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RESEARCH ARTICLE

Valuing biodiversity protection: Payment for Environmental Services schemes in Lao PDR

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Abstract
The design of a Payment for Environmental Services (PES) scheme that involves setting a 'pseudo market price' per unit of environmental service requires the estimation of demand and supply. This paper presents the results of discrete choice experiments aimed at estimating the demand for environmental and social services generated by a wildlife protection PES scheme in two protected areas in Lao PDR. The discrete choice experiments targeted international tourists sampled at Vientiane airport and the urban Lao population sampled in Vientiane City as potential buyers of the environmental and social services provided by the PES scheme. The survey was customised to a developing country context to address diversity in respondents' literacy levels, language limitations of the interviewers, socio-cultural conventions, and limited trust in confidentiality and anonymity of the survey process. The marginal benefits of the environmental services so estimated were used to inform the development of a PES scheme.

Keywords: anti-poaching patrols; biodiversity protection; discrete choice experiments; Lao PDR; non-market valuation; payments for environmental services (PES) schemes

1. Introduction

Payment for Environmental Services (PES) schemes are increasingly being used around the world in an attempt to increase the supply of environmental services that are not traded in markets (see, for example, Scheufele, 2016). PES schemes aim to link those who are willing to supply these environmental services with those who are willing to buy them, so that an exchange can occur. Linking prospective suppliers with potential buyers can be achieved through the lowering of transaction costs. This can be achieved through the actions of an intermediary or broker who independently provides information on supply and demand to intending producers and consumers so that prices can be determined.

The demand for non-market environmental services can be estimated by means of the discrete choice experiment method. This method facilitates the estimation of both use and non-use values provided by environmental assets in monetary terms. The discrete choice experiment method, based on Lancaster's 'characteristics value theory'

(Lancaster, 1966), originated in the marketing and transport literature (Louviere and Hensher, 1982; Louviere and Woodworth, 1983) and was first applied to an environmental context by Carson *et al.* (1990). Discrete choice experiments involve respondents to a survey being asked to make trade-offs between a range of characteristics, called attributes, which jointly describe a particular good or service. The attributes can take several levels and are bundled in choice options that are presented to respondents in choice questions. By making trade-offs in the choice questions, respondents reveal their preferences associated with each of these attributes.

The choice experiment method is widely used to estimate benefits associated with non-market environmental services. Examples of applications in developed countries include Doherty *et al.* (2014), Dias and Belcher (2015), Chaikaew *et al.* (2017), and Lew and Wallmo (2017). Examples of application in developing countries include Bennett and Birol (2010), Villalobos and Huenchuleo (2010), Wang *et al.* (2010), Mejía and Brandt (2015) and Rai *et al.* (2015).

This study presents the results of discrete choice experiments used to estimate the demand for reducing biodiversity loss in the context of designing a PES scheme intended to facilitate the supply of wildlife protection. The choice experiments targeted demand from international tourists visiting the Lao People's Democratic Republic (PDR)[1] (henceforth called 'tourists') and the residents of urban districts of Vientiane City,[2] (henceforth called 'residents').

The choice experiment questionnaire and the survey techniques employed included innovative elements to address challenges encountered in a developing country context and where cultural and language differences are apparent across respondents and between interviewers and respondents.

The choice experiments were especially designed to facilitate the use of their results in the development of prices to be paid for the supply of actions that will produce environmental services. The demand estimates elicited were used to inform the development and implementation of two pilot PES schemes.[3] Both schemes are based on a design that aims to mimic market processes by 'negotiating' pricing based on comparable estimates of demand and supply and hence require detailed information regarding the strength of demand (Scheufele and Bennett, 2017). The estimates of demand reported in this paper were used conjointly with the relevant marginal cost estimates (Scheufele and Bennett,

[1]'International tourists are tourists who enter Laos with a valid passport and visa obtained from a Lao embassy or consulate abroad, or a visa obtained on arrival at an international border checkpoint' (Tourism Development Department, 2016: 2). Foreign visitors who may be exempt from visa requirements but are not regional tourists are included in this definition. 'Regional tourists are foreign visitors from neighbouring countries such as: Thailand, China, Myanmar, Vietnam and Cambodia, which share borders with Laos. They enter Laos with valid border passes or passports' (Tourism Development Department, 2016: 2).

[2]The identified buyer segment within the Lao population was limited to the permanent residents of the Lao PDR and Lao PDR citizens living in the urban districts of Vientiane City (Chanthabuly, parts of Sikottabong, Xaysrtha, and Sisattanak). The budget constraint of households in rural districts was deemed too restrictive to enable any payments for environmental services.

[3]The two pilot PES schemes were designed and implemented through the project 'Effective Implementation of Payments for Environmental Services in Lao PDR'. The project was funded by the Australian Centre for International Agricultural Research within the Australian Government and is conducted by the Australian National University in collaboration with the Ministry of Natural Resources and Environment (Lao PDR), the Department of Forestry within the Ministry of Agriculture and Forestry (Lao PDR), the National University of Laos and the University of Western Australia. For further information, visit https://ipesl.crawford.anu.edu.au/.

