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Analysis

Payments for ecosystem services and agricultural intensification: Evidence from a choice experiment on deforestation in Zambia

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ABSTRACT

Agriculture is considered to be one of the major drivers of deforestation worldwide. In developing countries in particular this process is driven by small-scale agriculture. At the same time, many African governments aim to increase agricultural productivity. Empirical evidence suggests, however, that win-win relationships between agricultural intensification and forest conservation are the exception. Payments for Ecosystem Services (PES) could be linked to agriculture support programmes to simultaneously achieve both goals. Due to potentially higher profits from intensified agriculture than from pure cash transfers, potential payment recipients may prefer in-kind over conventional cash payments. Nevertheless, little scientific evidence exists regarding the preferences of potential PES recipients for such instruments. We report from a discrete choice experiment in Zambia that elicited preferences of smallholder farmers for PES contracts. Our results suggest that potential PES recipients in Zambia value in-kind agricultural inputs more highly than cash payments (even when the monetary value of the inputs is lower than the cash payment), highlighting that PES could potentially succeed in conserving forests and intensifying smallholder agriculture. Respondents who intended to clear forest within the next three years were found to require higher payments, but could be motivated to enrol in appropriately designed PES.

1. Introduction

Deforestation and forest degradation is recognized as major source of global CO_2 emissions, especially in developing countries (Van der Werf et al., 2009). Hosonuma et al. (2012) estimate that four-fifths of forest loss between 2000 and 2010 was associated with agricultural expansion, largely driven by small-scale agriculture in developing countries. Meanwhile, increasing agricultural smallholder productivity is for many African governments a critical pathway to achieve the Sustainable Development Goals of ending poverty, achieving food security, and improving nutrition. To achieve this, many African governments reintroduced input subsidy programmes (Jayne and Rashid, 2013).

It remains however contested whether agricultural intensification decreases deforestation. Benhin (2006) highlights that in the absence of improved technologies many small-scale farmers rely on newly-cleared and fertile forest land as a cheap production input. Hence, increasing agricultural yields on existing farmland could reduce the pressure to clear new areas. At the same time agricultural intensification commonly increases the relative returns from agriculture vis-a-vis forestry, creating stronger incentives to expand agricultural areas (Angelsen and Kaimowitz, 2001). Especially in frontier regions, promoting agricultural productivity may in fact increase pressure on forests (Angelsen, 2010). Ewers et al. (2009) conclude that increased yields of staple crops saved forest land in developing countries between 1979 and 1999. But a potential reduction in cultivated areas was counterbalanced by increasing cultivation of non-staple crops. In a global, cross-country analysis of historic data, Rudel et al. (2009) find no general evidence for agricultural intensification reducing cultivated areas. Consequently, a fundamental question is how to increase productivity of smallholder agriculture without further aggravating pressure on forests.

Payments for Ecosystem Services[1] (PES) are an increasingly discussed and implemented policy instrument to reduce deforestation (e.g. Muradian, 2013). PES play a central role in REDD + as part of global climate change mitigation strategies (Angelsen, 2009). In the context of deforestation, PES are predominantly conceptualized as incentives that compensate land owners for the opportunity costs of alternative land uses.

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[1] Following Wunder (2015, p. 241) we understand PES as "voluntary transactions between service users and service providers that are conditional on agreed rules of natural resource management for generating offsite services".

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This paper evaluates the scope of PES schemes that restrict forest clearing by smallholder farmers by offering conditional assistance in agricultural intensification.[2] The underlying idea is that participating farmers receive agricultural inputs conditional on land use practices which maintain the capacity of ecosystems to provide essential services. The novelty of the proposed combination of agricultural support and PES is that farmers potentially attain benefits from increased productivity that are larger than the direct benefits received in the scheme, allowing to reduce transfer amounts compared to conventional PES. To our knowledge no literature explicitly focused on the potential link between agricultural support programmes and PES (cf Karsenty, 2011). Designing PES as supportive incentives through providing agricultural support may also outperform conventional PES in terms of complementing existing motivations for conservation behaviour. Experimental studies have shown that the supportive framing of incentives crowd-in intrinsic motivations for environmental-friendly behaviour (Frey and Jegen, 2001; Vollan, 2008; Cranford and Mourato, 2014). In contrast, PES framed as pure market transactions may reduce such intrinsic motivations (Muradian, 2013; Rode et al., 2015).

To the best of our knowledge, incentivizing PES with support for agricultural intensification is a yet rarely implemented approach. There is evidence that beneficiaries can prefer in-kind payments over cash payments (Engel, 2016). One explanation is that in-kind payments can assure productive investments instead of immediate consumption (Asquith et al., 2008; Zabel and Engel, 2010). PES recipients in Bolivia opted for payments in beehives and apiculture training instead of cash (Asquith et al., 2008). In-kind payments may be furthermore a viable alternative to cash payments in locations where access to certain goods is constrained. Zabel and Engel (2010) conducted a choice experiment among potential recipients for a carnivore protection scheme in India. They find that the delivery of in-kind payments is preferred by respondents living further away from markets where access to products is connected to high transaction costs.

There is also evidence that in-kind payments can support the adoption of environmentally friendly practices. Wunder and Albán (2008) report from two PES in Ecuador that provide training in forestry in addition to cash payments. Grillos (2017) presents PES, which provide in-kind payments with various goods that can be used for environmental conservation. Cranford and Mourato (2014) evaluated the prospective benefits of a credit-based PES scheme through a choice experiment in Ecuador. Under the proposed instruments borrowers would be required to adopt environmentally friendly agricultural practices such as agroforestry and would in return benefit from reduced interest rates. Kaczan et al. (2013) elicit preferences for different payment mechanisms among potential PES participants in Tanzania. They include an up-front fertilizer payment in addition to annual cash payments in their choice experiment. Upfront fertilizer would significantly increase the profitability of environmental-friendly agroforestry. They find that respondents would accept PES contracts of 10 years only by receiving this up-front payment.

Research on in-kind-based PES[3] highlights however some challenges related to alternative payment vehicles (cf Engel, 2016): a) In-kind payments are ideally divisible into small units to allow flexible compensation. In the case of training activities this seems hardly possible. b) In-kind payments are ideally required on a regular basis. For instance in the case of Asquith et al. (2008), demand for beehives and apiculture training is decreasing after some years, requiring to adopt new payment vehicles. c) In-kind payments are often required or implemented as up-front payment, especially if it aims to promote environmental friendly practices. It seems difficult or impossible to withdraw such once-off payments in case of non-compliance (Kaczan et al., 2013). Agricultural inputs for seasonal agriculture can circumvent many of these pitfalls. First, inputs such as seeds and fertilizer can be divided into small units that would allow compensation proportional to the individual conservation efforts. Second, such inputs are usually required every year, so that annually receiving inputs can be conditional on the conservation outcomes in the prior year.

