Ecological Economics 114 (2015) 104–116

Contents lists available at ScienceDirect

Ecological Economics

journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods

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ARTICLE INFO

Article history:
Received 8 January 2014
Received in revised form 21 February 2015
Accepted 23 February 2015
Available online xxxx

Keywords:
Cultural ecosystem services
Bequest value
Discrete choice experiment
Discount rate
Economic valuation
Madagascar

ABSTRACT

Perhaps the most understudied ecosystem services are related to socio-cultural values tied to non-material benefits arising from human–ecosystem relationships. Bequest values linked to natural ecosystems can be particularly significant for indigenous communities whose livelihoods and cultures are tied to ecosystems. Here we apply a discrete choice experiment (DCE) to determine indigenous fishers' preferences and willingness-to-pay for bequest gains from management actions in a locally managed marine area in Madagascar, and use our results to estimate an implicit discount rate. We validate our results using a unique rating and ranking game and other mixed methods. We find that bequest is highly valued and important; respondents were willing to pay a substantial portion of their income to protect ecosystems for future generations. Through all of our inquiries, bequest emerged as the highest priority, even when respondents were forced to make trade-offs among other livelihood-supporting ecosystem services. This study is among a relative few to quantify bequest values and apply a DCE to model trade-offs, value ecosystem service flows, and estimate discount rates in a developing country. Our results directly inform coastal management in Madagascar and elsewhere by providing information on the socio-cultural value of bequest in comparison to other ecosystem service benefits.

1. Introduction

Perhaps the most understudied ecosystem services are related to socio-cultural values tied to non-material benefits arising from human–ecosystem relationships (Chan et al., 2011). Cultural ecosystem services are defined by the Millennium Ecosystem Assessment (MEA, 2005, p. 894) as “the non-material benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation and aesthetic experience, including, e.g., knowledge systems, social relations and aesthetic values.” Cultural ecosystem services provide benefits to society, yet can be intangible and subjective, and do not transmit clear demand signals, making quantification difficult (MEA, 2005). Innovative approaches, such as participatory and GIS modeling and mapping, contingent valuation, and the extrapolation of secondary market data, have facilitated assessments of some cultural ecosystem services (Hernández-Morcillo et al., 2013 and the references therein). Yet economic valuations have largely focused on recreational and aesthetic benefits (e.g. Bergstrom et al., 1990; Cisneros-Montemayor et al., 2013; Cisneros-Montemayor and Sumaila, 2010; Grêt-Regamey et al., 2008; van Beukering and Cesar, 2004), while other aspects, such as bequest, remain elusive (Hernández-Morcillo et al., 2013).

Bequest value is a non-use value representing the importance people place on preserving or maintaining ecosystems for future generations (Chan et al., 2012b; Krutilla, 1967). Non-use values accrue independently of a person's own use of a resource, and they are often associated with irreplaceable resources (O'Garra, 2009). The perception that valued ecosystems are irreplaceable is often deeply tied to local socio-cultural values, and may persist despite the availability of physical substitutes (Crowards, 1995; O'Garra, 2009). Communities often develop unique relationships with ecosystems through rich histories of human–environment interaction and the continuity of culture, and place a high value on their endowment to future generations (Garibaldi and Turner, 2004). Bequest values of ecosystem service

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http://dx.doi.org/10.1016/j.ecolecon.2015.02.028
0921-8009/

benefits therefore comprise an important component of total economic value.

Bequest values linked to natural ecosystems can be particularly significant for indigenous communities (O'Garra, 2009), whose production methods and livelihoods are often reliant on ecological structures and functions (Casey et al., 2008; Pearce and Warford, 1993). Moreover, indigenous communities often have deep attachments with particular ecosystem services that play a unique role in shaping their cultural identity, embedding them in traditions and narratives, ceremonies, and discourse (Garibaldi and Turner, 2004). Many communities steward important ecosystems because these services are crucial for supporting the continued existence and ability for maintaining integrity of cultural practices.

In this study we apply a discrete choice experiment (DCE) to determine indigenous fishers' preferences and willingness-to-pay (WTP) for bequest gains from management actions in a locally managed marine area (LMMA) in Madagascar. We design our DCE in a way that allows for the estimation of an implicit discount rate, reflecting the time preference of the local community. We validate our results by employing a unique rating and ranking game and other mixed methods.

We expect this study to make an important contribution to the field of environmental valuation. Cultural ecosystem service valuations are scarce, and little information exists on bequest values, particularly in low income indigenous communities (but see O'Garra, 2009). This study is also among a small number to apply a DCE to model trade-offs and value ecosystem service flows in a developing country context (Bennet and Birol, 2010b).[1] Our results can also directly inform marine and coastal management in Madagascar and elsewhere by providing crucial information on the often-overlooked socio-cultural value of bequest, and by providing information on the time horizon of indigenous fishers.

The remainder of our paper is structured as follows: we begin with a discussion of the DCE approach for cultural ecosystem service valuation, with a particular focus on applying it in developing countries and indigenous communities. We then proceed with a description of our study site. Next we present our study design and methods, followed by our results. We then conclude with a discussion of our results and their implications for environmental decision-making and valuation more broadly.

2. DCEs for Cultural Ecosystem Service Valuation

DCEs, originally developed by Louviere and Hensher (1982) and Louviere and Woodworth (1983), are increasingly being used by economists to elicit preferences and values for non-market ecosystem services (e.g. Adamowicz et al., 1994; Boxall et al., 1996; Hanley et al., 1998; Hoyos, 2010; Walsh et al., 1984). Based on a well-tested theory of choice behavior (Thurstone, 1927), DCEs can be used to model complex hypothetical scenarios involving trade-offs between several attributes that model real-world decision making. The flexibility of the approach allows for the attributes to be comprised of diverse ecosystem services, which may interact in complex ways. Given that a payment vehicle is also included as an attribute, preferences for estimated part-worth utilities, or the WTP for incremental changes in ecosystem services, can be estimated and compared based on respondents' choices.

