Local people's preferences for biodiversity offsets to achieve 'no net loss' for economic developments

Abstract

Understanding people's preferences for biodiversity offsetting activities can help to design offsets that achieve 'no net loss' (NNL) of biodiversity while incorporating the use and cultural values associated with this biodiversity. We use a stated preference choice experiment to solicit preferences for different proposed biodiversity offsets, linked to two hydropower developments in Uganda, with the aim of improving social outcomes of the offsets. We surveyed 1,215 respondents from six villages located along the river impacted by the hydropower projects. Overall, people preferred offsets and compensatory activities that benefit the entire village rather than just a few individuals. People opposed the removal of non-native trees from their Central Forest Reserve and some responded negatively towards free access to spiritual sites. Respondents' choices were influenced by gender, age, education level, length of time lived in the village, level of poverty, and whether they believed that the hydropower development had affected their wellbeing. Preferences also varied significantly between villages. Our findings provide insight into locally preferred options for biodiversity NNL offsets. They also demonstrate the use of choice experiments to inform decisions about biodiversity offsets, as part of ensuring that NNL strategies do not make local people worse off.

Keywords: choice experiment, Uganda, hydropower, biodiversity no net loss, equity, compensation

Introduction

Biodiversity offsets are the last step in a hierarchy of mitigation measures (avoidance, minimisation, remediation and offsetting) used to compensate for residual biodiversity losses caused by development projects, in order to achieve 'no net loss' (NNL) of biodiversity as a minimum, or preferably a 'net gain' (Habib et al. 2013). Offsets aim to balance economically important development with the conservation of biodiversity and ecosystem services (Bull et al. 2013). For offsets to be effective, they need to be designed and implemented to satisfy ecological, economic and social needs (Burton et al. 2017). Most research has focused on offset design and implementation from an ecological perspective (e.g. Habib et al. 2013). However, social and ethical considerations are just as important if biodiversity NNL strategies are to be successful (Griffiths et al. 2018). This has led to recent work exploring the social costs of offsetting (e.g. Bidaud et al. 2015), ethical dimensions (Ives & Bekessy 2015), and public attitudes and preferences (Scholte et al. 2016; Bull et al. 2017b; Burton et al. 2017; Rogers & Burton 2017; Vaissière et al. 2018).

Incorporating the values that people place on biodiversity into offset design and implementation can help to make them more equitable (BenDor et al. 2008). Perceptions of equity influence people's attitudes towards, and acceptance of, conservation activities (including offsets), impacting their long-term sustainability (Sommerville et al. 2010). Understanding local people's preferences early in offset design can therefore: a) ensure that decisions are appropriate for the local social-cultural and environmental contexts; b) encourage ownership; c) build trust and reduce conflict; and d) reduce implementation costs (Sterling et al. 2017). Overall, this helps in designing NNL strategies that both meet conservation objectives and leave local people 'no worse off' in terms of their perceived wellbeing (Griffiths et al. 2018).

Quantifying preferences using economic nonmarket valuation techniques such as choice experiments (CEs) can provide important insights into what activities and policies people are more likely to support (Scholte et al. 2016; Burton et al. 2017; Rogers & Burton 2017). International best practice guidelines for designing offsets, (e.g. by the Business and Biodiversity Offsets Programme (BBOP)), encourage the use of economic tools to evaluate the impacts of development and offsetting on local people's biodiversity-based livelihoods and amenities (BBOP 2009). Such tools provide additional insights compared to the stakeholder consultations that accompany the typical Environmental and Social Impact

Assessment (ESIA) process.

CEs investigate people's preferences as a function of the attributes of the policy or good being evaluated, and the characteristics of individuals affected by the policy (Moro et al. 2013; Johnston et al. 2017). Whilst individuals have numerous cognitive biases that may inhibit rational choices, choice experiments assume that in stating their preference between choice alternatives, individuals choose the alternative that yields the highest individual benefit (utility) to them, whatever the nature of these benefits (e.g. selfish or altruistic). Social preferences are as consistent with the theory underlying choice experiments as individual (private) preferences, and many authors have used the method to illustrate the impacts of behavioural influences on choice (e.g. Czajkowski et al. 2017). CEs provide insight into the relative importance to individuals of different attributes describing a policy option or good, and their willingness to give up some of one attribute to have more of another. They are a widely-used method for environmental valuation (Hoyos 2010), having been adopted in diverse fields of conservation; bushmeat hunting (Moro et al. 2013; Nielsen et al. 2014), designing payments for ecosystem services (PES) schemes (Beharry-Borg et al. 2013; Greiner et al. 2014), and consumer preferences for and drivers of the illegal wildlife trade (Hinsley et al. 2015; Hanley et al. 2017). Furthermore, the method can be used to evaluate the effect of socio-demographic factors on preferences and behaviour. 'Best practice' standards for the design, implementation and analysis of CEs are now emerging (Johnston et al. 2017), which allow policy-makers to have more confidence in interpreting the results of CE studies.

Where local communities rely on natural resources for their livelihoods, poorly planned offsets can exacerbate poverty. We used a case study of two hydropower projects in south-eastern Uganda and an associated biodiversity offset to explore: 1) what compensatory activities people who are immediately dependent on natural resources prefer as part of a biodiversity offset; 2) whether observable socio-demographic variables influence these preferences; 3) whether these preferences differ between geographically separate villages; and 4) whether preferences differ between villages experiencing different economic effects from the projects.