A better understanding of the preferences of small-scale farmers is crucial to designing and implementing such novel incentive schemes. Programmes based on the target group's preferences have a higher enrolment and likelihood of contract adherence (Petheram and Campbell, 2010). This relates not only to payment-related characteristics as indicated above, but also to attributes such as contract length or implementing organization. This paper sets out to answer three research questions:

1. Do potential PES recipients prefer agricultural support through input provisioning over cash payments?
2. How are such PES programmes best adapted to farmers' preferences in terms of payment-unrelated characteristics?
3. Can such programmes motivate farmers who are most likely to carry out environmentally destructive activities to enrol in PES to ensure environmental effectiveness?

Zambia provides a suitable showcase for this research, as it is one of the most densely forested countries in Africa and experiences high deforestation rates. Small-scale agriculture is considered to be one of the major drivers of deforestation (Vinya et al., 2011). At the same time, increasing agricultural productivity of small- and medium-scale farmers, particularly through a fertilizer subsidy programme, is a policy objective in Zambia (Mason et al., 2013).

PES schemes require clearly defined property rights over forests, either at the individual, community or state level (Wunder, 2009). Most PES are discussed and implemented under individual property rights of forests. In this case, recipients receive a compensation conditional on conserving the private forest area. In the case of common property forests, a larger group of forest users can potentially engage in deforestation. For this type of property rights, group-based PES where payments are conditional on the conservation performance of the group and not the individual are appropriate (Engel, 2016). Land in Zambia is vested in, administered, and controlled by the president and shall be used for the common benefit of the people of Zambia (RoZ, 1995 Art. 3, 5). Similarly, ownership of trees and forest produce on any land is vested in the president (RoZ, 1999 Art. 3). Individualized tenure on customary land such as our project area is limited to use rights (RoZ, 1995 Art. 8). Critical is in particular the stipulation of the Forest Act that trees may be felled and land cleared by residents of customary areas for the purpose of agriculture (RoZ, 1999 Art. 38). The majority of land in Zambia is under customary tenure (61%), where also most forests are found (63%) (ZFD and FAO, 2008). In these areas, local chiefs and headmen allocate individual land use rights to the local population.

In this tenure situation, individual contracts for forests with individual use rights or group payments for common forests alone would risk that deforestation is simply shifted to areas that are not covered by PES. We therefore collected individual preferences for receiving payments that compensate farmers for remaining on their current privately-owned agricultural land and not converting forests to new cultivation areas, irrespective of whether the forest is located on land used privately or communally. Such individual contracts would require however a full enrolment rate at the community level, since non-participating farmers could continue to clear both private and common forests. This hints at the general challenge of PES schemes for common property forests. There are different options for addressing these challenges ranging from individual contracts targeting most conservation-averse residents, customary and/or statutory regulatory backup and group contracts.

[2] Participating farmers would receive agricultural inputs, conditional that they have not cleared any additional forests for agriculture. This conditionality contrasts such instrument from conventional input subsidy programmes and complies with the PES definition provided by Wunder (2015, p. 241).

[3] Two studies have elicited preferences for PES with in-kind group payments such as health, education and employment projects or productive assets (Balderas Torres et al., 2013; Costedoat et al., 2016). Since these benefits would accrue at the collective level, one cannot infer which proportion is due to the in-kind payment alone.

Although we do not explicitly focus on group contracts in this study, individual preferences ideally also inform the design of such PES. Discussing respective institutional options is, however, beyond the scope of this paper.

We use a Discrete Choice Experiment (DCE) to elicit preferences for PES contract design attributes, in particular preferences for cash vs- in-kind payments. In addition, we include payment-unrelated attributes such as contract length, implementing organization and forest co-benefits to identify which contract characteristics best motivate farmers to enrol in PES schemes. Our DCE allows to separately analyze preferences of farmers with and without intentions to clear forest in the near future. Through this we can evaluate which PES contracts motivate farmers who are most likely to engage in environmentally destructive activities to enrol in PES to ensure environmental effectiveness. Our results suggest that potential PES recipients in Zambia value in-kind agricultural inputs more highly than cash payments (even when the monetary value of the inputs is lower than the cash payment), highlighting that PES could potentially succeed in conserving forests and intensifying smallholder agriculture. Respondents who intended to clear forest within the next three years were found to require higher payments, but could be motivated to enrol in appropriately designed PES.

2. Method and Experimental Design

2.1. Stated Preferences and Discrete Choice Experiments

We compare alternative PES contract designs using Discrete Choice Experiments (DCE). In the field of environmental economics, stated preference methods in general and DCE in particular have been applied for the valuation of ecosystem services or other non-market environmental goods (Carson and Czajkowski, 2014). More recently the method has also been used to reveal preferences for policy instruments such as PES (e.g. Balderas Torres et al., 2013; Costedoat et al., 2016; Cranford and Mourato, 2014). The methodology rests on the assumption that respondents' choices between hypothetical alternatives – in our case PES contracts - reveal the order of their preferences. The hypothetical nature of decision making in DCE however raises questions concerning the incentive compatibility. The so-called hypothetical bias may result from lack of incentives for respondents to truthfully reveal their preferences. Several techniques have been proposed to minimize this hypothetical bias. Among them cheap talk is widely used, but its effectiveness has been debated (see Ladenburg and Olsen (2014) for a discussion on this topic). Despite these drawbacks, DCE offer the advantage of not requiring the costly and lengthy implementation of policy programmes to elicit revealed preferences. DCE also allow to evaluate potential combinations of programme characteristics simultaneously, while deriving an overall 'willingness to accept' for programme participation (Kaczan et al., 2013).

We included in the introduction of the DCE a short reminder to carefully make the decisions (see Online-Appendix B). In addition, we adopted a sequential design. First respondents were asked to choose between two contracts and afterwards asked if they would accept it over the status quo. Especially in the choice situations between alternative contracts we are, however, little concerned about structural biases as the attributes do not provoke strong social desirability. We acknowledge that in the decision whether to accept the better of the two contracts respondents may feel that it is expected from them to choose a contract. But as in any other DCE, we cannot determine to what extent a hypothetical bias is present and our findings should be consequently interpreted with caution."

2.2. Theory and Econometric Models

In our choice experiment, each alternative PES contract is described by a set of attributes (see Section 2.3). We assume that respondent n chooses between $j = 1, \dots, J$ contracts, that each generate a utility U_{nj}. We assume that respondent n maximizes her overall utility by accepting the contract with the relatively largest utility. Let U_{nj} denote the overall utility of respondent n for contract j that consists of a systematic, observed utility component V_{nj} and an unobserved utility component ε_{nj}.

$$U_{nj} = V_{nj} + \varepsilon_{nj} \tag{1}$$

The observed utility component of respondent n is assumed to be a linear additive function of x_{njk} variables for $k = 1, \dots, K$ attributes that describe contract j, each weighted with a coefficient β_{njk}:

$$V_{nj} = \sum_{k=1}^{K} x_{njk}\, \beta_{njk} \tag{2}$$

To analyze our experimental data, we applied the random parameter logit (RPL) model[4] as it allows for preference heterogeneity across the sampled population to be taken into account. It assumes that the coefficients β_{jk} vary over respondents (but not across choice situations) with density $f(\beta)$. This density can be characterized by parameters θ such as mean and variance of $\beta's$ in the population. RPL allows the repeated choices of the same respondents across different choice situations to be accounted for (Revelt and Train, 1998).