Due to their flexibility, DCEs are perhaps the most appropriate available method for eliciting values in complex situations involving trade-offs between multiple ecosystem services, particularly those linked to socio-cultural values (Adamowicz et al., 2008; Noonan, 2003; Rolfe et al., 2000). Land and seascapes simultaneously provide provisioning, regulating, cultural, and supporting ecosystem services that are interrelated in complex ways, and decisions to maximize one or few may have to be made at the expense of others (Bennett et al., 2009; Rodríguez et al., 2006). In indigenous communities where local livelihoods and culture are inextricably tied to the natural environment, strengthening the rules governing natural resource use can help to ensure not only long-term ecological sustainability, but also socio-cultural sustainability. Yet the success of such management scenarios depends on the willingness of local resource users to give up short-term economic gains from resource extraction to achieve long-term ecological and economic results. The DCE approach is useful for modeling these trade-offs, and can uncover the importance of the less tangible, intrinsic cultural values for achieving successful, sustainable management (Hicks et al., 2009).

2.1. DCE Empirical Model

The choice modeling technique is based on the idea that any good or environmental scenario can be described in terms of its characteristics, called attributes, and the levels (representing changes in quality or quantity) of these attributes. In a DCE, respondents are asked to choose between different bundles of goods (in this case ecosystem services) described in terms of their attributes and attribute levels, at least one of which is typically some form of payment (Hanley et al., 1998). The analysis of choices is based on the characteristics theory of value (Lancaster, 1966) and random utility theory (McFadden, 1974; Thurstone, 1927), which describe discrete choices in a utility maximizing framework. If an individual's utility function is assumed to be dependent on a vector V of environmental attributes Z and socioeconomic characteristics S, and assuming the utility function can be partitioned into two components, one deterministic, observable component (V_{in}) and one random and unobservable component (ε_{in}), it can be formulated as (Hanley et al., 1998):

$$U_{in} = V(Z_n, S_i) + \varepsilon(Z_n, S_i) \tag{1}$$

where:

U_{in} total utility (U) individual i derived from alternative n
V_{in} observable utility (V) individual i derived from alternative n
ε_{in} unobservable utility (ε) for individual i from alternative n
Z_n particular attributes of ecosystem service Z in choice n
S_i attributes of the individual i.

The incorporation of the random component allows us to make probabilistic statements about individual behavior, where the probability of individual i choosing alternative n rather than m in a given choice set C is the probability that the random utility of alternative n is greater than the random utility of alternative m. The probability of choosing alternative n is then (Boxall et al., 1996; Hanley et al., 1998):

$$P(n|C_i) = \text{Prob}(V_{in} + \varepsilon_{in} > V_{im} + \varepsilon_{im}) \forall n \neq m \in C. \tag{2}$$

Employing a multinomial logit model for estimating choice probabilities, we assume that the random error ε_{in} is identically and independently distributed following a type I extreme (Gumbel) distribution with scale parameter μ, in which the true parameters are confounded (Hanley et al., 1998; McFadden, 1974). The probability of choosing alternative n is then:

$$P_{in} = \frac{\exp(\mu V_{in})}{\sum_n \exp(\mu V_{im}).} \tag{3}$$

As the scale parameter, μ, is confounded with the coefficients we would like to estimate (i.e., V_n, V_m), and μ is not directly identifiable from the data, we are unable to generate absolute estimates of the coefficients independent of our multinomial model. However, because the scale parameter is constant within an estimated model, it is valid to compare the relative sizes of coefficients within the same model

[1] Other comparison methods, however, such as the damage schedule approach, have also been used to value environmental changes (Chuenpagdee et al., 2001).

(Alpizar et al., 2003). Also, as the scale parameter is inversely related to the variance in the error term, given by $\delta^2 = \Pi^2/6\mu^2$, it is valid to make such comparisons among models, given appropriate controls on the respective scale parameter ratios (Alpizar et al., 2003; Hanley et al., 1998).

Since the model estimation derives from random utility theory, welfare estimates of changes in attribute levels can be estimated and compared similar to the method applied in contingent valuation models (Hanemann, 1984). The marginal value of an attribute change could be given by the ratio of the coefficients of the attribute in question and that of the payment attribute, holding all else equal. This can be conceptualized as the part-worth or marginal WTP for the attribute, calculated as:

$$WTP_{attribute} = \frac{-\beta_{attribute}}{\beta_{payment}} \tag{4}$$

where *WTP* represents the marginal rate of substitution between the payment attribute and the attribute in question, and β refers to the parameter estimates of the attribute levels.

DCEs have also been used to compute implicit discount rates reflecting individual time preferences for utility in cases where two monetary attributes are included that represent short-term costs and long-term benefits (e.g., Hausman, 1979; Min et al., 2014). The implicit discount rate *r* can be computed from the formula:

$$\beta_2 = \beta_1 \frac{r(1+r)^t}{(1+r)^t - 1} \tag{5}$$

where β_1 and β_2 represent the estimated coefficients on short-term and long-term income respectively, and *t* is the time period in which future income accrues (Min et al., 2014).

2.2. DCE Challenges in Developing Countries and Indigenous Communities

Careful study design can help address a number of known methodological and practical challenges to applying DCEs in developing countries and indigenous communities. To guide ecosystem management, important attributes with realistic levels should be tied to the local context and relevant to the local policy process (Alpizar et al., 2003; Bennet and Blamey, 2001). Equally as important, the payment vehicle needs to be an appropriate and reliable measure of wealth (Bennet and Birol, 2010b; Christie et al., 2012). Researchers also need to bear in mind potential issues of literacy, low scientific understanding and education, low local research capacity, spiritual and cultural nuances which outside researchers may have difficulty understanding, and potential issues gaining access to marginal groups (Bennet and Birol, 2010b; Christie et al., 2012). Guidelines for overcoming these challenges are summarized by Bennet and Birol (2010b).