Uganda is in the process of updating their environmental legislation to include biodiversity offsetting as a requirement, putting the country ahead of many others in the region. We provide an empirical example of how CEs can inform the design of socially-acceptable biodiversity NNL strategies, including biodiversity offsets. Our aim is to illustrate practical application of the 'no worse off' principle defined by Griffiths et al. (2019), ensuring that biodiversity NNL strategies for development projects leave local

people ‘no worse off, or preferably better off’ in terms of their perceived wellbeing.

Material and methods

Study area

Our study concerns the first large-scale biodiversity offset in Uganda, linked to to the 250MW World Bank-funded Bujagali Hydropower Project (approximately 8km downstream of the town of Jinja). We worked in six villages along the Victoria Nile River in south-eastern Uganda, experiencing different levels of impact from hydropower development (Fig 1). Currently, biodiversity offsetting is not a legal requirement in Uganda. However, during the design phase, in 2007, the World Bank stipulated that a biodiversity offset be developed to compensate for the residual loss of biodiversity incurred. The World Bank, Ugandan Government and developers therefore agreed to create the so-called Kalagala Offset (Esmail 2017).

Two of the study villages (Kikubamutwe: Bujagali-West; Kyabirwa: Bujagali-East) are located either side of the river adjacent to the Bujagali Hydropower Project. Construction of the Bujagali dam was completed in 2012. Another two study villages (Kalagala: Kalagala-West; Bubogo Bugobi: Kalagala-East) are downstream of Bujagali, within the Kalagala Offset catchment, where no development is occurring but where offset activities would mostly be situated. The final two villages (Nampaanyi: Isimba-West; Bwase Buseta: Isimba-East) are located about 40km downstream of Bujagali, adjacent to the Isimba Hydropower Project, which is currently under construction but without biodiversity offsets.

As documented in the project’s Environmental and Social Impact Assessments (ESIAs; R.J. Burnside International 2006; Ministry of Energy and Mineral Development 2013), both hydropower projects resulted in significant ecological impacts, including loss of riparian and forest habitats, inundation of islands and, in the case of the Bujagali dam, loss of land in the Jinja Wildlife Sanctuary. In addition to social and cultural heritage impacts associated with this loss of biodiversity, additional impacts included resettlement, loss of agricultural land and the flooding of waterfalls and shrines that are dwelling sites for spirits. Specific obligations for the Kalagala offset, which aimed to avert expected biodiversity loss from the ecological impacts, included:

1. Setting aside the Kalagala Falls and Itanda Rapids downstream of the Bujagali dam to protect their

natural habitat and ecological, social and spiritual values.

2. Enabling tourism development activities at the Kalagala Falls site.
3. Not developing power generation in the future that could adversely impact the Kalagala Falls and Itanda Rapids.
4. Conserving, through a sustainable management program, the ecosystems of three CFRs (Mabira, Kalagala and Nile Bank; Fig 1).

Data collection

The CE formed part of a larger questionnaire implemented in respondents' homes. This included questions on socio-demographics, how the dams have affected individuals' ability to lead a good life (a proxy for wellbeing) and household poverty, measured using a Basic Necessities Survey (Davies 2016). All households were randomly selected and where possible, the household head and another family member were interviewed. Villages at Bujagali and Kalagala were larger than at Isimba, so to maintain a consistent proportion of individuals sampled per village, more individuals were sampled in these villages. A total of 1,215 individuals were interviewed (424 individuals from 286 households at Bujagali, 472 individuals from 283 households at Kalagala and 319 individuals from 178 households at Isimba). Four local enumerators were trained to undertake the survey, which was undertaken between September 2016 and February 2017. Full ethics approval was given by Oxford University and the Uganda National Council for Science and Technology.

Attribute selection and choice experiment design

During the CE, respondents were shown three hypothetical alternatives per choice set, representing realistic offset scenarios which differed in their attributes and levels. As this CE was conducted after the development had occurred, we did not include an "opt-out" option in our experimental design since this was not realistic. Ideally, CEs should be carried out as early as possible, preferably during the design and feasibility stages of the project and offset. Results can be then be included in the Environmental and Social Impact Assessment (ESIA) and considered during the project authorisation process.

In each choice set, respondents were asked to select their most preferred alternative. Attributes and

levels were chosen to represent the four main offset obligations, consistent with the Kalagala Offset Sustainable Management Plan (Ministry of Water and Environment 2009) which were both feasible and practicable, but also aimed to provide compensatory benefits to local people. This was accomplished by undertaking a literature review, then a focus group meeting with national and local Ugandan Government representatives who were familiar with the offset management plan. The resulting attributes and levels were discussed with representatives from the Ministry of Water and Environment (the Government body coordinating the Kalagala Offset) to ensure their feasibility. Five attributes were chosen (Table 1). Four attributes had three levels that included: i) the current situation (baseline); ii) a compensatory activity with a small additional social benefit to the local community or individual compared to the baseline; or iii) a compensatory activity with a large additional social benefit to the local community or individual. The fifth attribute had four levels, with an additional level falling under ii above.

CEs often include a monetary attribute to calculate respondents' marginal willingness-to-pay (WTP) for changes in attribute levels (Scholte et al. 2016). A monetary attribute was not deemed necessary in this case, as we were interested in establishing the relative importance of a diverse set of activities, rather than placing a dollar value on offset outcomes (Aravena et al. 2014; Rogers & Burton 2017). Instead, we calculated trade-offs using the Marginal Rate of Substitution (MRS) between the five non-monetary attributes.