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2018) to set the 'price' per anti-poaching patrol (Scheufele *et al.*, 2018), with a stochastic wildlife population model used to convert patrol effort into wildlife diversity outcomes (Hay *et al.*, 2017; Renton *et al.*, 2017).

The remainder of this paper is structured as follows. Section 2 sets out the application by providing information on the research design, survey logistics and associated practical challenges, experimental design and econometric framework. Section 3 presents the results. Section 4 closes with a conclusion.

2. Applications

The demand for increased biodiversity protection was estimated for the two pilot PES scheme areas: the Phou Chomvoy Provincial Protected Area (PCPPA) and the Green Peafowl Species Conservation Zone (GPSCZ). The marginal willingness to pay of tourists and residents for biodiversity protection in the two areas was estimated using four discrete choice experiments (split-samples).

The survey material consisted of an interviewer protocol, a questionnaire script, show cards, answer sheets, and choice booklets that contained the choice questions.[4] The respondents were asked to record their choices in a paper booklet without being observed by the interviewer. The booklet was then submitted in a sealed envelope to ensure anonymity and confidentiality and minimise drivers of response bias. Additionally, the respondents were assured by the interviewers that the survey was anonymous (no names were recorded) and confidential. Potential drivers of response bias, especially for the resident split-samples, included the desire to please the interviewer and/or an unwillingness to have their true preferences revealed to the interviewer. The use of show cards and the choice question booklets was also designed to reduce communication barriers between the Lao interviewers and the tourist respondents who had a range of English language competence. Where language was a barrier, it was found that reading skills were superior to oral skills. Furthermore, where oral skills were not restrictive, the slow pace of spoken delivery by the Lao interviewers was found to be frustrating to respondents. To enhance communications further, graphics and images were used extensively (see figure 1 for an example). Potential interviewer bias was minimised by using show cards, envelopes for submitting the choice booklets, and interviewer training.

The survey material was customized to the two target populations (tourists and residents). The survey material differed between the split-samples with respect to target groups in terms of the language of delivery, filter questions, questions regarding socio-demographic characteristics, the payment vehicle and the levels of the cost attribute. The resident questionnaires were presented in Lao, whereas the tourist questionnaires were in English. The use of additional languages to account for the diversity of international tourists was not possible due to language limitations of the Lao interviewers. The survey material was also made specific for the two protected areas (the PCPPA and the GPSCZ) in further split-samples. This resulted in four split-samples: PCPPA/tourists; PCPPA/residents; GPSCZ/tourists; and, GPSCZ/residents.

[4]Focus groups with residents (29 respondents for GPSCZ and 33 for PCPPA) and a pilot survey targeting tourists (41 respondents for GPSCZ and 32 for PCPPA) were used to test the survey material, survey mode and the sampling process. The collected data were also used to estimate priors for the development of the experimental designs used for the main surveys. Due to practical constraints, it was not possible to conduct focus groups with tourists or a pilot survey for residents.

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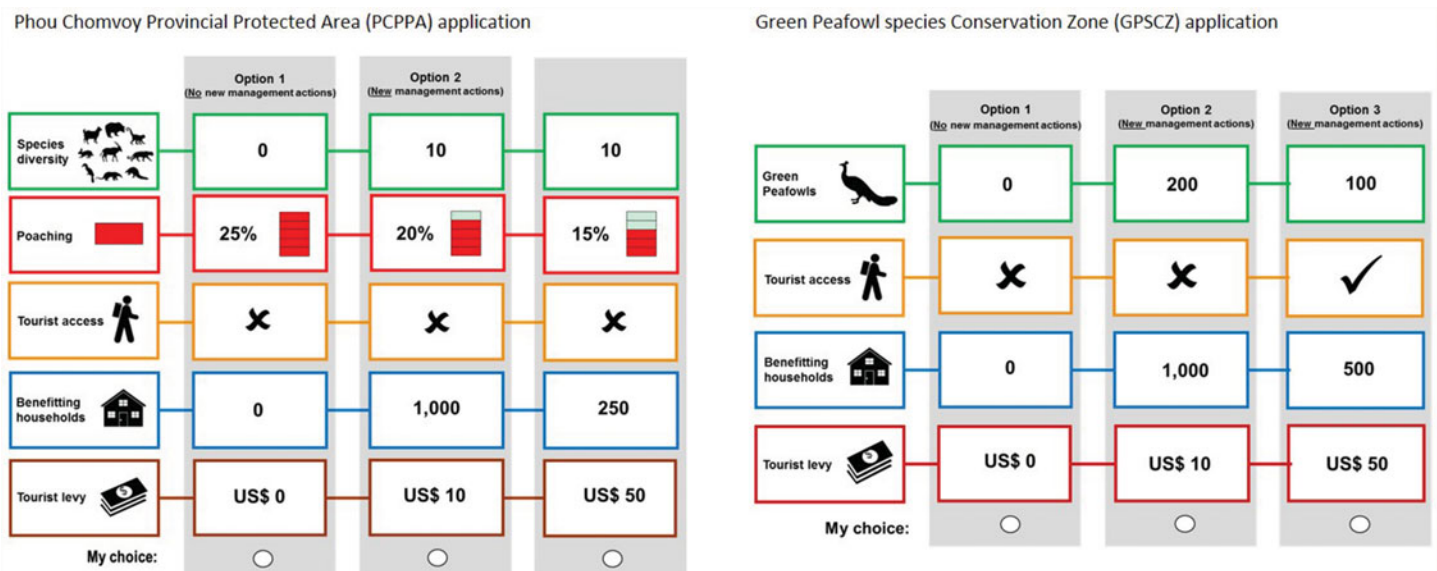