3. Study Site

Our study site is the Velondriake LMMA, located in the southwest region of Madagascar (Fig. 1). Velondriake encompasses a collection of islands, mangrove forests, coral reefs, and other coastal ecosystems spanning more than 1000 km^2 (Harris, 2011). The LMMA currently supports a low-income population of over 7500 people living in 24 villages known as the Vezo (Barnes-Mauthe et al., 2013). The Vezo have subsisted for generations from traditional fishing activities, and the ability of their natural environment to provide an uninterrupted flow of marine and coastal ecosystem services supports nearly all aspects of their livelihood and food security (Barnes-Mauthe et al., 2013; Harris, 2007). People's incomes and diets derive from marine resources, mangroves provide a crucial source of timber, fuelwood, and fodder, villages along the shoreline are protected by reefs and mangroves, and social interactions are mediated by the sea (Barnes-Mauthe et al., 2013; Rasolofo, 1997).

Velondriake means “to live with the sea” (Harris, 2007), reflecting the intimate relationship between the marine environment and the cultural identity of the Vezo, known as the “fishing people” or “the people who struggle with the sea and live by the coast” (Astuti, 1995; pg. 5). In contrast to the “ethnicity” concept, which captures the idea that people are born with a particular cultural identity, the Vezo instead maintain that they *become* Vezo through their daily coastal activities (Astuti, 1995). This conceptual definition of “cumulative personhood” is prevalent throughout Madagascar (Astuti, 1995), where people share a concept of culture and self which is “achieved gradually and progressively throughout life, and even after death, rather than ascribed and fixed definitively at birth” (Southall, 1986, p.417). Accordingly, the Vezo define themselves in terms of their occupation – fishing – and being Vezo is grounded in the place where they live — by the coast (Astuti, 1995). Among the Vezo, it is often stated that the only way to be Vezo is to act Vezo, and if one cannot fish and live by the coast, they are not Vezo (Astuti, 1995). By extension, people can become (or return to being) Vezo if they live by the coast and are able to provide for themselves and their family through fishing. As being Vezo is bound to a functioning coastal environment, the *Vezo bequest* – the ability of future generations to live as Vezo – is an essential cultural ecosystem service.

Recent years have shown a substantial increase in climate-induced pressures and direct anthropogenic impacts which threaten the livelihoods, cultural identity, and economic security of the Vezo, including chronic political instability, population growth, increased migration to the coast, an escalation of extreme weather events, degradation of key habitats including mangrove forest and coral reefs, and a deterioration of marine fisheries catches (Ateweberhan and McClanahan, 2010; Cheung et al., 2010, 2012; Giri and Muhlhausen, 2008; Harris, 2007, 2011; Le Manach et al., 2012). In the absence of national and regional institutional capacity to respond to these pressures, local communities came together with support from non-governmental organizations and the National Marine Sciences Institute to establish (in 2006) and ratify (in 2009) the first LMMA in the Western Indian Ocean (Harris, 2007, 2011; Oleson, 2011). Various management measures had been enacted at the time of the study, including a series of temporary octopus fisheries closures, bans on destructive fishing practices, and an integrated population–health–environment program, and others were under consideration (Andriamalala and Gardner, 2010; Harris, 2011).

4. Materials and Methods

4.1. DCE Experimental Design

With the challenges of applying DCEs in developing countries in mind and in line with the guidelines laid out in Bennet and Birol (2010a), we took several steps in designing our DCE. We began with community focus groups ($n = 7$) and key informant interviews ($n = 26$) to identify (i) important cultural and other difficult to value ecosystem service benefits likely affected by a hypothetical management scenario, and (ii) an appropriate payment vehicle. In this case, the hypothetical scenario was conceptualized as a general strengthening of rules governing the use of natural resources within the LMMA, and specifically included management measures that were familiar to the respondents, including a strict enforcement of a ban on destructive fishing methods, expanding areas permanently closed to fishing, increasing the number of octopus fishing reserves, and limiting the destruction of mangroves and coral reefs. These preliminary interviews and focus groups confirmed that villagers perceived direct linkages between these strengthened management measures, the state of the coastal resources, and the future flow of ecosystem services, particularly fish provisioning, bequest, shoreline protection, and social cohesion.

Attributes and levels were initially developed during focus groups, and were refined after several expert consultations with local collaborators and key informants, and after a pre-test in multiple villages. All levels either reflected current conditions or experts' opinions on