Attributes and levels were arranged into choice sets using statistical design theory. If a full factorial design, which includes all possible combinations of attribute levels, was used to create the choice sets, the total number of choice cards would be too large to present to a respondent (e.g. our design would generate 108 choice cards with three alternatives in each card; Hoyos 2010). Therefore, a fractional factorial design was used in which only a fraction of the total number of attribute level combinations were selected to create an efficient design (Hensher et al. 2015; Johnston et al. 2017). The design was generated in the specialised design software Ngene Version 1.1.2 (ChoiceMetrics 2014, Sydney, Australia).

Making choices over a large number of choice cards with many alternatives places a significant cognitive burden on respondents. Therefore, we decided to show every respondent six choice cards with three alternatives in each card. The order in which the cards were presented was randomised. An unlabelled efficient design was used (Hensher et al. 2015). Bayesian priors for the parameters of the attributes were estimated (Greiner et al. 2014), assumed to be normally distributed around a given

mean, with a standard deviation of 0.2. This accounted for possible misspecification and provided a degree of uncertainty around the parameter values, thereby leading to a more robust design (Greiner et al. 2014; Hensher et al. 2015). The priors were used by Ngene to create the efficient design and the efficiency was optimised and expressed as a Bayesian D-error.

Each choice card showed the attribute levels pictorially and a preceding section of the questionnaire explained the CE and gave background information on each attribute and level (Appendix A). Debriefing questions followed the CE (Appendix A), providing a qualitative assessment of attribute non-attendance (i.e. whether the respondent ignored some of the attributes whilst making their choices). Every individual sampled completed the choice experiment, thus the total number of choice observations is 1,215*6=7,290.

The questionnaire was piloted with 74 respondents in a seventh village on the west bank of the river. The pilot checked the respondents' understanding of the attributes, levels and choice task and showed that the CE and supporting questionnaire were clear and user-friendly. Data from the pilot were analysed using a random parameters logit (RPL) model and the resulting parameter estimates used as priors to inform the Bayesian D-efficient design for the final survey (Greiner et al. 2014). Pilot results were not included in the final analysis.

Data analysis

Choice data from all villages were first pooled for analysis, and then analysed separately. Data were first explored with a multinomial logit model (MNL), followed by an RPL model, as it takes into account preference heterogeneity and error correlation across each respondent's choices. For brevity, only the results from the RPL model are presented here. Dummy coding was used to capture non-linear preference variation across three attribute levels (tourism revenue sharing, tree planting and access to sacred sites). The RPL models were estimated using Nlogit 5 (Econometric_Software_Inc 2010) and 500 Halton draws were used to simulate distributions of attributes that were assumed to be normal. A Krinsky-Robb test was undertaken for the pooled sample results, using 2000 draws, indicating whether respondents distinguished between the different options (levels) within the same attribute.

Socio-demographic factors often influence people's choices (Glenk et al. 2011). To investigate preference heterogeneity, an RPL model was run using the pooled choice data, with six socio-

demographic variables interacted multiplicatively with all the attributes and levels; gender, age, education, poverty, how long a respondent had lived in the village, and whether they thought that the dam affected their ability to lead a good life. We hypothesised that people who had lived in the village longer were more likely to value investment that benefitted the village rather than individuals. We also hypothesised that people who felt their wellbeing had changed negatively as a result of the dam may feel disillusioned with any associated compensation activities and may therefore have more negative attitudes towards potential offset activities.

After establishing which attributes and levels significantly influenced choices, the relative importance of each attribute was compared between villages and with the pooled sample. The sizes of attribute parameters resulting from the RPL models are not directly comparable across villages as the estimated parameters are confounded by their scale factors (i.e. error variance heterogeneity; Swait & Louviere 1993). Thus, we calculated ratios of attribute coefficients, representing the MRS between attributes (the rate at which respondents were willing to trade off one desirable attribute against another; Lancaster 1966), by dividing attribute parameter estimates by a numeraire that: i) was significant in all villages; ii) had linear preferences; and iii) had the lowest average coefficient of variation (CV). The 'sustainable livelihood schemes' attribute was selected on this basis. MRS were calculated using R version 3.2.1 (R Core Team 2015). A likelihood ratio test (Greene 1997) was undertaken to test the null hypothesis that all villages had the same preference parameters, and a formal comparison of the MRS for each village and the pooled data was undertaken using the approach proposed by Poe et al. (1994).

Results

Characteristics of respondents

Of the total sample (1,215 individuals), 38% were male and 62% were female; 65% were below the age of 45, 54% had a primary school level of education and 87% had lived in their village for more than ten years (Appendix B). Average household poverty levels were similar across villages. When asked how the construction of the dams had affected their ability to lead a good life, 9% said positively or very positively, 30% were indifferent, 8% said they did not know or would rather not say, and 53% said negatively or very negatively.

Preferences for offset activities

Looking first at the pooled data without interactions with socio-economic variables, all attributes and levels have a significant effect on choices at least at the five percent level, with the exception of the planting of native trees (Appendix C). Clearing of alien (non-native) trees and neither visitors nor residents paying to access spiritual sites are the only attribute levels with negative parameter estimates, showing that respondents dislike them. The reference levels of no tree planting/clearing and mixed payment to access spiritual sites (residents do not pay but visitors pay) were the preferred options. Respondents felt most negative towards no one paying to visit spiritual sites.