Figure 1. Example choice sets presented to tourist respondents

The PCPPA is a mainly mountainous part of the Northern Annamite Ranges covering about 22,300 hectares. It is located in the Bolikhamxay Province on the border with Vietnam. The GPSCZ covers about 8,000 hectares within the Phou Khao Khouay National Protected Area located in the Vientiane Capital Province. Both areas are 'biodiversity hotspots' providing habitat for a range defined by IUCN as Endangered and Critically Endangered species (IUCN, 2016). The PCPPA application focussed on the protection of 19 wildlife species classified as Endangered and Critically Endangered (IUCN, 2016). The GPSCZ application focussed on the protection of a single wildlife species, the Critically Endangered (IUCN, 2016) Green Peafowl (Pavo muticus).

The questionnaires were structured as follows. After some filter questions relating to the travel purpose, visa requirements and country of origin of tourist respondents and citizenship/permanent residence of local residents, respondents were provided with background information including photographs and explanations about the protected area and future management options. The respondents were told that the protected area (PCPPA and GPSCZ) was home to a range of wildlife species, which are under pressure from poaching. They were further informed that some of these species were threatened with extinction, that their current populations range from 5 to 50 animals per species, and that about 25 per cent of these animals are poached each year.

This was followed by the choice tasks, which asked respondents to make a sequence of five choices between three management options regarding wildlife protection. Each choice consisted of one 'no new management actions' option at no additional cost and two 'new management actions' options at an additional cost. Respondents were presented with a show card and an example choice question that provided detailed information on the attribute levels (called 'outcomes' in the show cards) associated with each choice option (figures 1 and 2). The choice options were mainly described by symbols to assist resident respondents with low literacy levels and tourist respondents' (potential) English language limitations.

Each choice option was described by attributes (five for PCPPA and four for GPSCZ), representing a combination of environmental services (*species diversity:* number of species present in PCPPA; *poaching*: percentage of animals poached per year in PCV; *Green Peafowls*: number of birds present in GPSCZ), social services (*tourist access*: availability of tourist access to protected area; *benefitting households*: number of households located in close proximity to protected area that would benefit from improved living conditions as a result of an additional payment to village funds), and the associated costs to enjoy these services (*tourist levy*: one-off tourist levy; *household payment*: monthly household payment through electricity bill). The attributes levels are summarized in table 1.[5]

A Bayesian[6] s-efficient experimental design[7] was used to generate the choice sets.[8] An s-efficient design optimizes for sample size. This design type was used because data collection was restricted to face-to-face interviews (instead of a less costly but impractical Internet survey). Consequently, the achievable sample size was limited. Four separate

[5]The levels of the attributes of the environmental services were determined through predictions based on stochastic wildlife population models.

[6]500 Halton draws were taken.

[7]Sándor and Wedel (2001) introduced Bayesian efficient designs, while Ferrini and Scarpa (2007) were the first to apply these designs in an environmental economics context. S-efficient designs were introduced by Bliemer and Rose (2005).

[8]All designs were created using Ngene 1.1.2.

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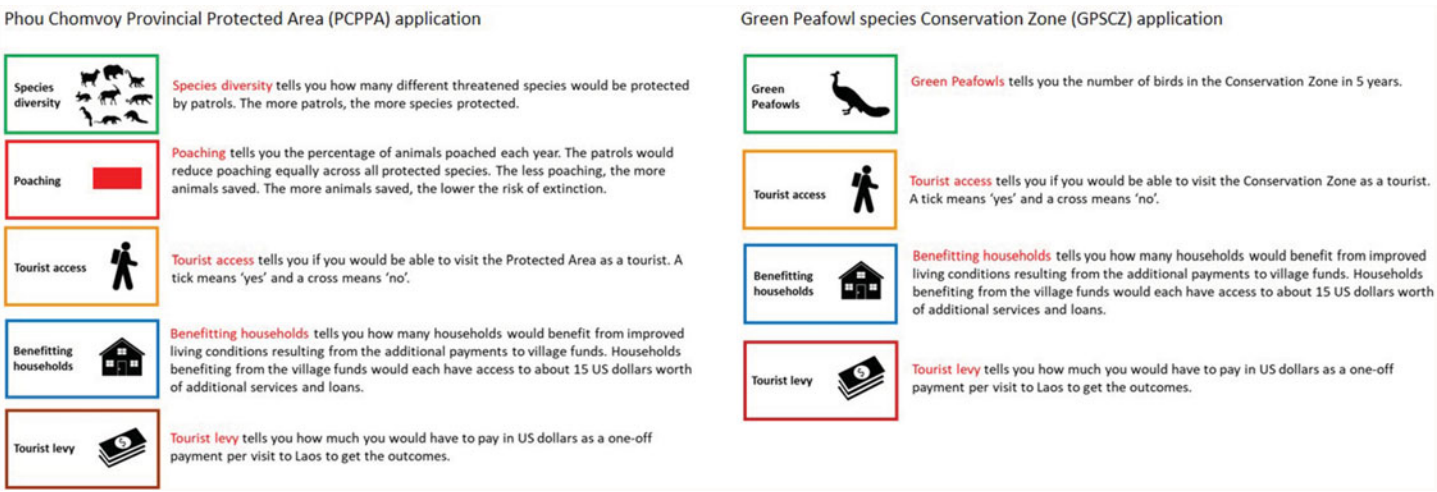