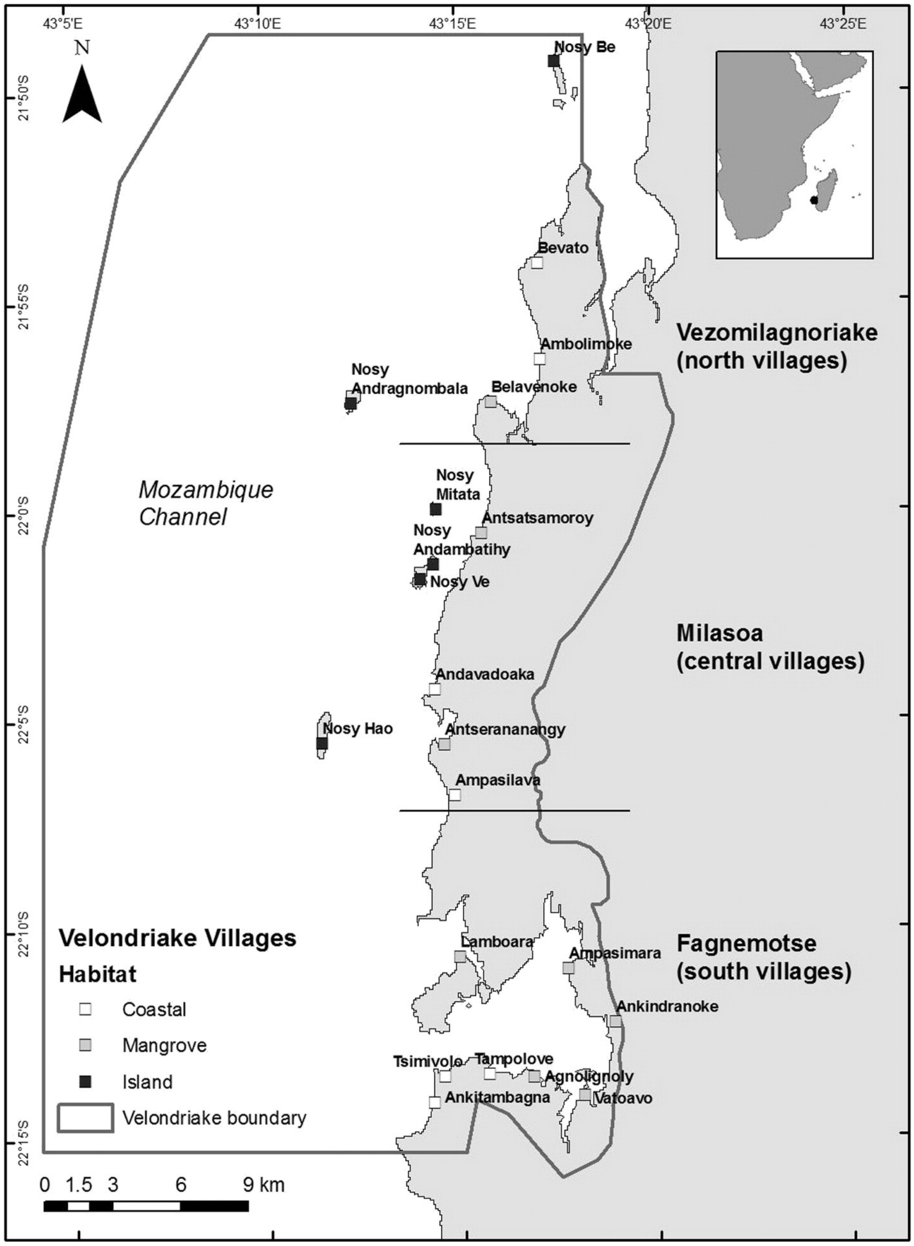

Fig. 1. Map of the Velondriake Locally Managed Marine Area, southwest Madagascar.
Barnes-Mauthe et al. (2013).

expected changes due to management or lack thereof. In addition to bequest, the final ecosystem service attributes included were social cohesion, shoreline protection, and long-term commercial fisheries catch. The payment vehicle consisted of a short-term loss in commercial seafood income per spring tide (approximately every 14 days), which was identified in focus groups and by key informants as the most frequently used time horizon for thinking about income in the region. Attributes and levels are described further in the following section and are presented in Table 1.

4.1.1. Attributes and Levels

Because the traditional Vezo lifestyle and cultural identity is inextricably tied to fishing (Astuti, 1995; Harris, 2007), local management actions can directly affect the bequest cultural ecosystem service (Christie et al., 2003; Oleson, 2011; White et al., 1994). Villagers already face the reality that people have to leave the Vezo lifestyle due to declining fisheries, which can no longer support fast-growing families. People expressed sadness and frustration that while they thought their children might still be able to fish, their future descendants may have to farm or move to the city to look for work due to the resource's decline. They cited this loss of their Vezo culture and inability to pass it on to future generations as major motivations for engaging in management. This set the context for the bequest attribute: if stricter management improved the ecological resources and service flows, particularly seafood, this would mean their descendants could continue to fish and live as Vezo; the more successful and durable the conservation, the longer the fish would last, and the more generations would see the benefit. The bequest attribute's levels reflect the consensus from interviews: status quo (1 additional generation), a short-term improvement (2 generations), and a long-term gain (5 generations; Table 1).

As a key component of social capital, social cohesion is considered a cultural ecosystem service which captures the idea that activities enabled by ecosystems, such as traditional fishing and the management of natural resources, are associated with interactions between individuals that contribute to rich cultural networks of relationships (Chan et al.,

Table 1
Description of attributes and their levels. Currency is 2010 Malagasy Ariary (MGA).

Attribute	Description	Levels[a]
Bequest	Bequest of the Vezo fishing culture and lifestyle, captured as the number of future generations able to live as Vezo	Low (status quo): 1 generation Medium: 2 generations High: 5 generations
Social cohesion	Inter-village collaboration, measured as the number of people from each village attending inter-village meetings to participate in the management of the LMMA	Low (status quo): 2 people per village Medium: 4 people per village High: 6 people per village
Shoreline protection	The ability of coral reefs and mangroves to act as storm barriers, captured as the frequency with which respondents need to repair their house due to storm damage	Low protection (status quo): 1× every 3 years Medium protection: 1× every 4 years High protection: 1× every 5 years
Commercial fisheries	The prospective long-term gain in commercial seafood income, captured as the value of seafood that a household sells per spring tide from year 2 through year 10 after implementation of the hypothetical scenario	Status quo: MGA 30 k per tide[b] Low gain: MGA 60 k per tide Medium gain: MGA 70 k per tide High gain: MGA 80 k per tide
Short-term income (*payment vehicle*)	The payment vehicle is represented by a short-term loss in commercial seafood income, captured as the value of seafood that a household sells per spring tide in the first year after implementation of the hypothetical scenario	Status quo: MGA 50 k per tide[b] Low loss: MGA 25 k per tide Medium loss: MGA 15 k per tide High loss: MGA 5 k per tide

[a] The currency exchange rate in 2010 was USD 1 = MGA 2090.
[b] These were not included as options in the experimental design because fisheries catch was expected to decline in the short-term whether or not management action was taken (the status quo catch was not sustainable), and catch was expected to increase by some degree in the long-term as a result of all management scenarios. Thus the status quo is presented here for comparison purposes only.