In order to identify sample segments with shared preferences and socio-economic characteristics, we also applied a latent class model (LCM). Instead of assuming that $\beta's$ are continuously distributed with parameters θ, LCMs assume a discrete distribution of $\beta's$ with a finite set of values. As a consequence, LCMs do not require any a-priori distributional assumptions for $f(\beta)$. LCMs assume that the sample is segmented in a given number of latent classes q, each with shared preferences and hence specific parameter estimates β'_q. Latent class membership probabilities are estimated for each individual conditional on socio-economic covariates.

Based on the LCM we furthermore estimated choice probabilities for a PES contract optimally adapted to the respondents and the status quo with variable transfer amounts. This allows us to derive estimations for the minimum transfer amounts needed to make respondents with forest clearing intentions accept PES. The detailed methodology can be found in Online-Appendix A. Both RPL and LCM were estimated with *R* 3.2.3 (R Core Team, 2015) using the *GMNL Package* (Sarrias and Daziano, 2015).

Respondents were confronted with a series of choice situations. Each choice situation consisted of two separate PES contracts that differed in their attributes. We adapted a sequential design (Veldwijk et al., 2014). Firstly, respondents were asked which of the two PES contracts they preferred. Secondly, they were asked whether they would accept the preferred contract over the status-quo without PES. See Online-Appendix B for the general introduction of the choice experiment and a choice situation example.

To reduce the number of choice situations presented to each respondent we generated an efficient design. Recent empirical evidence suggests that efficient designs gain more precise parameter estimates than the commonly used orthogonal designs (Bliemer and Rose, 2011; Yang et al., 2014) and perform better in terms of behavioural efficiency (Yao et al., 2014). The generation of efficient designs requires prior knowledge of parameter estimates, which can sometimes be obtained from existing studies. We conducted a pilot study to gain prior estimates. The pilot survey covered 73 individuals (292 choice observations) in eight randomly selected villages, using an orthogonal design. Based on the estimated parameters of a conditional logit model a D-Efficient Design was generated with the software package Ngene. To reduce the cognitive burden for respondents and reduce fatigue, the 16 generated choice situations were further split into four sets with four

[4] A detailed theoretical derivation for the RPL model and LCM can be found in Train (2009).

choice situations each. The respondents were then randomly assigned to one of the sets.

2.3. Attributes & Hypothesis

To answer the first research question, i.e. the potential scope of providing agricultural inputs instead of cash payments at reduced programme costs, the defining attribute of the choice experiment specifies how the payments are made. Including realistic payment vehicles in the choice sets, required us to combine several specific characteristics within the payment attribute. Cash payments on one hand can be done monthly or annual. In this case, they are designed to compensate farmers for the additional income they could derive from newly cleared agricultural areas, around the harvest season starting from April. Agricultural inputs are, in contrast, required before the growing season in November/December each year. In a similar manner, in-kind payments can be either inputs that are delivered to each village or vouchers that can only be redeemed in shops that are based in the district capital. Including several distinct payment attributes such as timing, location and payment type would have led to unrealistic combinations (such as monthly payments in agricultural inputs). We therefore opted to include four credible combinations of timing, location and type of payment within one attribute. This has however the disadvantage that we cannot clearly identify whether and to what extent particular aspects of a payment vehicle influenced its final valuation. We included two different levels of in-kind payments with variation in the delivery plus two kinds of cash payment: (a) annual cash payments in April each year; (b) monthly cash payments; (c) in-kind payment with agricultural inputs (seeds, fertilizer and pesticides) delivered to the village[5] at the beginning of each growing season (hereafter referred to as input payments); (d) in-kind payment with agricultural inputs (see above) as a voucher that can be redeemed in the district capital at the beginning of each growing season (hereafter referred to as voucher payment).

Kaczan et al. (2013) conducted a choice experiment on PES in Tanzania and found a strong preference for a one-off upfront in-kind fertilizer payment over individual or collective cash payments. We therefore expect input and voucher payments to be preferred to cash payments (Hypothesis 1). While input payments include the delivery of the inputs to the village and voucher payment implies that transport must be covered by recipients, we expect input payments to be preferred to voucher payments (Hypothesis 2).

PES commonly aim at compensating for the opportunity costs of conservation (Engel, 2016). The main economic benefits of forest clearing in the research area accrue due to the shifting of agriculture from old fields to newly cleared areas with higher soil fertility. Initial levels for the payment amounts were therefore estimated by reviewing literature on the opportunity costs of agricultural land uses, in particular maize yields in Zambia (Xu et al., 2009). Further adaptation throughout the pre-test and pilot led to a final range of 8.2–65.8 US$ per year per acre. With the maximum amount it is possible to cover the entire input costs for maize cultivation (optimal quantity of fertilizer as suggested by Xu et al. (2009) and hybrid seeds). The corresponding values for monthly cash payments were included, if the payment vehicle was monthly cash payments.[6]

Regarding our second and third research questions, we included four attributes besides payment vehicle in the design (see Table 1). Knowledge about recipients' preferences regarding these attributes allows adapting PES designs to reduce transfers amounts, to assure high enrolment rates and effectiveness in terms of environmental outcomes.

[5] It was specified that the inputs are delivered to the village, but not whether to the households directly or to a central point in each village. We belief that this distinction would however only result in small changes in the valuation. Villages are relatively small and due to small field sizes the actual amount of fertilizer per household would be small.

[6] In the payment amount description for input and voucher payments, we specified the amount with respect to fertilizer (see Online-Appendix B).

Table 1
Attributes, levels and hypotheses.

Attribute	Levels	Hypotheses
Payment vehicle	Annual cash payment (in April each year) Monthly cash payments Voucher payments (before the growing season) Input payments (delivered before the growing season)	H1: respondents prefer on average input and voucher payments over annual and monthly cash payments. H2: respondents prefer on average input over voucher payments.
Payment levels[a] (Zambian Kwacha per year per acre)	60 (8.2US$) 120 (16.4US$) 240 (32.9US$) 480 (65.8US$)	
Contract duration	10 years 20 years	
Implementing organization	Government of Zambia NGO	
Forest co-benefits	No extraction Firewood extraction Subsistence extraction Commercial extraction	H3: respondents have on average a preference for less restrictive forest co-benefits over more restrictive levels.

[a] Based on average exchange rate in June 2014 (1 USD = 7.3 ZMW).