Figure 2. Attribute descriptions

Table 1. Attributes and their levels

PCPPA (tourist and inhabitant split-samples)		GPSCZ (tourist and inhabitant split-samples)	
Attribute	Attribute levels	Attribute	Attribute levels
Tourist levy – tourist split sample only (One-off tourist levy – US$)*	$0 $5 $10 $20 $50	*Tourist levy* – tourist split sample only (One-off tourist levy – US$)*	$0 $5 $10 $20 $50
Household payment – inhabitant split sample only (Monthly household payment through electricity bill – Lao ₭)*	₭ 0 ₭ 5,000 ₭ 10,000 ₭ 20,000 ₭ 40,000	*Household payment* – inhabitant split sample only (Monthly household payment through electricity bill – Lao ₭)*	₭ 0 ₭ 5,000 ₭ 10,000 ₭ 20,000 ₭ 40,000
Species diversity (Number of species)	0 5 10 15 20	*Green Peafowls* (Number of birds)	0 50 100 200 300
Poaching (Percentage of animals poached per year)	25% 20% 15% 10% 5%		
Tourist access (Availability of tourist access to protected area)	1 (yes) −1 (no)	*Tourist access* (Availability of tourist access to protected area)	1 (yes) −1 (no)
Benefitting households (Number of households located in close proximity to the protected area that would benefit from improved living conditions as a result of an additional payment to village funds)	0 250 500 1,000 1,500	*Benefitting households* (Number of households located in close proximity to the protected area that would benefit from improved living conditions as a result of an additional payment to village funds)	0 250 500 1,000 1,500

Note: *US$1 = ₭8,177.68 (27.01.2017 Oanda.com).

designs were generated to account for different payment vehicles (across the two groups of respondents) and different attributes (across the two zones).

Each design consisted of 20 choice sets divided into four blocks that were randomly assigned to the respondents. The sequence of the choice sets in each block was randomized to minimise any ordering effects. This resulted in 20 different choice booklets per split-sample.

The discrete choice experiment surveys were conducted through personal interviews.[9] Data were collected from 5 to 15 December 2015 by drawing two samples from each of the two 'PES buyer' populations. Tourists were interviewed in the departure

[9]The interviews were conducted by 50 students (in pairs) from the Faculty of Economics and Business Management at the National University of Laos. The students interviewed randomly in their assigned buyer group and protected area. Due to potential interviewer bias, comparisons of the results across the four split-samples should be done with caution. The training of the students as well as the management and

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lounge at Wattay International Airport in Vientiane City using a random sampling method. The interviews were scheduled to cover the departure times of all international flights leaving the Lao PDR. The residents were interviewed at their homes. Maps showing district boundaries were not available. Interviewers were equipped with the Google Earth app on their mobile phones, which provided information on the location of the randomly selected starting points for random household sampling.

The econometric models used to analyse the choice data are based in random utility theory (Thurstone, 1927; McFadden, 1974, 1980). The collected data were analysed using a mixed logit model specification, which relaxes the restrictive assumptions of the conditional logit model (Revelt and Train, 1998; Train, 1998). All non-cost parameters were assumed to be normally distributed (1,000 Halton draws) to account for preference heterogeneity. The cost parameter for the two populations *(tourist levy* and *household payment)* were specified as non-random. Generic error components were included to allow for differences in the variances of the error terms between the 'no new management actions' option and the two 'new management actions' options, and thus to relax the IID (independent and identically distributed random variables) assumption. Panel specifications were used to account for repeated choice observations. All models were estimated in STATA 13 using the Newton-Raphson algorithm.

The inclusion of a cost attribute in the choice sets facilitates the estimation of implicit prices. An implicit price is a monetary value of a unit change in the provision of a particular non-monetary attribute. Implicit prices (IP) for attributes were derived by taking the ratio of estimated distributions of cost and non-cost parameters obtained from a choice model defined in utility space (Hanley and Barbier, 2009):

$$IP_k = -\frac{\beta_k}{c}, \tag{1}$$

where $\beta_k \forall k \in 1, \ldots, K$ represents the vector of the non-cost parameter estimates and c is the cost parameter estimate. A parametric bootstrapping procedure (10,000 repetitions) was used in the estimation of the attribute implicit prices to account for sampling errors (Krinsky and Robb, 1986).