2012a; MEA, 2005). These networks can contribute to successful collaborative management of ecosystems by facilitating cooperation and collaboration among stakeholders (Plummer and FitzGibbon, 2006; Pretty, 2003), yet can also potentially be augmented or eroded *by* management initiatives (Barnes-Mauthe et al., 2014; Burke, 2010). In Velondriake, collaborative inter-village meetings are held periodically to discuss and agree on management measures and actions for the LMMA. Focus group discussants and key informants felt that the number of people from each village attending these meetings was a good reflection of social cohesion. They also expected social cohesion to be enhanced by improved management, with the justification that discussing, agreeing on, implementing, and enforcing management measures would increase participation in inter-village meetings. Participation in community events, meetings, or organizations is indeed a well-established indicator of social cohesion (Berger-Schmitt, 2000; Chan et al., 2006; Rajulton et al., 2007). Thus, inter-village collaboration, measured as the number of people from each village attending inter-village meetings [low (status quo) = 2, medium = 4 or high = 6, Table 1] was selected to represent social cohesion. Focus group discussants, key informants, and local experts agreed that the levels were within the range for which constructive decision-making would still be possible.

Velondriake lies on the southwest coast of Madagascar, which is prone to frequent cyclones and tropical storms. Mangrove forests and coral reefs comprise a large portion of Velondriake's coastal and marine habitat, acting as an important barrier to hazardous storm surge, yet these ecosystems are increasingly threatened by overexploitation and destructive extraction methods (Giri and Muhlhausen, 2008; Harris, 2007, 2011). Improved management measures, such as enforcement of a ban on destructive fishing practices that damage the reef's structure and function and restrictions on dune and mangrove destruction, will increase shoreline protection, a regulating ecosystem service, by improving the natural habitats' ability to dissipate wave and wind energy (Arkema et al., 2013). Vezo homes are constructed of reeds lashed to small poles lightly driven into sandy substrate, and are typically located just above the high tide mark. In consultation with focus group discussants and key informants, shoreline protection was captured in our DCE by the frequency with which respondents needed to repair their homes due to storm damage, which at the time of data collection was about once every three years. Thus, in the DCE a decrease in frequency from the status quo represents an increase in shoreline protection [low (status quo) = once every three years, medium = once every 4 years, and high = once every 5 years; Table 1], a range that was vetted in focus groups. While no local data exist to directly link home damages to the quality of the near shore environment, anecdotal evidence suggests that reefs, mangroves, and dunes provide important protection, and elsewhere linkages between coastal habitat and home damage has been studied in detail (Badola and Hussain, 2005).

Commercial fisheries provide a key provisioning ecosystem service with important economic value (Barnes-Mauthe et al., 2013). Enhanced resource management rules have improved commercial fisheries outcomes in Velondriake and in other collaboratively managed marine areas (Christie et al., 2003; Cinner et al., 2006; Oleson, 2011; Oliver et al., 2015), which is the expectation in our hypothetical scenario as well. In the DCE, commercial fisheries were captured by a prospective long-term gain in commercial seafood income, represented as the value of seafood that a household sells per spring tide [low = MGA 60 k, medium = MGA 70 k and high = MGA 80 k; Table 1; MGA 2090 = USD 1 in 2010] from year 2 through year 10 after implementation of the hypothetical scenario.

Stricter management will require trading off short-term returns, which we represented by the willingness to forego some income over the coming year to achieve future returns. While one year is likely too short to accrue ecological returns, we chose a short period to ensure it fit with local time horizons, which may be quite high (Astuti, 1995; Tucker, 2012). This attribute is captured as the value of seafood per spring tide that a household sells during the first year of implementation of the hypothetical scenario, where a higher loss in income is represented by a lower value per spring tide [low = MGA 25 k, medium = MGA 15 k, and high = MGA 5 k; Table 1].[2]

Choice experiments testing willingness to incur short-term costs for long-term gains, often where both are expressed in monetary terms, have a long history in the energy and health literatures (Hausman, 1979; Ida and Goto, 2009; Min et al., 2014). In this literature, long-term gains and short-term losses are treated as separate and independent attributes. We follow this approach and treat short-term losses and long-term gains in commercial fisheries as independent attributes in both the indirect utility function and the statistical design underlying the DCE. This approach is supported by the results of our focus groups,

[2] Implementation of management measures was expected to negatively affect short-term seafood sales and positively affect long-term seafood sales. Since at least one management measure would be implemented with certainty, the status quo for both short-term and long-term seafood sales was omitted from our experimental design; i.e., the attribute levels representing the status quo were not used to describe the management options. Also note that subsistence fishing was not affected in our hypothetical scenario.

which indicated that the Vezo conceptualize incomes from future catch beyond a year (the long-term gain) as distinct from the tangible reduction in income over the coming year (the short-term cost), and had no trouble making trade-offs between the two. For these reasons, we considered it appropriate to use the short-term loss in commercial fisheries income as a payment vehicle. The inclusion of separate and independent attributes for short-term and long-term incomes measured in monetary terms allow us to compute an implicit discount rate for the sample population.