Several choice experiments included the contract duration as an attribute in their experimental design. Overall empirical evidence is inconclusive. Some studies found a preference for shorter contracts (5 vs 9 vs 17 years) (Balderas Torres et al., 2013), while others found preferences for longer contracts (15 vs 25 vs 35 years) (Arifin et al., 2009) and (3 vs 10 years) (Zabel and Engel, 2010). In the latter cases, however, the provision of the environmental service required large investments that are only likely to pay-off after long periods. In the research area, clearing is for most households an irregular activity. Roughly half of the respondents (49%) have cleared in the last 5 years. The majority of these households (73%) has cleared in this period only once. Only 6% has cleared every year within this period. Short contract periods would therefore risk that households simply clear forest after a PES contract expires. We therefore specified a minimum contract duration of 10 years and included a second level of 20 years.

In the context of REDD+, it has been demonstrated that PES schemes can be implemented by governments directly or through other organizations under a multi-level REDD+ scheme (Wertz-Kanounnikoff and Angelsen, 2009). Empirical studies from Zambia suggest that trust in the government, particularly at the local level, is low. Non-Governmental Organization (NGO) leaders are, however, considered to be less corrupt (Mulenga et al., 2004). Therefore, we gave two options for implementing organization: the Government of Zambia and a generic NGO. To our knowledge, none of the reviewed choice experiments on PES in developing countries varied the implementing organization in their design.

Various timber and non-timber forest products play a significant role in the livelihoods of rural communities in Zambia and provide common coping strategies in times of idiosyncratic shocks (Kalaba et al., 2013). We included four levels of forest co-benefits that each specify what kind of forest products can be extracted and for what use: (a) no extraction of any type of forest product; (b) only the collection of dead firewood is allowed for home consumption; (c) collection of any timber and non-timber forest product is allowed for home consumption; (d) collection of any timber and non-timber forest product is allowed for home consumption and commercial use. The last corresponds with the current level of forest use restrictions. Evidence from Vietnam suggests that potential PES recipients want to keep their rights to collect forest products (Petheram and Campbell, 2010). Due to the overall importance of forest products for rural livelihoods in Zambia, we therefore expect respondents to show a clear preference for weaker forest use restrictions (Hypothesis 3).

An Alternative Specific Constant (ASC) is included in the econometric model to capture the overall utility derived from the status quo (Hensher et al., 2015, pp. 53–54). The co-benefits attribute is included in effects coding,[7] since the commercial and subsistence extraction of forest products is allowed in the status quo. The remaining attributes cannot be defined for the status quo, as they apply only to situations with a PES contract. In this case a hybrid coding is preferred (Cooper et al., 2012). The payment amount variable is treated as quasi-continuous and defined as 0 US$ for the status quo. The final observed component of the utility models for Contracts A, B and the status quo can hence be summarized as follows:

$$\begin{aligned} V_{A/B} = {} & \beta_0\ \text{annual.cash}_{A/B} + \beta_1\ \text{monthly.cash}_{A/B} \\ & + \beta_2\ \text{input}_{A/B} + \beta_3\ \text{voucher}_{A/B} + \beta_4\ \text{amount}_{A/B} \\ & + \beta_5\ \text{duration}_{A/B} + \beta_6\ \text{no.benefits}_{A/B} + \beta_7\ \text{firewood}_{A/B} \\ & + \beta_8\ \text{subsistence.benefits}_{A/B} + \beta_9\ \text{commercial.benefits}_{A/B} \\ & + \beta_{10}\ \text{organization}_{A/B} \end{aligned} \quad (3)$$

$$V_{SQ} = \beta_{SQ} + \beta_9\ \text{commercial} \cdot \text{benefits}_{SQ} \quad (4)$$

3. Study Context and Sample

The study is based on a sample of 320 smallholder farmers located in Mumbwa District in the Central Province of Zambia, roughly 160 km from the nation's capital (see Fig. 1). The research area is part of a dedicated buffer zone of the Kafue National Park, the Mumbwa Game Management Area. The area was selected due to its diversity in forest-agriculture landscapes and accelerating forest clearing. While the research site still hosts significant areas of forest, agriculture especially through smallholders continually reduces forested areas. Between 2010 and 2014, 49% of our sampled households cleared forest. Of the respondents, 42% indicated that they intended to clear additional forest in the next three years. These deforestation dynamics cannot be considered sustainable: between 2010 and 2014 the area of agricultural land of our sample increased by 32%.

Within Mumbwa District we selected the Chibuluma and Kabulwebulwe chiefdoms in the western part of the district. They comprise 45 and 73 villages respectively and accommodate roughly 1400 households each. Lists of all villages in both chiefdoms were compiled and 22 villages were selected randomly.[8] Based on household lists obtained from traditional authorities, 18 households were randomly selected per village and the respective household heads were invited to participate. In cases where the household head was ill or absent, the acting household head was interviewed. This applied to 17% of respondents.

Qualitative, exploratory research was conducted between April 2014 and May 2015 in Zambia. The choice experiments and a corresponding household survey were conducted between May and September 2015. We tested the experimental design with an initial pre-test with twelve respondents to review attribute levels, explanation of choice tasks and contracts. To assure that respondents have understood the experiment and managed to compare the two different contracts, each choice experiment was individually administered by a research assistant. The attributes of each contract were explained in-depth and respondents could ask questions at any point of the experiment. Difficulties in choosing can result in delayed responses, fatigue and boredom. We have neither experienced those signs during the pre-test nor during the actual survey. Key socio-economic characteristics and variables used in the LCM are summarized in Table 2.

Maize constitutes the most important crop in the sample occupying approximately 60% of the cultivation area in 2013/14 and 300 out of 320 households cultivated the crop. On average households from the sample achieve maize yields of 1.5 t/ha. Similar yields are found by more comprehensive studies in the same agro-ecological region of Zambia (Xu et al., 2009). Fertilizer is predominantly applied for maize cultivation. Overall, 192 households (60%) have applied fertilizer for maize in the season 2013/14, while only 11 households (3%) applied fertilizer to other crops, mainly vegetables. Out of the 125 households that have not applied any fertilizer, 90% state that cash constraints were the main reason for not using any fertilizer. On average 120 kg/ha of fertilizer was applied to maize, which is significantly lower than the official recommendation by extension services of 400 kg/ha (Xu et al., 2009).

Recent studies however indicate that official recommendations for fertilizer quantities promoted by extension services are often not economically viable for farmers (e.g. Duflo et al., 2008). While the economic profitability of fertilizer application depends on a number of moderating variables such as maize-fertilizer price ratio, timely application and seed varieties, Xu et al. (2009) find that between one third and two third of the recommended nitrogen quantity is economically viable for smallholder farmers in the same agro-ecological region in Zambia, if provided on time. In our sample, 41% and 81% of fertilizer users have applied in 2013/14 below one and two third of the official recommendations respectively. Increasing the application of fertilizer, especially if combined with the adoption of hybrid seeds, would consequently allow most smallholder farmers in our sample to increase maize yields.