The offset activity with the highest marginal utility value in the pooled data (and therefore the most preferred activity) is tourism revenue-sharing. Of the two revenue-sharing options, investing revenues in community development was almost twice as favoured as investment in CFR management (MRS ratio = 165.7 vs 88.3; Appendix D). The next highest MRS ratio (about half the value of CFR management) was for tree planting/clearing; the planting of native trees was most preferred, then combined tree planting/clearing, with the reference level (no tree planting/clearing) next, and clearing of alien trees last. Next, respondents preferred for everyone (residents and visitors) to pay for access to spiritual sites. This activity is preferred over the reference level of mixed payment, with no payment last. Respondents preferred sustainable livelihood schemes where they earnt high amounts of money, followed by schemes employing the most people. However, preferences for these two activities (MRS ratio = 1.0 for sustainable livelihood schemes (baseline) and 0.9 for employment; Appendix D) are very similar and much smaller than preferences for the other attributes and levels.

There is a statistically significant difference between the two tourism revenue-sharing attribute levels (investment in CFR and investment in community development) as well as between the two levels in the payment to access spiritual sites attribute (visitors and residents pay; neither visitors nor residents pay). The three tree planting/clearing programme attribute levels also have significant differences, except for the planting of native trees level vs combined tree planting/clearing (Appendix E).

Geographical variation in marginal utility values is evident, with respondents in the different villages having significantly different preferences for choice alternatives (Figure 2; Likelihood ratio test: X^2 statistic = 306.84, df = 90, $p < 0.01$; Appendix F). In particular, preferences in Bujagali-West were more likely to differ significantly from those of other villages and from the pooled data (Appendix G). Three

attributes had consistently positive effects on choice across all villages, namely sustainable livelihood schemes, employment and tourism revenue-sharing (both investing in the CFRs and investing in community development). As with the pooled sample, respondents in all villages preferred sustainable livelihood schemes that yield the greatest amount of money. In all villages, revenue invested in community development was preferred over investment in the CFRs, but both were more preferable than the reference level of no revenue-sharing. Activities that employed more people were preferred over the reference level, but not by much.

Inter-village differences are particularly observed with the tree planting/clearance programme and payment to access spiritual sites, both in statistical significance and preferences for different levels (Figure 2; Appendix D). Three villages had statistically significant positive utilities for planting of native trees, two of which also had significant positive utilities for combined planting/clearing. Two other villages had statistically significant negative utilities for clearing alien trees. There were no obvious correlations between geographical location and utilities related to tree planting/clearing (e.g. with respect to proximity to the CFRs). However significant preferences with respect to access to spiritual sites were only observed in the Bujagali villages (which had lost their spiritual sites as a result of dam construction). Respondents in Bujagali-West had significantly positive utility for everyone paying to access the spiritual sites while those in Bujagali-East had significantly negative utility for no-one paying, with respect to the baseline of visitors paying and residents not (Figure 2; Appendix D).

To investigate preference heterogeneity further, we interacted six socio-demographic variables with attribute levels (Table 2). Significant interactions indicate a trend even when the mean main effect is non-significant, because in this RPL model an attribute parameter is decomposed into a sum of the mean effect, interaction terms and a random part. For example, on average revenue sharing has no significant effect on choice. But some people care about this attribute, depending on their individual characteristics. Gender interacts significantly with the attribute, meaning men are more likely than women to prefer revenue-sharing.

The most significant differences between demographic groups related to poverty: less poor people (with higher basic necessities scores) had significantly higher preferences for tourism revenue-sharing and the combined planting/clearing of trees, but more negative attitudes towards sustainable livelihood schemes. People who stated that their lives had been positively affected by the dams had significantly more negative attitudes towards tourism revenue-sharing being used for community development. They

also had more positive preferences for clearing of alien trees and planting of native trees. More educated people were significantly more negative in their preferences towards tourism revenue-sharing, whether it was for CFR management or for development. Men were significantly more positive towards investment in CFRs than women. People who had lived in the village the longest, and younger people, tended to prefer sustainable livelihood schemes, while older people were more likely to prefer employment generation.

Discussion

Our results show that people affected by the dam's impact on biodiversity prefer compensation that benefits their whole village, rather than compensation that only benefits targeted individuals. Overall, tourism revenue-sharing was most preferred, with revenues invested in community development; this was sometimes twice as preferred as the next activity. Given high poverty levels in Uganda (about 19.7% of the population live below the poverty line; UNDP 2014), it is unsurprising that people would prefer activities contributing to community-level improvements, such as the building of schools, clinics, roads and providing potable water. In addition, tourism revenue-sharing is widely undertaken in Uganda, so the concept may be readily understood.

The next two most-preferred activities involve improving the degraded CRFs in the study area, either through directing revenue-sharing to CFR management or a tree planting/clearance scheme. Approximately 85% of Uganda's population relies directly on natural resources for livelihoods (Final Draft NEMP 2014), and fuelwood contributes more than 96% of energy for cooking (USAID 2015). In addition to fuelwood, non-timber forest products are used for charcoal, medicinal herbs, food and crafts (Tugume et al. 2016). If people in the study area can continue to access the CFRs as part of the offset (albeit with restrictions), they may benefit considerably from their restoration and maintenance. Tugume et al. (2016) found that people around the Mabira CRF (within the Kalagala Offset catchment) recognised the non-financial benefits of forests, and in particular, their importance in rainfall formation.

Provisioning of natural resources and climate regulation may explain why respondents opposed the removal of alien trees in the CFRs. Alien species (e.g. Paper Mulberry and Eucalyptus) are fast growing and valuable sources of timber and fuelwood (USAID 2006). Households living in areas with alien species harvest higher quantities of firewood, charcoal and poles than those living in areas without them

(Mungatana & Ahimbisibwe 2012). This could create a conflict between achieving NNL for biodiversity (e.g. removal of alien species) and ensuring local people are 'no worse off' when people use and value alien trees.