4.1.2. Discount Rate

A discount rate reflects the time preference of society or the rate at which current and future income would be exchanged. Understanding discount rates can be critical for policy development in situations where stakeholders may be expected to give up short-term benefits for long-term gains, and high discount rates among fishers have been cited as a key source of overexploitation (Sumaila and Walters, 2005; Teh et al., 2014; Teh, 2011). However, empirical evidence to estimate a local discount rate is generally unavailable, undermining economic analyses and project appraisals. Estimating an implicit discount rate through a DCE therefore represents a novel way of obtaining this information, and has been employed to understand time preferences for decision-making in health (Ida and Goto, 2009; Louviere and Lancsar, 2009) and energy (Hausman, 1979; Min et al., 2014), although we believe ours is the first to use it for ecosystem services. We estimate an implicit discount rate from the choice experiment results by computing the ratio of marginal utilities for short-term and long-term incomes (see Eq. (5)).

4.1.3. DCE Statistical Design

The DCE statistical design includes five attributes with three levels each. A complete factorial design including all possible combinations of attributes and levels would use 243 ($3 * 3 * 3 * 3 * 3 = 243$) choice tasks. From the 243 possible combinations, 36 optimal choice tasks with two alternative combinations of attributes and one fixed status quo were generated in a series of six different choice set versions (six choice tasks per version) in SSI Web 6.0 Sawtooth Software. To generate optimal choice sets, the software employs an orthogonal method, which develops fractional designs by selecting profiles that balance independent influences of all the attribute effects. A fixed choice task was included in all six versions to familiarize respondents with relatively simple trade-offs, which gave us a total of 37 choice tasks. We tested the statistical design using simulated data and found it to be efficient for estimating statistically significant main effects for our sample size. Respondents were therefore asked to complete six consecutive choice tasks with three alternatives (options) including a status quo. Because literacy was a concern in the LMMA, choice tasks were artistically represented as pictograms developed in consultation with community members (see Fig. 2). Pre-testing of the DCE resulted in adjustments in the ordering of attributes on the choice cards due to a detected bias. An example of a final choice task can be found in Fig. 2.

4.1.4. Logistic Regression Model

Based on the model in Section 2, we tested a conditional logit regression on the main effects to estimate attribute coefficients based on the maximum likelihood procedures using Nlogit 4.0. The effects were dummy coded to enable identification of non-linear effects, and omitted categories were the lowest levels for each attribute, generally representing the status quo. We tested for interactions with personal characteristics, attitudes and perceptions, and ecosystem service cluster. We also tested for preference heterogeneity and the presence of subgroups by employing random effects and latent class models.

4.2. DCE Validation

To validate our DCE results we employed a variety of mixed methods. DCE participants were first asked to state their level of understanding of the DCE experiment and their primary motivation when making choices in the DCE. We also asked respondents to state their level of agreement with a series of statements concerning their perceptions and attitudes about bequest and the importance of being Vezo, willingness to accept short-term income losses for potential long-term gains, environmental awareness, and ecosystem management. Finally, we employed a simple rating and ranking game using beans as weights to examine the priority order and importance of the ecosystem service benefits included in our DCE, in addition to five others: food from fisheries ("subsistence fisheries"), ceremonial practices involving local ecosystems ("ceremonies"), traditional medicine ("medicine"), waste disposal ("waste"), and participation in decision-making in the LMMA ("agency"). In the game, respondents first ranked in priority order these ecosystem services, which were illustrated using pictograms and described in an oral narrative that was developed in focus groups and tested during the pilot survey. Respondents were then given a total of 20 beans and were asked to rate the relative importance of the ecosystem services by allocating beans to the ecosystem services in four rounds of five beans each. To estimate potentially distinct groups holding different value sets within the sampled community, we analyzed subjects' ecosystem service ratings using hierarchical clustering.

Using the R package *cluster*, we performed Ward's Hierarchical Clustering with a similarity metric of Euclidean distance between each subject's first round rating values of all nine services. Using the R base function *prcomp*, we further displayed variation within and among these clusters using a principal component analysis ordination that maximally spreads the centroids of the identified clusters. Finally we displayed the mean ratings of each ecosystem service per clustered group, with bootstrapped 95% confidence intervals of the mean. The game did not provide information on the relative importance of the nine ecosystem services in specified units, thus it cannot be compared to contingent rating and ranking or used to evaluate trade-offs. The information from the game does however offer interesting insight into the ways in which different groups prioritize these ecosystem services, and can be qualitatively compared to the DCE results.

4.3. Sampling

The DCE experiment, follow-up questions, and rating and ranking game were conducted via face-to-face interviews using a stratified random sampling technique accounting for differences in habitat surrounding the villages (coastal, mangrove, island, which could affect fishing practices and social structures) and geographic location (north, central, south, which could affect economic access and other social connections) (Fig. 1).[3] In line with recommendations of Bennet and Birol (2010b) to improve reliability, we extensively trained and supervised local survey teams fluent in Vezo and ran daily quality checks. We alternatively interviewed the male and female heads of households.

5. Results

5.1. Sample

The response rate was high (>95%). The total sample (not including the pilot) included 258 respondents. We removed 63 of the 258 responses from our database due to respondents' disclosure that they did not understand the DCE.[4] Our final sample consisted of 195 respondents, which were found to be representative of Velondriake's population in terms of Vezo identity, gender, and habitat surrounding the

[3] The DCE was conducted in conjunction with a household survey as a part of a broader initiative, i.e., every household that participated in the household survey detailed in Barnes-Mauthe et al. (2013) also participated in the DCE.

[4] 77% of the total 258 respondents stated that they believed the DCE was either clear or very clear, while 22% felt that it was somewhat clear and the remaining 1% did not believe that it was clear. Only responses from those that believed it was clear or very clear were included in our analysis.