4. Results

4.1. Random Parameter Logit Model

We report models of the combined dataset with (a) the choices between two hypothetical contracts and (b) the choice to accept or reject the preferred contract.[9] The dataset comprises two questions per choice set, so with 320 individuals and four choice sets each a total of 2560 choice observations were obtained. The RPL model includes four random parameters for attributes that are found to be heterogeneously distributed, indicated by significant standard deviations of parameters at the 0.01 level (Table 3). All random parameters were specified as normally distributed.

The results of the RPL model indicate that input payments are significantly preferred over any other payment vehicle (first column Table 3). The least preferred vehicle is monthly cash payment, followed by annual cash payments. Even though voucher payment is the second most preferred level, the effect is not statistically significant from the grand mean of all payment vehicle levels. We observe a significant heterogeneity regarding the valuation of input payments in the sample, indicated by a significant standard deviation of the random parameter. Nevertheless, small fractions of respondents favour alternative payment vehicles. Only 4.9%, 0.78% and 0.13% of respondents prefer voucher, annual and monthly cash payments, respectively, over input payments. Overall, we can confirm Hypothesis 1 that respondents prefer on average input and voucher payments over annual and monthly cash payments. Furthermore, we can confirm Hypothesis 2 that respondents prefer on average input over voucher payments.

The RPL model results allow the marginal rate of substitution between specific attributes of interests to be calculated (Hensher et al., 2015, p. 378). Specifically, we are interested in how much the payment

[7] When an ASC is used for the status quo, dummy coding would result in confounding the ASC with the base category effect of the dummy coded variable. In this case, effects coding is preferred over dummy coding as it specifies the estimates of the effect codes relative to the average effect of the variable and not relative to a specified base category (Bech and Gyrd-Hansen, 2005).

[8] Two randomly selected villages could not be covered by the study. In one case the headman denied permission to conduct research, while the headman position in the other village was vacant and recruiting of respondents proved difficult. In other villages, a few invited households could not participate due to absence or illness. Two respondents refused to participate in the choice experiment and were excluded from the dataset. To what extent this affects the representativeness of our sample cannot be determined.

[9] Models with the choice between the two hypothetical contracts only are presented in Online-Appendix D.

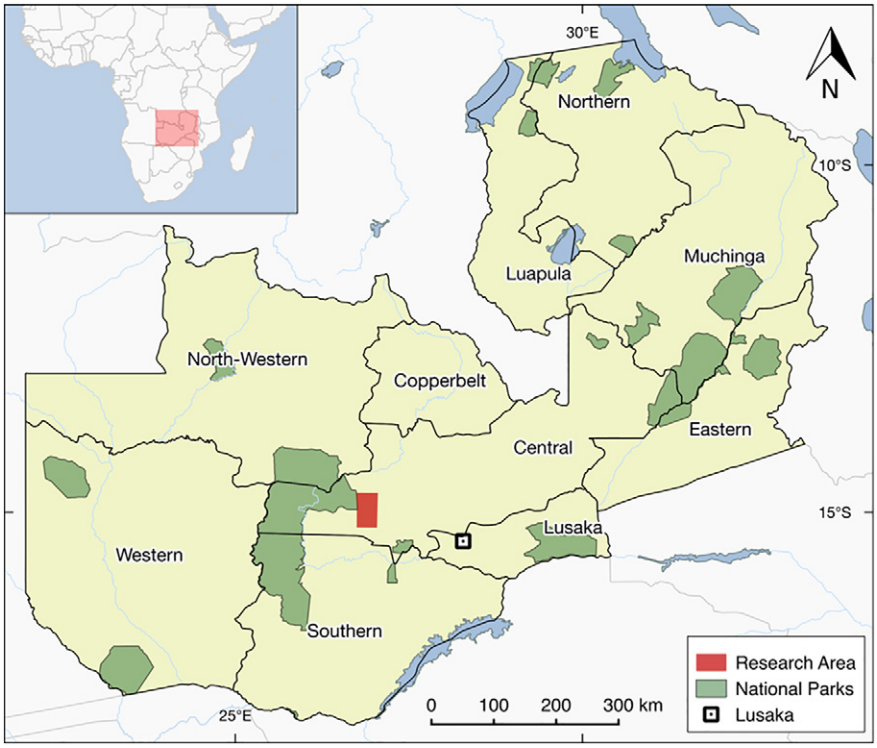

Fig. 1. Geographical location of the research area.

level in US$ per year per acre should change to maintain the same level of utility, if respondents were paid with vouchers or inputs instead of annual cash transfers. On average, respondents would require 79.1 and 25 US$ per year per acre less if they received agricultural inputs or vouchers, respectively, instead of cash.

The status quo parameter is negative, implying that on average respondents prefer the contractual limitations of the PES contract to the status quo. The random parameter distribution indicates that 18.5% have a positive parameter estimate for the status quo and hence would require additional incentives to accept the proposed contracts.

Higher payments are preferred over smaller ones. The four levels of forest co-benefits show a significant impact on the respondents' choices. A full prohibition of any forest use is the least preferred attribute level, followed by firewood benefits only. In contrast to Hypothesis 3, the level that permits extraction of forest products for subsistence use is preferred over contracts that allow collection of forest products for commercial purposes. This difference in effects is significant at the 0.05 level (one sample, right-tailed z-test: $H1: subsistence \cdot benefits > commercial \cdot benefits$, $z = 1.921$, $p - value = 0.027$). On average, respondents would accept 9.8 US$ per acre per year less if commercial extraction of forest products was not allowed, while maintaining their right to collect forest products for their subsistence. In addition, our sample tends to prefer an NGO to the government as the implementing organization. This effect is small in magnitude but statistically significant at the 0.01 level. Contract duration is the only attribute that shows no significant effect on respondents' contract choices.

In addition, we further split the sample between respondents with and without self-stated intention to convert forests to agricultural land in the next three years. The respective regression results are shown in the second and third column of Table 3. Overall, valuations of the individual attributes are similar between both sub-samples. Both groups prefer input over voucher and cash payments. The only noticeable difference is in the status quo valuation. Respondents with

Table 2
Socio-economic characteristics of sample.

Statistic	N (%)	Mean	St. Dev.	Min- Max
Age (years)	320	44.74	15.70	19–87
Female respondents	103 (32%)			
Education (years of schooling)[a]	320	6.38	3.17	0–13
Respondents who migrated in last five years	54 (17%)			
Risk aversion score[b] (1–3 risk loving, 4 risk neutral, 5–6 risk averse, 7–8 highly risk averse)	320	6.62	2.26	1–8
Total Field Size (cultivated and fallows in hectare)	320	6.88	10.26	0.40–80.94
Cultivation area 2014/15 as percent of total field size	320	63.03	29.22	0–100
Total cash income (2014/15) in US$[c]	319[d]	706.60	1559.40	0–18,190
Crop production share among total cash income (2014/15)	307[d]	44.63	39.80	0–100
Years of fertilizer use (2010–2014)	320	2.61	2.09	0–5
Number of years when forest was cleared (2010–2014)	320	0.75	1.10	0–5
Respondents with clearing intention (2015–2017)	134 (42%)			

[a] Education above higher secondary school is coded as 13 years.
[b] Elicited through a risk experiment (see Online-Appendix C).
[c] 1 US$ = 7.3 ZMW.
[d] The remaining respondents could not provide this information.