3. Results

The two tourist split-samples consisted of 345 respondents who participated in the PCPPA survey and 333 respondents who participated in the GPSCZ survey. The response rates (excluding protesters[10]) were about 60 per cent and 78 per cent, respectively. The response rate differences may be explained by differences in the level of rigour by which interviewers followed the sampling protocol.[11]

The characteristics of both tourist split-samples and the tourist population[12] are presented in table 2. χ^2 tests were conducted to check for differences. The split-samples are

monitoring of the survey was conducted by the team of the project 'Effective Implementation of Payments for Environmental Services in Lao PDR'.

[10]Protesters were defined as respondents who may hold a positive value but refused to disclose it. The PCPPA and GPSCZ split-samples included 9 and 16 protesters, respectively.

[11]To obtain conservative estimates of aggregate demand, the lower response rate of 60 per cent associated with the PCPPA survey could be applied to the GPSCZ survey data.

[12]2015 Statistical Tourism in Laos (Tourism Development Department, 2016). The available statistics were limited.

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Table 2. Respondent characteristics of the two tourist split-samples

Variable		PCPPA	GPSCZ	Population
Gender	Female	40.78%	49.25%	NA
	Male	59.42%	50.75%	NA
Highest level of education	Primary education	0.00%	0.00%	NA
	Secondary education	11.59%	19.94%	NA
	Tertiary education	88.41%	80.06%	NA
Age	18–24	21.45%	21.45%	NA
	25–29	30.43%	29.31%	NA
	30–39	18.55%	17.22%	NA
	40–49	14.78%	13.90%	NA
	50–59	8.70%	12.39%	NA
	60–69	4.64%	3.32%	NA
	70–79	1.16%	2.42%	NA
	80 and older	0.29%	0.00%	NA
Country	Africa and Middle East	2.03%	1.80%	1.66%
	Americas	19.77%	26.41%	13.90%
	Asia and Pacific	26.16%	26.15%	50.51%
	(Australia and New Zealand)	*11.63%*	*12.01%*	*6.16%*
	Europe	52.03%	45.64%	33.93%
Average household income		$81,813	$83,750	NA
Average size of travel party		2.00 people	2.00 people	NA
Average stay		8.3 days	8.8 days	7.5 days
N (respondents)		354	333	

statistically different from the population data with respect to the socio-demographics that were available at the population level. The respondents, on average, stayed longer in the Lao PDR. Asian respondents are under-represented while Europeans, North Americans and Australians/New Zealanders are over-represented. The difference in representation may be explained, to some extent, by language problems, given that the surveys were conducted exclusively in English.

The two resident split-samples consisted of 206 respondents who participated in the PCPPA survey and 207 respondents who participated in the GPSCZ survey. The response rates (excluding protesters[13]) were 42 per cent and 48 per cent, respectively.[14]

[13]Protesters were defined as respondents who may hold a positive value but refused to disclose it. The split-samples included 23 protesters for each of the PCPPA and GPSCZ split-samples.

[14]Again, to obtain conservative estimates of aggregate demand, the lower response rate of 42 per cent associated with the PCPPA survey could be applied to the GPSCZ survey data.

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The characteristics of both resident split-samples and the resident population[15] are presented in table 3. χ^2 tests were conducted to check for differences. The split-samples are statistically different from the population data with respect to the socio-demographics that were available at the population level. Females are overrepresented in the sample. The respondents, on average, have achieved higher education levels than the population. The age group from 18 to 24 years is under-represented, whereas the age group from 40 to 59 is over-represented. Government employees, state enterprise employees and unpaid family workers are over-represented. Private employees, self-employed respondents, and students are under-represented. The differences between the split-samples and the corresponding populations may be explained by the schedule used for sampling: interviews could only be conducted between 8:30 am and 6:00 pm. Interview times outside this schedule were deemed to be unsafe (for the interviewers) and impolite (with respect to the respondents).