Following revenue-sharing and tree planting/clearance, respondents preferred for people to pay to access spiritual sites, with some having negative attitudes towards free access. However, there was some suggestion that people in both villages at Bujagali felt most strongly about access to spiritual sites. This is where the sacred sites have either been lost or disturbed because of the dam, whilst those at Kalagala are intact and still attract paying visitors.

Despite significantly influencing choice, preferences for offset activities that could benefit only a few individuals (e.g. sustainable livelihood schemes and employment), were relatively low. At most, two people per village would be employed by the Government to assist with monitoring and evaluating the status of the CFRs while only people who agreed to stop harvesting in the CRF will be allowed to participate in the sustainable livelihood schemes. Perhaps respondents felt that it was unlikely that they themselves would be the recipients of these benefits and hence preferred the activities benefitting the whole village, or perhaps they actively preferred more socially equitable activities despite lower opportunities for individual benefit.

Influence of socio-demographic variables on preferences

It is important that compensation activities linked to biodiversity offsets are targeted to the worst-affected and vulnerable groups (Griffiths et al. 2019). Our findings suggest a high degree of preference heterogeneity in our sample. The fact that more educated people had negative attitudes towards revenue-sharing may be because they were more sceptical about revenue-sharing benefits actually reaching the villages and were better informed about how carefully these processes need to be managed. For example, tourism revenue-sharing is widely applied around Ugandan protected areas, but is often criticised for revenue not reaching local communities, creating distrust and resentment (Franks & Twinamatsiko 2017). People who had lived in the village the longest were most positive about sustainable development enterprises, perhaps because people who have a strong attachment to a place are more likely to want to improve it. The fact that older people placed a higher value on employment than younger people could be because in rural areas, the elderly do not receive a pension

and are therefore reliant on their social networks for care and economic support. In some cultures, women may not be allowed to plant trees or their personal and household activities may constrain their participation in activities such as managing the CFRs. For example, in some regions in Uganda it is taboo for women to plant trees as this demonstrates land ownership (Mukasa et al. 2012), which may explain the gender differences in positivity towards tree planting.

Implications for biodiversity offsets and biodiversity NNL

CEs have been used to explore people's attitudes towards biodiversity offsetting activities in Australia (e.g. Burton et al. (2017); Rogers and Burton (2017)), Scotland (e.g. Scholte et al. (2016)) and France (e.g. Vaissière et al. (2018)). However, all these studies were in developed countries. To our knowledge, this is the first study that uses CEs to explore people's preferences towards biodiversity offsetting activities in a developing country, where local people rely on natural resources for subsistence and livelihoods.

Biodiversity conservation is most effective when policies account for human preferences and choices. We show how CEs can be used to design biodiversity offsets that provide compensation activities preferred by the people who are affected by the biodiversity impact of an economic development project. The method provides a way to engage local affected communities in offset design that extends the standard consultations under an Environmental and Social Impact Assessment (ESIA). We found that our respondents felt comfortable answering the CE survey, understood the concept, and were interested in the outcome. Focus group meetings with local people and implementing agencies to design the attributes and levels for the CE provided an opportunity for discussion of what types of offsets are feasible and could address both social and biodiversity needs, and for new ideas to emerge. It is increasingly recognised that greater investment in community engagement via various participatory approaches, including CEs, can lead to more sustainable and resilient conservation interventions (LaRiviere et al. 2014) and help businesses gain a 'social license' to operate (Kemp et al. 2006). CEs can also assess which socio-demographic factors influence people's preferences, thereby allowing for the design of targeted biodiversity offsets for individual development projects.

A conceptual framework and decision-making process has been proposed by Gardner et al. (2013), indicating steps to be followed to meet a biodiversity NNL outcome. They set out three conditions

necessary if residual impacts are to be offset (losses and gains of biodiversity are COMPARABLE, gains are ADDITIONAL, and gains are LASTING). Building on this framework, we suggest a fourth condition – losses and gains in biodiversity should not make people worse off. CEs could help meet this condition, but in order to be most effective, they need to be carried out early on in the project lifecycle, i.e. during the offset specification and design stage set out by Gardner et al. (2013).

Griffiths et al. (2019) advocate that people should be left no worse off in terms of their wellbeing as a result of gains and losses in biodiversity and that this should be complementary to, rather than prioritised over, efforts to achieve biodiversity NNL. They, and international good practice (such as that from the Business and Biodiversity Offsets Programme) suggest that economic tools such as CEs could be one approach to measuring people's preferences for offsetting activities and providing insight into what trade-offs are acceptable to the local people who are directly or indirectly affected by gains and losses in biodiversity under a NNL strategy.

Although we cannot comprehensively review the pros and cons of including socioeconomic considerations into biodiversity offsetting, if one has twin policy goals of: i) preventing net reductions in biodiversity, and ii) preventing those affected by the project from being worse off as a result of the offset, then this implies taking peoples preferences into account in the design of offsets and biodiversity NNL strategies for individual development projects.