Table 3
Results of the random parameter logit models.

	Full dataset	Future clearing	No future clearing
Status quo	−2.45 (0.28)***	−1.57 (0.38)***	−3.14 (0.43)***
Annual cash payment[b]	−0.42	−0.51	−0.35
Monthly cash payment	−0.80 (0.11)***	−0.73 (0.17)***	−0.88 (0.14)***
Voucher payment	0.08 (0.08)	0.25 (0.13)**	−0.06 (0.11)
Input payment	1.14 (0.16)***	0.99 (0.24)***	1.29 (0.22)***
No forest benefits	−1.97 (0.18)***	−1.88 (0.28)***	−2.09 (0.25)***
Firewood benefits	−0.23 (0.09)***	−0.54 (0.15)***	−0.04 (0.11)
Subsistence forest benefits	1.20 (0.10)***	1.42 (0.17)***	1.07 (0.13)***
Commercial forest benefits[b]	1.00	1.00	1.06
Amount	0.02 (0.00)***	0.02 (0.00)***	0.02 (0.00)***
Contract duration	−0.04 (0.06)	0.03 (0.09)	−0.08 (0.08)
Organization	0.12 (0.04)***	−0.01 (0.07)	0.20 (0.06)***
Standard deviation[a]			
Status quo	2.73 (0.29)***	2.72 (0.42)***	2.77 (0.42)***
Input payment	0.64 (0.15)***	0.71 (0.22)***	0.64 (0.22)***
No forest benefits	0.81 (0.13)***	0.96 (0.25)***	0.75 (0.17)***
Firewood benefits	0.54 (0.12)***	0.59 (0.21)***	0.55 (0.16)***
AIC	2445.89	1108.48	1328.36
Log likelihood	−1208.95	−540.24	−650.18
Num. obs.	2560.00	1088.00	1472.00

Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
[a] All random parameter estimates are based on 1000 Halton Draws. The random parameters are assumed to be normally distributed.
[b] The parameter of the effects-coded base category is calculated as the negative sum of the other level estimates (Cooper et al., 2012).

clearing intention value the status quo less negatively: 28% of respondents with intention to clear have a positive status quo valuation compared to only 13% of the respondents without clearing intention.

4.2. Latent Class Logit Model

In order to further explore the heterogeneous preferences for contract attributes and how they are related to socio-economic covariates, we present a LCM. This also allows us to identify whether preferences for those households most likely to clear forest are systematically different. We determined three classes as appropriate due to relatively good performance across different information criteria.[10] Table 4 summarizes the parameter estimates for each class and respective class membership predictions based on socio-economic covariates.

With respect to payment vehicle we find that Class 3 does not choose their contract depending on how payments are made. No payment vehicle coefficient is significant. However, this class is most sensitive to payment levels. In contrast, Classes 1 and 2 show similar preferences for input over voucher payments and monthly and annual cash payments are the least preferred payment vehicle. Both classes seem to dominate the average preferences found in the RPL model. Access to fertilizer does not consistently predict preferences for input payments. Even though Classes 2 and 3 have different preferences for input payment, respondents of both classes applied fertilizer less frequently in the last five years than Class 1, as indicated by negative and significant coefficients.

Socio-economic covariates show that past and future clearing behaviour significantly affects class membership probabilities. Respondents who cleared less frequently in the past five years and have plans to clear in the next three years are more likely to belong to Class 1. The largest Class 2 (64%) has a negative appraisal for the status quo, whereas the small Class 1 (12%) would require additional incentives to enter the contract, indicated by a positive and significant status quo coefficient.

[10] The Akaike's Information Criterion, the modified Akaike's Information Criterion with penalty factor three and the Bayesian Information Criteria (see Online-Appendix F for more information).

Table 4
Latent class model parameter estimates.

Class	1	2	3
Status quo	2.45 (0.41)***	−2.68 (0.23)***	−0.57 (0.45)
Annual cash payment[a]	−0.90	−0.38	0.15
Monthly cash payment	−1.10 (0.33)***	−0.86 (0.13)***	0.43 (0.41)
Voucher payment	0.32 (0.24)	0.14 (0.09)*	−0.46 (0.41)
Input payment	1.68 (0.39)***	1.10 (0.18)***	−0.12 (0.47)
No forest benefits	−0.40 (0.44)	−1.82 (0.20)***	−3.14 (1.02)***
Firewood benefits	−0.48 (0.24)**	0.17 (0.09)*	−1.84 (0.35)***
Subsistence forest benefits	0.26 (0.24)	1.06 (0.11)***	1.96 (0.69)***
Commercial forest benefits[a]	0.62	0.59	3.02
Amount	0.01 (0.00)**	0.01 (0.00)***	0.06 (0.01)***
Contract duration	−0.02 (0.15)	−0.15 (0.07)**	0.55 (0.33)*
Organization	−0.12 (0.11)	0.10 (0.04)**	0.09 (0.24)
Class membership			
Intercept		1.00 (0.32)***	1.41 (0.37)***
Age		0.02 (0.00)***	−0.00 (0.01)
Gender (female)		−0.33 (0.16)**	0.05 (0.19)
Migrated (last five years)		−1.07 (0.19)***	−0.86 (0.22)***
Risk aversion		0.13 (0.03)***	−0.05 (0.03)*
Years of fertilizer use (last five years)		−0.23 (0.04)***	−0.16 (0.04)***
Years of clearing (last five years)		0.68 (0.16)***	1.46 (0.18)***
Planned clearing		−0.53 (0.14)***	−0.78 (0.17)***
Average class membership probability	11.51	64.31	24.18
AIC		2317.47	
Log likelihood		−1112.73	
Num. obs.		2504.00	

Standard errors in parentheses.
*** $p < 0.01$.
** $p < 0.05$.
* $p < 0.1$.
[a] The parameter of the effects-coded base category is calculated as the negative sum of the other level estimates (Cooper et al., 2012).

4.3. Estimated Choice Probabilities and Sensitivity to Payment Amount

Next, we illustrate to what extent the different latent classes are sensitive to changes in payment levels. The LCM model is used to estimate choices between the status quo and the PES contract most preferable to the sample respondents. Furthermore, we estimate the share of respondents with clearing intentions who are likely to accept PES contracts at varying payment levels. The RPL suggests that, on average, the most preferred contracts feature input payments, subsistence forest benefits, a 10-year contract duration and an NGO as implementing organization. Even though the optimal PES contract was designed according to the RPL results, the design does not strongly oppose the preferences of any class from the LCM. Individual choice probabilities were estimated for the overall LCM, conditional on class membership probabilities (see Online-Appendix A). Respondents with a choice probability >0.8 for the PES contract are classified as accepting the PES contract, whereas those with choice probabilities >0.8 for the status quo are classified as refusing the contract. The results are illustrated in Fig. 2.