The econometric results of the PCPPA application are presented in table 4. The *tourist levy/household payment* parameter estimates are statistically significantly different from zero ($p < 0.000$) and have the expected negative signs. This suggests that lower cost options are preferred to higher cost options, *ceteris paribus*. For the tourist split-sample, the *species diversity* parameter estimate is statistically significantly different from zero ($p < 0.000$) and has the expected positive sign. This indicates that a higher degree of species diversity provides a higher utility than a lower degree, *ceteris paribus*. The *species diversity* parameter estimated for the resident split-sample is not statistically significantly different from zero ($p = 0.194$), suggesting a zero marginal utility from more species diversity. The *poaching* parameter estimates are statistically significantly different from zero ($p = 0.004$ and $p = 0.020$, respectively) and have the expected negative signs. This indicates that lower poaching levels provide a higher utility than higher poaching levels, *ceteris paribus*. The *tourist access* parameter estimates are statistically significantly different from zero ($p < 0.000$ and $p = 0.007$, respectively) and have the expected positive signs, indicating that the opportunity of having access to the protected area provides a higher utility than not having access, *ceteris paribus*. The *benefitting households* parameter estimates are statistically significantly different from zero ($p < 0.000$ and $p = 0.032$, respectively) and have the expected positive signs. This suggests that the respondents' utility increases with an increase in the number of households benefitting from improved living conditions through payments to the village development funds, *ceteris paribus*. The parameter estimate of the *income* variable (interacted with the constant) is positive and statistically significantly different from zero at the 10 per cent confidence level ($p = 0.067$) in the tourist split-sample. This indicates that respondents with higher household income were more likely to choose a 'new management actions' option than those with lower household income, *ceteris paribus*. The parameter estimate of the *education* variable (interaction with the constant) is positive and statistically significantly different from zero at the 1 per cent confidence level ($p = 0.005$) in the resident split-sample. This suggests that respondents who have achieved a higher education level were more likely to choose a 'new management actions' option compared to those who achieved a lower education level, *ceteris paribus*.[16]

[15]Results of the population and housing census 2015 (Government of Lao PDR, 2016). Questions about household income were included in the census.

[16]Since more highly educated respondents are over-represented in the sample, the results may be biased upwards.

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Table 3. Respondent characteristics of the two resident split-samples

Variable		PCPPA	GPSCZ	Population
Gender	Female	58.74%	56.04%	50.46%
	Male	41.26%	43.96%	49.54%
Education	No education	1.94%	2.91%	1.31%
	Less than 6 years primary education	7.28%	1.94%	23.52%
	Primary education	8.74%	7.77%	1.10%
	Secondary education	29.13%	32.52%	49.91%
	Vocational education	19.90%	18.93%	11.63%
	Tertiary education	33.01%	35.92%	12.53%
Age	18–24	10.68%	13.53%	21.54%
	25–29	12.14%	8.70%	15.95%
	30–39	22.82%	25.12%	22.63%
	40–49	25.73%	24.15%	15.88%
	50–59	17.48%	15.94%	11.40%
	60–69	7.28%	7.73%	6.29%
	70–79	3.40%	3.86%	3.71%
	80 and older	0.49%	0.97%	2.60%
Main activity last 12 month	Government employee	26.70%	32.37%	13.71%
	Private employee	2.43%	2.42%	18.36%
	State enterprise employee	12.62%	9.66%	2.61%
	Employer	3.88%	3.38%	1.14%
	Self-employed	4.37%	4.35%	17.15%
	Unpaid family worker	20.87%	13.53%	3.02%
	International organisation or NGO	0.49%	4.83%	0.56%
	Unemployed	3.40%	1.93%	2.79%
	Student	3.40%	4.83%	21.11%
	Household duties	14.56%	15.46%	14.24%
	Other	7.28%	7.25%	5.31%
Average household income		37,883,100₭	44,571,080₭	NA
Average household size		5.4	4.3	4.6
Household head	Yes	46.12%	45.41%	
	No	53.88%	54.59%	
N (respondents)		206	207	

Note: US$1 = ₭8,177.68 (27.01.2017 Oanda.com).

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Table 4. Panel mixed logit model – PCPPA application

	Tourists			Residents		
Variable	Coefficient	*p*-values	Standard error	Coefficient	*p*-values	Standard error
Non-random parameters						
Constant	2.8121***	(<0.000)	0.6622	2.4073***	(<0.000)	0.6263
Household income	1.06E-05*	(0.067)	5.78E-06			
Education				2.1289***	(0.005)	0.7504
Tourist levy/household payment	−0.0445***	(<0.000)	0.0041	−4.09E-05***	(<0.000)	5.80E-06
Random parameters						
Species diversity	0.0742***	(<0.000)	0.0164	0.0158	(0.194)	0.0122
Poaching	−0.0507***	(0.004)	0.0174	−0.0374**	(0.020)	0.0160
Tourist access	0.4098***	(<0.000)	0.1108	0.2121***	(0.007)	0.0789
Benefitting households	0.0007***	(<0.000)	0.0001	0.0003**	(0.032)	0.0001
Standard deviations of random parameters						
Species diversity (*n*)	0.0584*	(0.076)	0.0329	0.0193	(0.606)	0.0373
Poaching (*n*)	0.1363***	(<0.000)	0.0200	0.0835***	(<0.000)	0.0175
Tourist access (*n*)	0.6620***	(<0.000)	0.1579	0.4651***	(<0.000)	0.1175
Benefitting households (*n*)	0.0009***	(<0.000)	0.0001	−0.0002	(0.521)	0.0004

Error component						
Sigma	2.9890***	(<0.000)	0.4864	3.4139***	(<0.000)	0.5041
Model statistics						
N (observations)	1,704			1,030		
LL_{β}	−1,284.8221			−877.8696		
$\chi^2_{(5)}$	241.67			253.07		
$p(\chi^2)$	<0.0000			<0.0000		

Notes: The orders of magnitude of the attribute data were adjusted to facilitate the estimation process. The results are presented in the original units as described in table 1. Different models were estimating including a range of socio-demographics. Model fit criteria (AIC, BIC) were used to decide on exclusions from the model.
*** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level; *p*-values in parentheses.