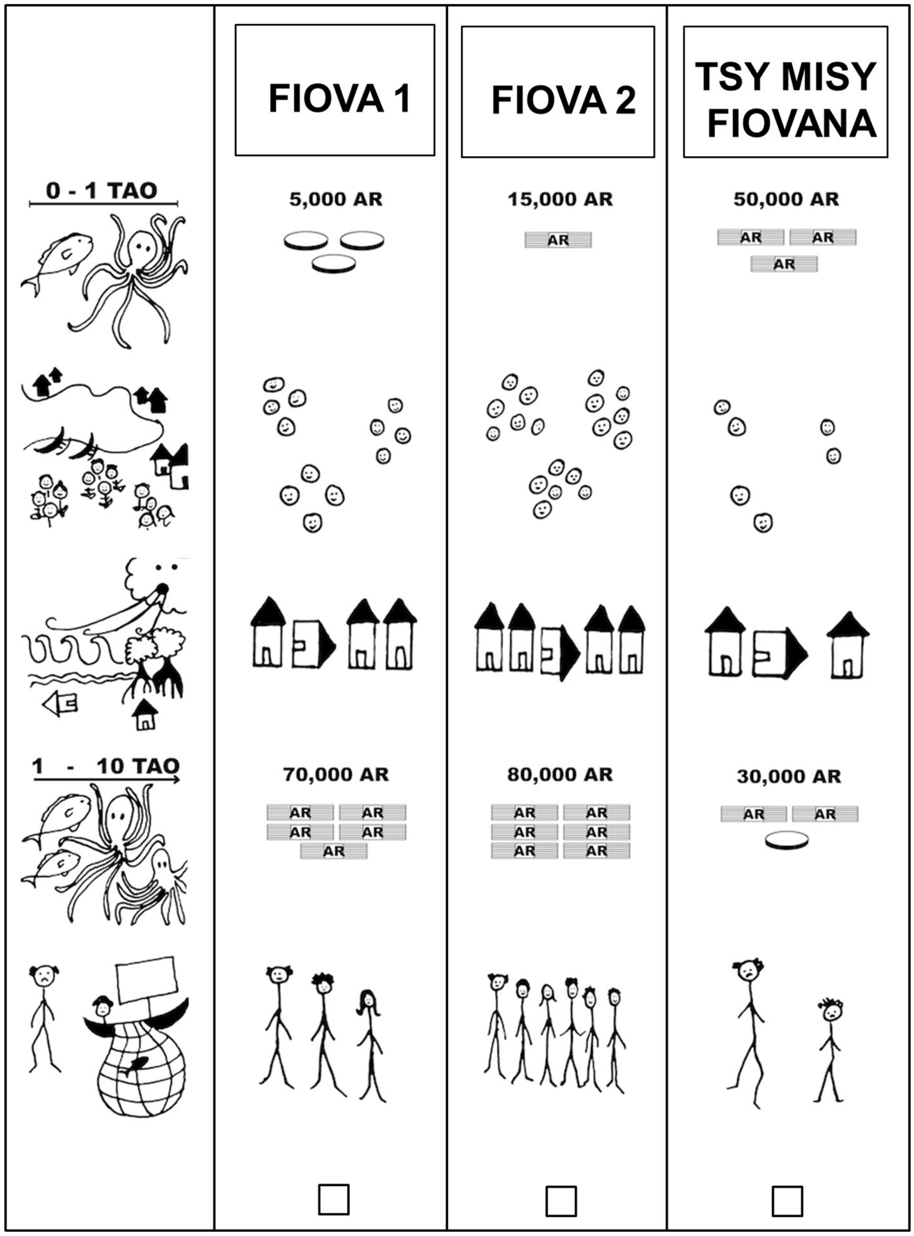

Fig. 2. Sample of choice task. The first row represents the short-term loss in income (and is the payment vehicle). The subsequent rows are social cohesion, shoreline protection, commercial fisheries (represented as long-term commercial fisheries income), and finally, bequest.

villages (Table 2). Nearly all (97%) of the respondents, and respondents' ancestors, were Vezo. Respondents were 31 ± 12 years old on average, 93% were fishers, and they had an average of 4 ± 3 dependents.

Table 2
Sample statistics.

	n	% of sample	% of population[a]
Total sample	195	–	–
Demographics			
Female	100	51%	52%
Male	95	49%	48%
Vezo	192	98%	97%
Habitat			
Mangrove	82	42%	37%
Coastal	58	30%	45%
Island	55	28%	18%

[a] Population statistics are based on information in Barnes-Mauthe et al. (2013) and Oliver et al. (2015).

5.2. Model Estimation

The results of the conditional logit regression on the main effects are presented in Table 3. The model fits the data well, with a pseudo adjusted R^2 of 0.32, which is within the acceptable range of 0.20–0.40 for discrete choice models (Hoyos, 2010; McFadden, 1974).[5]

The estimated coefficients on both bequest medium (2 generations able to live as Vezo) and bequest high (5 generations able to live as Vezo) are positive and statistically significant at the <1% level. In other words, there is a statistically significant, positive difference in preferences between the omitted base-level bequest category (1 generation able to live as Vezo) and bequest medium and high. Preferences for each additional generation of Vezo suggest decreasing marginal utility (Table 3). Both commercial fisheries categories are statistically significant at the

[5] Pseudo R^2 values do not have the direct interpretation of linear regression R^2 in terms of explained variance, but as a rule of thumb a pseudo R^2 can be interpreted as roughly equivalent to a linear regression R^2 of double its value.

Table 3
Results of the main effects dummy coded multinomial logit model, emphasizing bequest values.