Overall, we observe a major increase in respondents accepting the PES contract from 60% to almost 90% with payments doubling from 20 to 40 US$ per year per acre. Changes in payments below and beyond this range show only minor effects on choice probabilities. At the same time, we observe substantial differences for the acceptance probabilities between classes. Class 2 with a negative status quo coefficient is highly likely to accept the PES contract, irrespective of payment levels. Increases in payments have, however, a substantial positive effect on choice probability for Classes 1 and 3. Overall, choice probability for Class 3 is higher than for Class 1 and significantly increases from below 30% to roughly 80% within the payment range of 0–40 US$ per year per acre. Class 1 members are less sensitive to changes in payments levels. Class 1 is, however, critical for a PES scheme to provide additional environmental benefits. Respondents with future clearing plans are

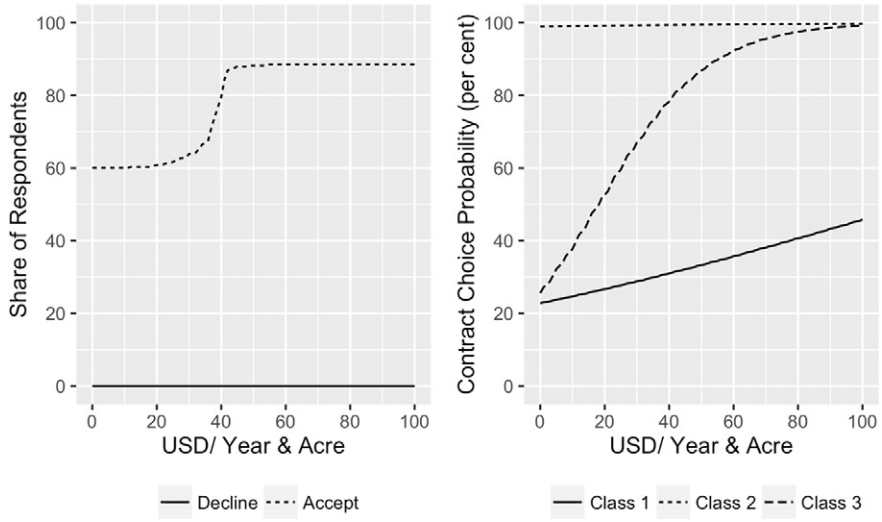

Fig. 2. Estimated choices and choice probabilities by latent classes for optimal PES contracts relative to payment levels.

more likely to belong to this segment. Thus, we separately estimated contract choice probabilities based on LCMs (see Online-Appendix E) for respondents with and without the intention to clear forest within the next three years (see Fig. 3). For respondents without clearing intention, contract acceptance is strongly increasing within the range of 0 to 10 US$ per year per acre to >90%. A relatively small share of <10% are likely to decline the PES contract irrespective of the payment amount. Respondents with plans to clear show an overall lower contract acceptance probability, with higher shares of indecisive respondents. But with payments rising from 20 to 40 US$ per year per acre, contract acceptance substantially increases from below 40% to >80%. While no respondents with clearing plans would refuse the contract, a share of almost 20% remains indecisive irrespective of the payment amount.

5. Discussion

5.1. Preferences for Cash Versus In-kind Payments

Our first research question was to evaluate to what extent respondents prefer in-kind agricultural support to cash payments. Potentially, profits from intensified agriculture allow respondents to achieve higher monetary benefits than solely from cash transfers. Similarly to Kaczan et al. (2013), who defined in-kind payments as one-off payments at the beginning of the contract, we find that payments as agricultural inputs (including fertilizer) are preferred to cash payments of the same value and with the same frequency (annual). Our results also suggest that voucher payments are preferred to cash payments. While preferences for input payments could be explained with significant transaction costs that occur when acquiring fertilizer with received cash payments, the preferences for vouchers over cash payments are less intuitive. We offer two potential explanations for these results.

Duflo et al. (2011) show both theoretically and empirically that present-biased farmers procrastinate over fertilizer purchase due to decision and transactions costs and alternative investment opportunities prior to the next growing season. Such farmers eventually fail to purchase fertilizer. If our respondents are however aware of such time-inconsistent behaviour, they could preventively prefer vouchers to cash payments. A second possible explanation for the preferences for voucher over cash payments is based on the capabilities to save cash payments. This is especially valid since the cash payments were designed to be paid out in April each year, around harvest time and months before fertilizers are commonly purchased. Lack of access to financial services and social obligations to share cash income with larger family networks potentially limit capabilities for saving cash over longer

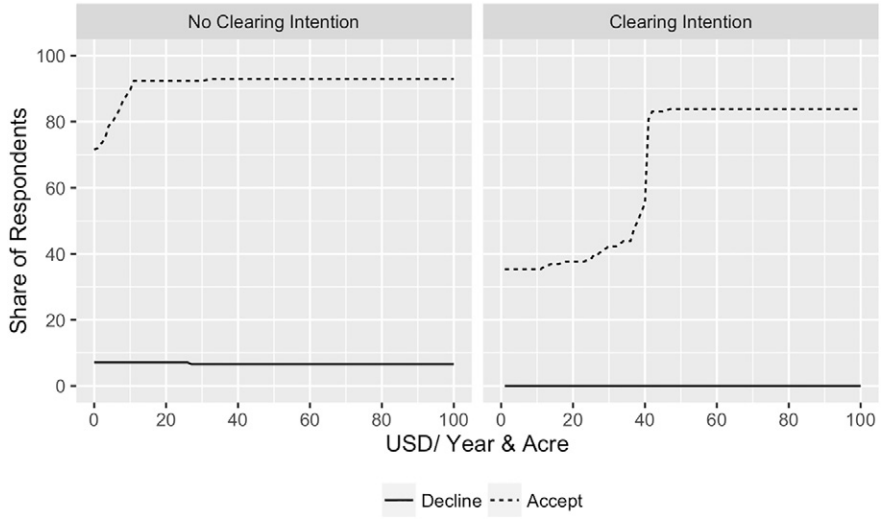

Fig. 3. Estimated choices for optimal PES contracts relative to payment levels of respondents with and without clearing intentions in the next three years.

periods. Voucher could be hence perceived as attractive pre-commitment device for farmers to assure that inputs are acquired before the next growing season (cf Bryan et al., 2010).