For the tourist split-sample, the estimated standard deviations of the random parameters are statistically significantly different from zero at the 1 per cent confidence level for all parameter estimates ($p < 0.000$) except *species diversity* ($p = 0.076$). This indicates preference heterogeneity for *poaching*, *tourist access* and *benefitting households* across respondents. For the resident split-sample, preference heterogeneity is only found with respect to the *poaching* and *tourist access* attributes as indicated by the significance levels of their estimated standard deviations ($p < 0.000$).[17] The error component parameter estimates are statistically significantly different from zero ($p < 0.000$) for both split-samples, indicating that the variances differ between the 'no new management actions' option and the two 'new management action' options.

The econometric results of the GPSCZ application are presented in table 5. The GPSCZ results are interpreted in the same way as the PCPPA results. All parameter estimates are statistically significantly different from zero (at least at the 5 per cent confidence level) and have the expected signs with the exception of the *tourist access* parameter estimated for the tourist sample and the *benefitting households* parameter estimated for the resident split-sample. The parameter estimate of the *income* variable (interacted with the constant) included in the tourist model is negative and statistically significantly different from zero at the 1 per cent confidence level ($p = 0.006$). This indicates that respondents who did not disclose their household income and were assigned the sample average were less likely to choose a 'new management actions' option than those who disclosed their household income. The parameter estimate of the *age* variable (interacted with the constant) included in the resident model is positive and statistically significantly different from zero at the 10 per cent confidence level ($p = 0.066$). This suggests that older respondents were more likely to choose a 'new management actions' option compared to younger respondents.[18]

For the tourist split-sample, the estimates of the standard deviations of the random parameters are statistically significantly different from zero at the 1 per cent confidence level for all parameter estimates. Given that the *tourist access* parameter estimate is not statistically significantly different from zero at the 1 per cent confidence level, this may indicate a bimodal distribution associated with this attribute. For the resident split-sample, preference heterogeneity is only found with respect to the *tourist access* attribute as indicated by the 1 per cent significance level of the estimated standard deviation.[19] The error component parameter estimates are statistically significantly different from zero at the 1 per cent confidence level for both split-samples.

The implicit prices of the PCPPA application are presented in table 6. All implicit prices are statistically significantly different from zero at the 5 per cent confidence level with the exception of the implicit price for *species diversity* estimated for the resident split-sample.

The implicit prices of the GPSCZ application are presented in table 7. All implicit prices are statistically significantly different from zero at the 5 per cent confidence level except for the implicit prices for *tourist access* estimated for the tourist split-sample and for *benefitting households* estimated for the resident split-sample.

[17] A model specification treating *species diversity* and *benefitting households* as fixed parameters produced results that were not statistically different from those presented.

[18] Since older respondents are over-represented in the sample, the results may be biased upwards.

[19] A model specification treating *Green Peafowls* and *benefitting households* as fixed parameters produced results that were not statistically different from those presented.

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Table 5. Panel mixed logit model – GPSCZ application

	Tourists			Residents		
Variable	Coefficient	*p*-values	Standard error	Coefficient	*p*-values	Standard error
Non-random parameters						
Constant	6.4056***	(<0.000)	0.9155	1.4769	(0.105)	0.9108
Household income	−2.8551***	(0.006)	1.0456			
Age				0.0365*	(0.066)	0.0199
Tourist levy/ household payment	−0.0579***	(<0.000)	0.0049	−5.82E-05***	(<0.000)	7.62E-06
Random parameters						
Green Peafowls	0.0027***	(0.010)	0.0011	0.0024**	(0.020)	0.0010
Tourist access	0.0848	(0.454)	0.1134	0.2861***	(0.008)	0.1071
Benefitting households	0.0009***	(<0.000)	0.0002	0.0003	(0.158)	0.0002
Standard deviations of random parameters						
Green Peafowls	0.0049***	(<0.000)	0.0010	−0.0021	(0.211)	0.0017
Tourist access	0.9759***	(<0.000)	0.1224	0.9780***	(<0.000)	0.1191
Benefitting households	0.0006***	(0.001)	0.0002	<0.0000	(0.971)	0.0008
Error component						
Sigma	−4.9962***	(<0.000)	0.7318	−3.0546***	(<0.000)	0.4174
Model statistics						
N (observations)	1,661		1,028			
LL_{β}	−1,089.6709		−806.9562			
$\chi^2_{(4)}$	426.76		273.1300			
$p(\chi^2)$	< 0.0000		<0.0000			

Notes: The orders of magnitude of the attribute data were adjusted to facilitate the estimation process. The results are presented in the original units as described in table 1.
*** = significant at 1% level, ** = significant at 5% level, * = significant at 10% level; *p*-values in parentheses.