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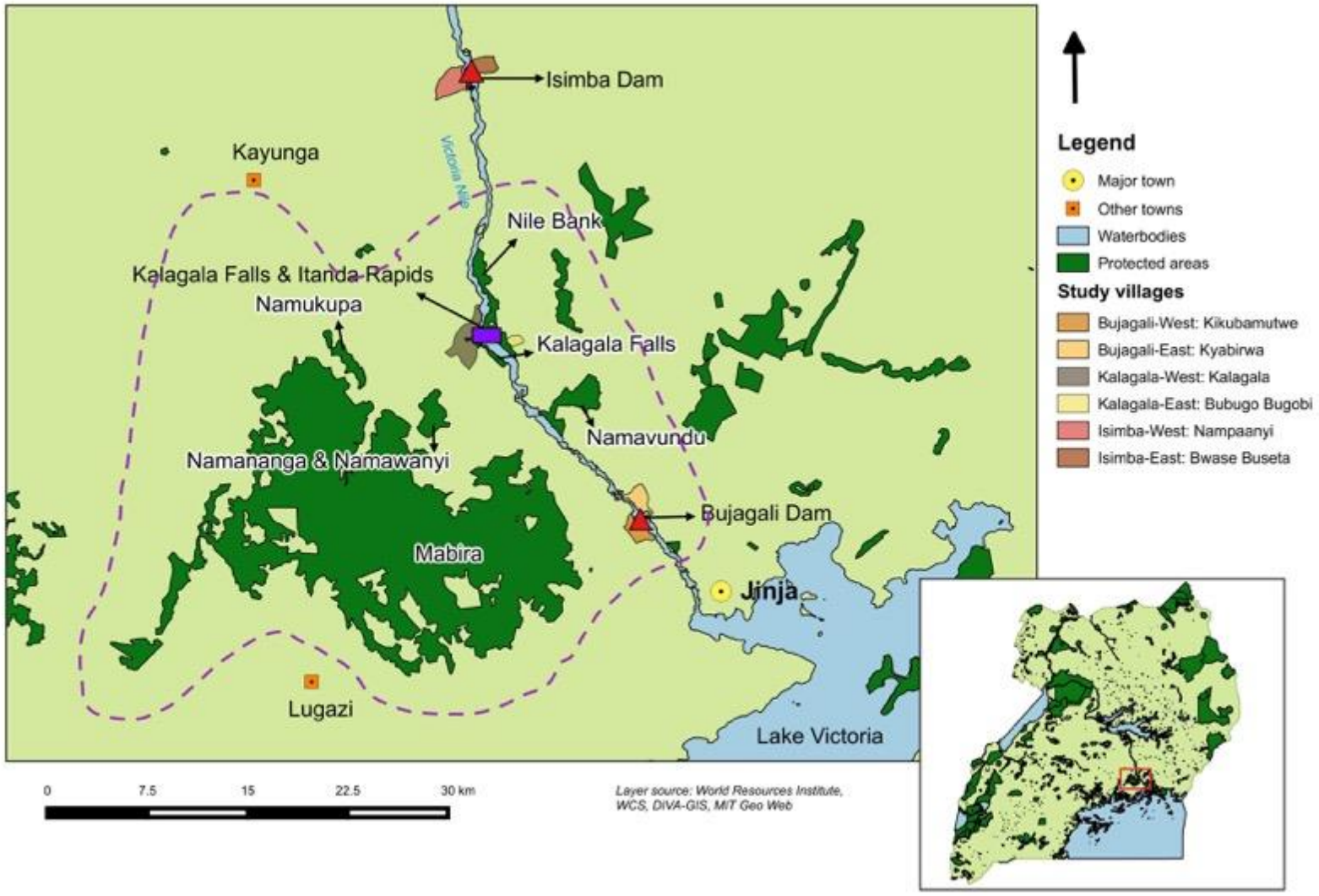

Figure 1: Study area, indicating the location of the six villages sampled. Purple dotted line delineates the Kalagala Offset catchment.