Even though both models find heterogeneity for the valuation of in-kind payments, adoption of such payment vehicles would not compromise contract attractiveness among sample segments. The LCM reveals that one fourth of the respondents are ambivalent regarding the payment vehicle, while the remaining respondents clearly prefer input and voucher payments. Interestingly, the LCM indicates that past fertilizer use cannot explain preference heterogeneity for input payments. Fertilizer adoption in our sample is relatively low and many farmers applying fertilizer often do not manage to acquire optimal quantities (see Section 3). Both the adoption of improved seeds and optimal fertilizer quantities would hence significantly increase agricultural productivity for the vast majority of the sampled farmers. Overall, these results underline that PES schemes paying in-kind with inputs or vouchers could achieve secondary developmental objectives of agricultural intensification.

From a policy design perspective, the preferences for input and voucher payments also indicate that certain payment vehicles can reduce the costs of PES. Respondents are willing to accept smaller transfer amounts under input or voucher payments, other attributes being equal. Considering that voucher and cash payments most likely imply transaction costs of similar magnitude, vouchers provide a viable option to reduce overall programme costs. Whether vouchers or input that is delivered to the villages are preferred in terms of cost-efficiency depends on the relative transaction costs for both vehicles. If input payments imply transaction costs above 54.1 US$ per year per acre compared to voucher payments, the latter payment vehicle is preferred.

5.2. Environmental Effectiveness of PES

To deliver effective positive environmental outcomes, PES schemes need to reach all segments of the population and, most importantly, those which are most likely to carry out environmentally destructive activities. Our models indicate that a large share of respondents would agree to PES contracts which contractually bind them not to clear any forest for agriculture, even without any additional payments. Kaczan et al. (2013) found similar results for a large segment of their sample. They explain differences in the status quo valuation with heterogeneous attitudes towards environmental policy interventions and different opportunity costs for agroforestry. In our case, preferences to save land for future generations or preferences for securing land-use rights for both their current agricultural land and forests are a potential explanation for the negative status quo valuation of the majority. Households with plans to clear forest within the next three years are more likely to require additional incentives to enrol in PES schemes, potentially due to higher opportunity costs of avoiding forest clearing.

Our initial hypothesis concerning forest co-benefits stated that lower restrictions of forest use are preferred to more restrictive ones. In contrast, the analyses found that restrictions of commercial forest use are preferred over the status quo, which allows to collect forest products both for subsistence and commercial purposes. Based on qualitative follow-up questions after the choice experiments, we explain this preference by concerns for excessive commercial extraction (mainly charcoal production). Only few households derive significant cash income from commercial extraction of forest products. Many respondents stated that a regulation of commercial extraction would conserve forests for subsistence use. This indicates that respondents' choices, at least partly, reflect which contract they want the overall community to accept. These findings also suggest that restrictions of the commercial use of forests can provide additional incentives for most respondents to enrol in such a PES scheme.

All three models highlight that respondents have positive preferences for the amount of incentive payments, which is also in line with former studies (Balderas Torres et al., 2013; Costedoat et al., 2016; Kaczan et al., 2013). Furthermore, most respondents with clearing plans can be motivated to participate in the PES scheme, if payment levels are sufficient. The estimated choice probabilities for an optimal PES design suggest that around 40 US$ per year per acre, contract acceptance increases substantially. Through separate models for households with and without clearing plans, we found that within the range of 20–40 US$ enrolment rates of households with clearing intention increase sharply up to 80%. DCE that capture preference heterogeneity can consequently help design PES schemes and set payment levels to ensure that critical segments of a population enrol and a positive environmental outcome is realized.

To be effective in achieving the desired forest conservation, the PES scheme we designed requires a full acceptance rate at the community level. Nevertheless, our results show that approximately 10% of the respondents are reluctant to accept an optimal contract design with payments between 40 and 100 US$ per year per acre. Moreover, we find that roughly 20% of respondents with clearing intentions remain indecisive regarding PES contracts that pay 40 US$ per year per acre. An effective scheme under a common property regime requires full enrolment rates. Our discrete choice experiment was solely designed as individual decision making. Consequently, it remains open whether reluctant respondents would alter their decision if the majority of a community joined a PES scheme. Potentially, further unidentified contract features could convince this small share of the population to join the scheme.

Despite different valuations for the status quo among respondents with and without clearing intentions, we do not find preference heterogeneity for the remaining contract attributes. Different preferences for these attributes would allow to offer specifically tailored contracts. Ideally, respondents without clearing intentions would then self-select into contracts with preferred characteristics and lower payment amounts. This would allow to cost-efficiently ensure full enrolment rates at the community level. Even though this does not apply to our sample, stated preferences methods, in particular DCE, allow to identify whether heterogeneous preferences allow for such self-selection mechanism.

The long-term environmental impact of any PES schemes ultimately depends on the question how households react to the termination of the incentives. Conventional PES provide additional monetary income for the time of PES contracts, which could be either used directly for consumption or invested in productive activities such as agriculture. In contrast, agricultural inputs are directly providing means to increase productivity from agriculture. With a termination of such PES, households are likely to have realized higher yields from agriculture and are confronted with higher incentives to increase their production by clearing additional forests (Phelps et al., 2013). As a result, renewing contracts under the input-based PES may require higher payments than under a conventional PES (if monetary transfers are predominantly used for consumption and not invested in agriculture). This could eventually compromise the relative cost advantage of the proposed PES schemes compared to conventional PES.

6. Conclusion

Our results indicate that there is a potential to harness synergetic interactions between PES for forest conservation and agricultural intensification. At our study site, most farmers expressed willingness to refrain from forest clearing if compensated through PES. Respondents show preferences for agricultural inputs or vouchers over cash transfers. Such PES schemes may also be more cost efficient, if additional transaction costs of agricultural input provisioning do not exceed the reduced transfer amounts that are possible compared to cash payments. We used fertilizer as an example as it is a technology which is well known in the study region. Further research could explore to what extent inputs related to more innovative and sustainable intensification strategies would be appreciated. This is especially important in areas, where such PES schemes may foster excessive fertilizer application, that in turn has adverse environmental impacts such as water pollution.

Moreover, we find that contract duration, implementing organization and permitted use of forests affect the valuation of PES contracts.

To effectively reduce deforestation, PES should specifically target households which are most likely to clear forest in future. Our results confirm that they demand higher payments than farmers who express no strong intention to extend their fields. Nevertheless, the vast majority of such respondents can be motivated to enrol for PES at reasonable payment levels. The methodology presented here provides the means to identify such critical segments of a PES target population and elicit their design preferences.

This hints at the challenge facing any PES scheme in an area with customary tenure but individualized land-use rights in ensuring full individual enrolment in the PES scheme. Without this, the environmental outcome of schemes is at high risk. Large forest areas could be cleared by only a few non-participating famers. In such cases, individual PES would have to be embedded in a polycentric multi-layer forest governance framework. Potential options include for example group contracts or customary laws that complement individual PES contracts. In the latter case, customary institutions could enforce and sanction land-use restrictions, if supported by a majority of the community. It remains for future research to investigate how and which alternative governance approaches best harness the individual preferences for PES contracts presented in this paper.

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ecolecon.2017.05.024.

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