successful also, at least in terms of farmer participation. The insignificance of the group payment variable meanwhile suggests that such collective incentives – often featured in CIS type programs – would need considerable modification to play a useful role.

Secondly, the non-linear expected response of farmers under increasing conditionality represents support for a COS type program, which generally features a higher level of conditionality than CIS type programs. Based on the results of this study it is wrong to assume that the simplest, easiest conditionality regime will always be most preferred. Finally, the strong preference for a static payment rate relative to a dynamic payment rate also suggests support for a CIS type scheme. This split sample treatment was a direct test of a literal interpretation of the COS paradigm, that payment is 'compensation for opportunity skipped.' Overall, this demonstrates that for the case of the East Usambaras, farmers preferred programs that combine a mixture of elements from different PES paradigms. This highlights the need to test preferences for design elements drawn from a range of approaches. It cannot be assumed that one particular approach will suit a given situation in its entirety.

Within a population there is likely to be substantial heterogeneity of preferences. We found evidence for the existence of a subsample of environmentally minded farmers who would enroll without payment, while another subsample would resist participation at all but very high rates of payment, regardless of other program attributes. To our knowledge there is only one published study that has likewise used latent class analysis for the assessment of preferences for PES programs. 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. Puzzlingly, they omit the status quo coefficient so 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 (a 'low resistance' group) far more prepared to participate than the other (a 'high resistance' group).

With regard to specific socio-demographic characteristics, this study found only sex and village of birth to have a significant impact on class membership. Males are more likely to fall into class 2, showing 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 dataset would present greater insights into the impact of particular variables.

In contrast, Ruto and Garrod (2009) found farmers with larger holdings more likely to participate, presumably because the per hectare payment method proportionately benefits larger farmers over smaller farmers. Other factors predicting membership in their low resistance group included higher levels of education, greater age and higher levels of environmental consciousness, findings which are common in the small literature available (see for instance Wynn, 2001). These results concerning specific socio-demographic variables were on the whole not replicated by our study. Education was not included in the model due to limited variation across the sample, and attitudinal type information such as environmental consciousness was considered problematic due to potential endogeneity.

Finally, the lack of difference between the direct valuation and inferred valuation approaches was a surprising result. Lusk and Norwood (2009; 2009a) demonstrated that inferred valuation can be an effective technique to mitigate 'social desirability bias', a type of hypothetical bias sometimes problematic in stated preference studies. However, the lack of discrepancy between models estimated using the direct valuation scenario responses and the inferred valuation scenario responses indicates that either social desirability bias is minimal in this case, or that these farmers failed to respond to the mitigating technique. To the best of our knowledge, this is the first application of the Lusk and Norwood approach (2009; 2009a) in a developing country, natural resource management context.

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