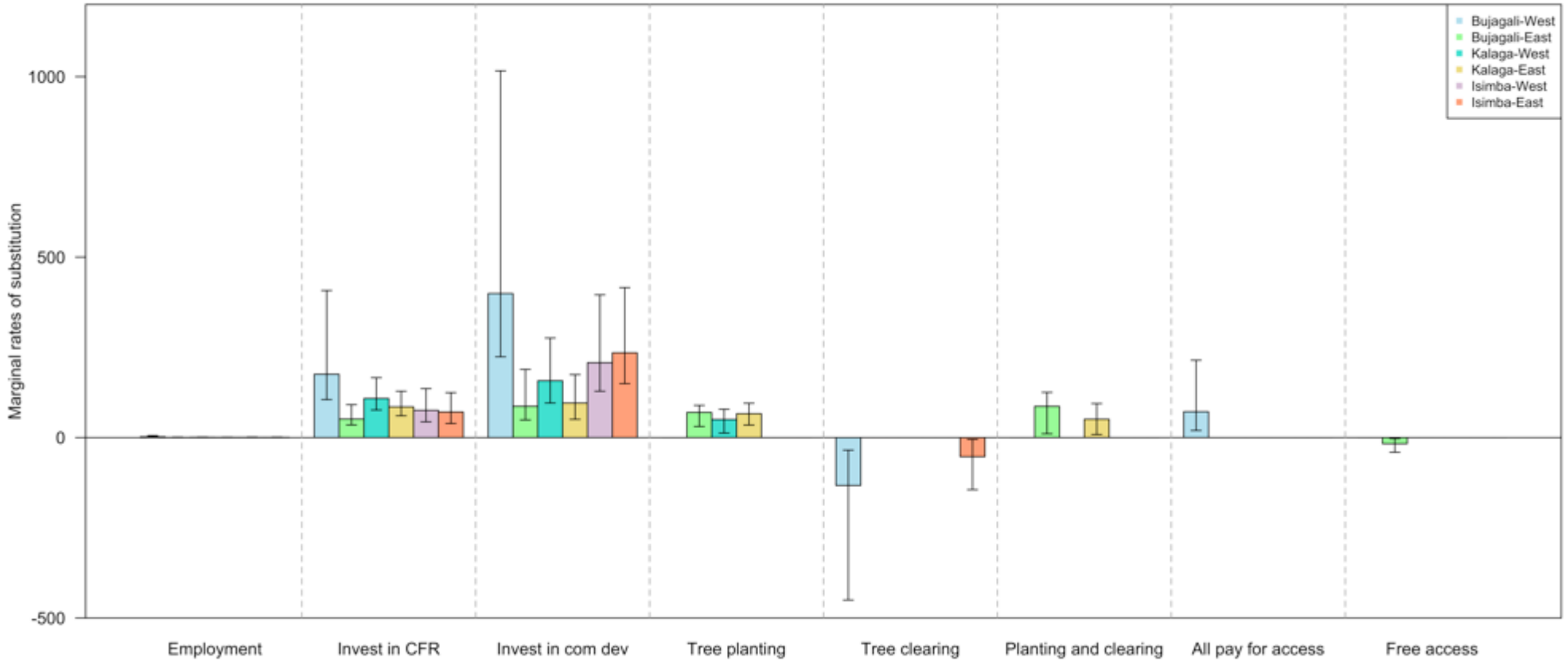

Figure 2: Marginal rates of substitution for significant RPL model parameter estimates for the individual villages. All values are relative to the 'sustainable livelihoods' attribute. (MRS = attribute RPL parameter estimate/ RPL parameter estimate for sustainable livelihood schemes)

Table 1: Attributes (offset activities) and levels used in the choice experiment

Offset activity (attribute)	Different options to choose from (levels)
Sustainable livelihood schemes Environmentally friendly business enterprises such as bee keeping and horticulture will be established that will help enhance household incomes. There will also be support for the planting of high value trees such as fruit trees on participants' land. Seedlings and technical support will be provided to farmers to plant these trees on their land. Schemes will be supported by the Ugandan Government, for example the Ministry of Water and Environment and the National Forest Authority under their Collaborative Forest Management Plan. Any household in the village would be allowed to participate in the scheme provided they are committed to the implementation of the enterprise as per specified terms and conditions, one of which would be that the participants stop cutting down trees in the CFRs. If there is evidence of a participant cutting down trees in the CRF, the participants' household will be excluded from the scheme for a year. Participating households will be guaranteed to receive a fixed price for their products so that they won't experience price fluctuations. By engaging in these enterprises and following the standards, participating households will have a chance to increase their income so that they can buy things they need like fuelwood, rather than needing to take it from the CFRs.	1. No scheme implemented (baseline) 2. Scheme implemented, participants earn UGX (Ugandan Shillings) 500 000 / year 3. Scheme implemented, participants earn UGX 1 000 000 / year
Monitoring and evaluation employment Residents in the villages located in the Kalagala offset	1. No employment to local residents (baseline)

and close to the CFRs will be employed by the Government to assist with monitoring and evaluating the status of the CFRs. This work will also include monitoring who is entering the CFRs and helping to ensure that only people who are allowed to enter and use the CFR's natural resources do so, and so there is less pressure on the CFRs. They will work alongside the Forest Guards contracted by the National Forest Authority, who will continue to work. People employed will earn 200 000 UGX per month and the jobs will last for 5 years. Employment opportunities will be spread evenly across the villages to ensure that people employed are not all from one village.	2. 70 people employed (about one person from each village surrounding the CFRs) 3. 140 people employed (about two people from each village surrounding the CFRs)
Tourism revenue-sharing and sustainable investment Rafting companies will benefit from the protection and maintenance of the Kalagala Falls and Rapids as well as any associated tourism development activities carried out as part of the Kalagala Offset. With this activity, a proportion of the tourism revenue derived from the river rafting permits will be earmarked for **either** the restoration and management of the CFRs **or** community development in villages located within the Kalagala offset (including those located near the Bujagali and Isimba dams). Community development encompasses activities that will benefit the community as a whole, not just individuals (for example the building of clinics, schools and roads as well as providing potable water). Restoring and managing the CFRs means making sure that only people with permits enter and the amount of fuelwood gathered is limited to what the CFRs can sustain, so that the forest recovers and is available for people to use in the future.	1. There is no money paid to the fund from a proportion of each tourist river rafting permit. This means that no money from rafting will be used for either community development or management and restoration of the CFRs. (baseline) 2. USD 3 / 10 000 UGX per tourist river rafting permit is paid into the fund, which adds up to about 3 000 USD / 10 000 000 UGX per year. This money will be earmarked for management and restoration of the CFRs. 3. USD 3 / 10 000 UGX per tourist river rafting permit is paid into the fund, which adds up to about 3 000 USD / 10 000 000 UGX per year. This money will be earmarked for community development in the villages.