Table 6. Implicit prices – PCPPA application

PCPPA		
Tourists		
Attribute	Implicit prices	95% Confidence interval
Species diversity	$1.67 (₭13,657)/Species	$1.00 (₭8,178)–$2.35 (₭19,218)
Poaching	$1.14 (₭9,323)/% Poaching reduction	$0.40 (₭3,271)–$1.80 (₭14,720)
Tourist access	$9.22 (₭75,398)/Access	$4.27 (₭34,919)–$14.44 (₭118,086)
Benefitting households	$0.017 (₭139)/Household	$0.012 (₭98)–$0.021 (₭172)
Residents		
Attribute	Implicit prices	95% Confidence interval
Species diversity	₭386/Species	₭-221–₭935
Poaching	₭913/% Poaching reduction	₭156–₭1,612
Tourist access	₭5,182/Access	₭1,504–₭8,739
Benefitting households	₭7/Household	₭1–₭13

Note: $US1 = ₭8,177.68 (27.01.2017 Oanda.com).

Table 7. Implicit prices – GPSCZ application

GPSCZ		
Tourists		
Attribute	Implicit prices	95% Confidence interval
Green Peafowls	$0.05 (₭409)/Bird	$0.01 (₭82)–$0.09 (₭736)
Tourist access	$1.46 (₭11,939)/Access	$-2.63 (₭-21,507)–$4.94 (₭40,398)
Benefitting households	$0.015 (₭123)/Household	$0.01 (₭82)–$0.022 (₭180)
Residents		
Attribute	Implicit prices	95% Confidence interval
Green Peafowls	₭41/Bird	₭6–₭87
Tourist access	₭4,914/Access	₭1,422–₭8,593
Benefitting households	₭6/Household	₭-2–₭13

Note: $US1 = ₭8,177.68 (27.01.2017 Oanda.com).

4. Conclusions

This study presented the results of choice experiments used to estimate the demand for environmental services (biodiversity protection in the PCPPA and the GPSCZ) and social services (tourist access and improvement in living conditions). The demand estimates of two groups of environmental and social services 'buyers' were used to inform the implementation of two pilot PES schemes designed to mimic market processes by 'negotiating' pricing based on comparable estimates of demand and supply.

The results suggest that both tourists and residents are willing to pay for reducing biodiversity loss through wildlife protection actions in both the PCPPA and the

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GPSCZ. Tourists were also willing to pay for an improvement in the living conditions of households that are located in close proximity to both the PCPPA and the GPSCZ, whereas the willingness to pay of the residents for improved living conditions is limited to the PCPPA. Residents are willing to pay for access to both the PCPPA and GPSCZ. Tourists are only willing to pay for access to the PCPPA, whereas their mean willingness to pay for access to the GPSCZ is zero.

The estimated implicit prices were fed into the PES design process. The flexibility inherent in choice experiment applications makes their results particularly suitable to this task. First they were aggregated from sample to population for a range of attribute level combinations. These aggregated implicit prices were then converted from 'output space' (reduction of biodiversity loss) into 'input space' (wildlife protection actions) (Scheufele *et al.*, 2018) using stochastic wildlife population models (Hay *et al.*, 2017; Renton *et al.*, 2017) to allow the estimation of a demand schedule. This schedule was compatible with marginal cost estimates in 'input space' generated through a sequence of conservation auctions for integration into a pseudo market model (Scheufele and Bennett, 2018).

Customizing the survey material and the sampling protocols to different environmental and social services, to a developing country context, as well as to different buyer groups and their respective social and cultural contexts, presented a range of challenges. They included the language diversity of respondents, diversity in respondents' literacy levels, language limitations of the interviewers, and socio-cultural conventions. Procedures to maximise confidentiality and minimise response bias were included in the interviewer protocols. Of particular concern was the potential desire of respondents to please the interviewer or the unwillingness of respondents to see their true preferences disclosed to the interviewer. This was addressed by designing and applying special procedures on choice set delivery and collection. For example, mixing oral and written survey material, presenting the choice attributes by symbols, using choice booklets to enable unobserved choices and thus confidential and anonymous delivery. Further research is needed to test if such procedures affect response bias, particularly across countries with different cultural mores and political constraints. Other measures that could be taken to reduce response bias include dissonance-minimising formats used in contingent valuation (Blamey *et al.*, 1999; Tran and Navrud, 2009).

Choosing a sampling method customised to the Lao PDR context presented further challenges. None of the samples drawn from the buyer populations were fully representative with respect to the tested socio-demographics. Possible explanations are the restrictive interview schedules, which only allowed residents to be interviewed between 9 am and 6 pm. The lack of maps showing district boundaries prevented a stratified sampling approach. A possible explanation for the non-representative nature of the tourist sample may be language barriers since the survey material was only available in English.

Nevertheless, this paper has demonstrated how choice experiments have the flexibility to produce demand estimates for environmental and social services for different buyer groups that can be used to inform the design and implementation of PES schemes in developing country contexts where cultural and language barriers exist across respondents and between respondents and interviewers.

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