In this case, revenue-sharing from rafting permits will happen for permits issued by all rafting companies in the area, not just Adrift. This will follow the Uganda Wildlife Authorities' revenue-sharing guidelines for its national parks, where local communities have a say in what programmes are initiated. Rafting companies will pay money into a fund, which is to be held and monitored by the Ugandan Government (such as the Ministry of Water and Environment).	
Native tree planting programme and alien tree removal in the CFRs Paper Mulberry trees are an invasive species and despite being useful to local people, they damage the environment by taking space and water from native trees, and are less good as homes for wildlife like birds. Village residents will be employed to remove these trees from the CFRs. Once the aliens have been cleared, native tree seedlings will be planted. Residents from villages in the Kalagala offset area will be employed to remove alien trees and plant the seedlings. They will also be employed for a further two years to assist with the maintenance of the new seedlings.	1. Clearing alien trees and planting of new indigenous trees (baseline) 2. Clearing of alien trees in the CFR only 3. Planting of native trees in the CRF only 4. No tree planting and alien tree clearing in the CFR
Access to spiritual sites at the Kalagala Falls and Itanda Rapids At present, village members near the Kalagala Falls and Itanda Rapids are allowed to visit the spiritual sites for free whilst visitors to the area pay UGX 1 000 to visit the sites. This money goes to local community organisations that provide guides to tourists. As part of this offset activity, the money charged to tourists to visit the site will be used to pay the guides and any extra money will be used to improve the site for everyone by ensuring that the sacred sites are protected, maintained and kept clean. The money could also be used to improve existing facilities like the gazebo as well as construct new facilities like toilets.	1. Free access to community members and a fee of UGX 1 000 to be paid by visitors (mixed payment). Money used for guides. (baseline) 2. Everyone (including outsiders and community members) will need to pay. Visitors will pay UXG 1 000 to visit the spiritual site whilst community members will pay UGX 500. Extra money used to improve the site for everyone. 3. Free access to everyone (including outsiders and community members). No money for guides or improving the site.

Table 2: RPL model parameter estimates and standard errors for the pooled village choice data, with both the mean effect and the interactions with socio-demographic variables. Standard errors are in parentheses, significant coefficients are in bold. Significance thresholds are 1% (***), 5% (**) and 10% (*).

Attribute / level	**Mean RPL model estimate**	**Socio-demographic variable interaction**					
		Gender (male)[a]	**Education level[b]**	**Time lived in village[c]**	**BNS score[d]**	**Dam-related wellbeing change[e]**	**Age[f]**
Sustainable livelihood schemes (Linear continuous: per shilling earned)	0.016 [0.010]	0.004 [0.004]	-0.002 [0.003]	**0.009 *** [0.003]**	**-0.022 * [0.012]**	0.002 [0.002]	**2.5e-04** **[1.2e-04]**
Employment (Linear continuous: per person employed)	0.028 *** [0.008]	0.001 [0.003]	-0.54427D-04 [0.002]	-0.003 [0.002]	-0.003 [0.009]	-0.001 [0.001]	1.5e-0.4* [0.9e-04]
Revenue sharing – investing in Central Forest Reserve	0.599 [0.751]	**0.517 ** [0.238]**	**-0.410 ** [0.174]**	0.026 [0.199]	**3.773 *** [0.853]**	-0.145 [0.104]	0.001 [0.008]
Revenue sharing – investing in community development	**3.864 *** [1.447]**	-0.077 [0.467]	**-0.872 ** [0.342]**	0.433 [0.374]	**4.479 *** [1.654]**	**-0.968 *** [0.205]**	-0.004 [0.016]
Tree planting programme - Planting of native trees	-0.808 [1.275]	-0.124 [0.434]	0.250 [0.312]	0.061 [0.331]	1.785 [1.520]	**0.325 * [0.185]**	-0.005 [0.015]
Tree planting programme - Clearing alien trees	-1.447 [1.448]	0.358 [0.506]	-0.191 [0.0364]	-0.058 [0.372]	1.937 [1.754]	**0.378 * [0.213]**	-0.023 [0.017]
Tree planting programme - Planting native trees and clearing alien trees	**-2.624 *[1.493]**	-0.058 [0.525]	-0.262 [0.376]	0.488 [0.376]	**5.210 *** [1.855]**	0.224 [0.220]	-0.020 [0.018]
Visitors and residents pay to access the spiritual sites	0.751 [0.903]	0.247 [0.317]	0.083 [0.227]	-0.037 [0.225]	-0.770 [1.120]	-0.185 [0.133]	0.014 [0.011]
Visitors and residents do not pay to access the spiritual sites	-0.345 [0.535]	-0.050 [0.176]	-0.100 [0.128]	0.031 [0.138]	0.187 [0.616]	0.051 [0.076]	-0.001 [0.006]

Standard deviations of parameters	
Sustainable livelihood schemes	**0.027 *** [0.002]**
Employment	**0.007 *** [0.001]**
Revenue sharing – investing in Central Forest Reserve	**2.065 *** [0.127]**
Revenue sharing – investing in community development	**3.315 *** [0.228]**
Tree planting programme - Planting of native trees	0.156 [0.255]
Tree planting programme - Clearing alien trees	**1.129 *** [0.135]**
Tree planting programme - Planting native trees and clearing alien trees	**0.974 *** [0.238]**
Visitors and residents pay to access the spiritual sites	**0.709 *** [0.132]**
Visitors and residents do not pay to access the spiritual sites	**0.862 *** [0.123]**
Model fit	
Log likelihood function	-5671.060
Pseudo R-squared	0.290
AIC/N	1.579

a Gender: Female = 0; Male = 1

b Education level: No education = 0; Primary = 1; Secondary = 2; College/ University = 3

c Time lived in village: Not sure = 0; < 5 years = 1; 5 – 9 years = 2; > 10 years = 3

d BNS score: low BNS scores = high level of poverty; high BNS = low level of poverty

e Dam-related wellbeing change: Don't know/ would rather not say = 0; Very negatively = 1; Negatively = 2; Neutral = 3, Positively = 4; Very positively = 5

f Age: Average age was taken for each category. 18-30 = 24; 31-45 = 38; 45-60 = 53; 61+ = 67