Attribute levels	Description	Coefficient	Std. error	p-value
Bequest low[a]	**1 generation**			
Bequest medium	**2 generations**	**0.857*****	**0.108**	**0.000**
Bequest high	**5 generations**	**1.993*****	**0.115**	**0.000**
Social cohesion low[a]	2 people/village			
Social cohesion medium	4 people/village	0.108	0.104	0.301
Social cohesion high	6 people/village	0.526***	0.103	0.000
Shoreline protection low[a]	1×/3 years			
Shoreline protection medium	1×/4 years	0.145	0.113	0.196
Shoreline protection high	1×/5 years	0.526***	0.110	0.000
Commercial fisheries low[a]	60 k MGA			
Commercial fisheries medium	70 k MGA	0.217**	0.110	0.048
Commercial fisheries high	80 k MGA	0.493***	0.118	0.000
Short-term income low[a]	25 k MGA			
Short-term income medium	15 k MGA	0.351***	0.106	0.001
Short-term income high	5 k MGA	0.029	0.108	0.786
Iterations completed		6		
Log likelihood		−636.121		
Pseudo adjusted R^2		0.318		
N		1362		

*** Significant at the 1% level.
** Significant at the 5% level.
[a] Omitted base level.

5% level or less. In contrast to bequest, preferences for long-term income from commercial fisheries show increasing marginal utility of income. The estimated coefficient for high long-term income (i.e., 80 k MGA instead of 60 k MGA) is more than double the estimated coefficient for medium long-term income (i.e., 70 k MGA instead of 60 k MGA).

Our results indicate that there are non-linear effects for the remaining attributes. There is no statistically significant difference in preferences between low and medium levels of social cohesion, but there is a positive and statistically significant difference in preferences for high levels of social cohesion, indicating increasing marginal utility associated with participation in inter-village meetings. Similarly, there is evidence of increasing marginal utility with reduced storm damage, i.e., the utility associated with reducing the return period of storm damage from once in three years to once in five years is more than proportional to the utility associated with reducing the return period from once in three years to once in four years (Table 3).

5.3. Preference Heterogeneity

In addition to the dummy coded conditional logit model testing for main effects presented in Table 3, we tested a series of models that included interactions with socio-demographic and psychometric characteristics in order to account for heterogeneity in the sample, which may have produced differences in preferences and values across attributes and levels. Specifically, we tested individual characteristics, such as gender, age, education, location and habitat of village, number of languages spoken, income, and number of dependents. We also tested for potential interactions with their answers to a series of statements concerning their perceptions and attitudes about bequest and the importance of being Vezo, willingness to accept short-term income losses for potential long-term gains, environmental awareness, and ecosystem management. Finally, we tested for potential interactions with the identified ecosystem service ratings clusters (see Section 5.6, Fig. 3). We found no significant interactions between any of these attributes (individual characteristics, perceptions and attitudes, ratings clusters) and the choices made by individuals in the DCE. We further explored possible preference heterogeneity in the sample by estimating a number of mixed (random) effects logit model specifications and through a latent class analysis. We estimated separate mixed logit models treating each attribute coefficient in turn as a random parameter using one thousand Halton draws and assumed normal and triangular distributions. None of the estimated random parameters were statistically significant. The relative value of the parameter coefficients and model fit of the random effects and latent class models were consistent with the conditional model, so we conclude that the conditional logit specification provides a reasonable representation of the data and thus limit our presentation to its results.

5.4. Welfare Analysis

Using the estimated coefficients presented in Table 3, we calculated mean WTP with respect to short-term income for each change implied by the attribute levels, which are presented in Table 4. WTP should be interpreted as the average short-term income one would forego to move from the omitted base level of each attribute to the attribute level listed in the table. For example, mean individual WTP for one additional generation to live as Vezo (bequest medium) is ~24 k MGA per spring tide. To move from a situation where only one future generation can live as Vezo (bequest low, the omitted category) to a situation where five future generations can live as Vezo (bequest high), mean individual WTP is ~57 k MGA per spring tide. By comparison, to move from a situation where only 2 people per village are attending inter-village meetings to a situation where six people per village are attending, mean individual WTP is ~15 k MGA per spring tide.[6] Mean WTP to increase shoreline protection to a point where homes would only need to be rebuilt at minimum every five years vs. the status quo of every three years is also ~15 k MGA per spring tide. For commercial fisheries, mean WTP to move from an expected baseline average income of 60 k to 70 k and 80 k MGA per spring tide from year 2 through year 10 after implementing the hypothetical scenario is ~6 k and 14 k MGA, respectively. We used the Krinsky and Robb (1986) procedure to estimate 95% confidence intervals for each WTP estimate (Table 4).

5.5. Discount Rate

Using the estimated coefficients for medium level short-term and long-term incomes (both of which represent a 10 k MGA increase in income from their respective baseline levels) we compute an implicit annual discount rate of 62%.

5.6. Validation of Results

When making choices in the DCE, 70% of respondents claimed that their primary motivation was bequest. A fifth (20%) stated that their primary motivation was income, while 9% and 1% stated that their primary motivation was shoreline protection and social cohesion, respectively. Our results also show that 99% of respondents believed that maintaining the Vezo identity is either important or very important, while only 1% believed it is not really important.

Answers to our Likert-scale questions concerning perceptions and attitudes about bequest, willingness to accept short-term income losses for potential long-term gains, environmental awareness, and ecosystem management are presented in Table 5, and generally confirm the DCE results. Nearly 100% of respondents agreed or strongly agreed that it is important to protect the sea to ensure that future generations can live the traditional Vezo lifestyle, and expressed pride in being able to say they are from Velondriake. A strong majority of respondents (73%) also expressed a willingness to accept short-term losses in commercial seafood sales for potential long-term gains. In terms of environmental awareness and ecosystem management perceptions, there was general agreement that management does not necessarily result in decreased marine fisheries catches. However, 16% of respondents were unsure if there was anything that could be done to increase fishery yields (i.e., “change the quantity of fish in the sea”), reflecting the greatest

[6] A more detailed analysis of social capital as an ecosystem service is provided by Barnes-Mauthe et al. (2014).

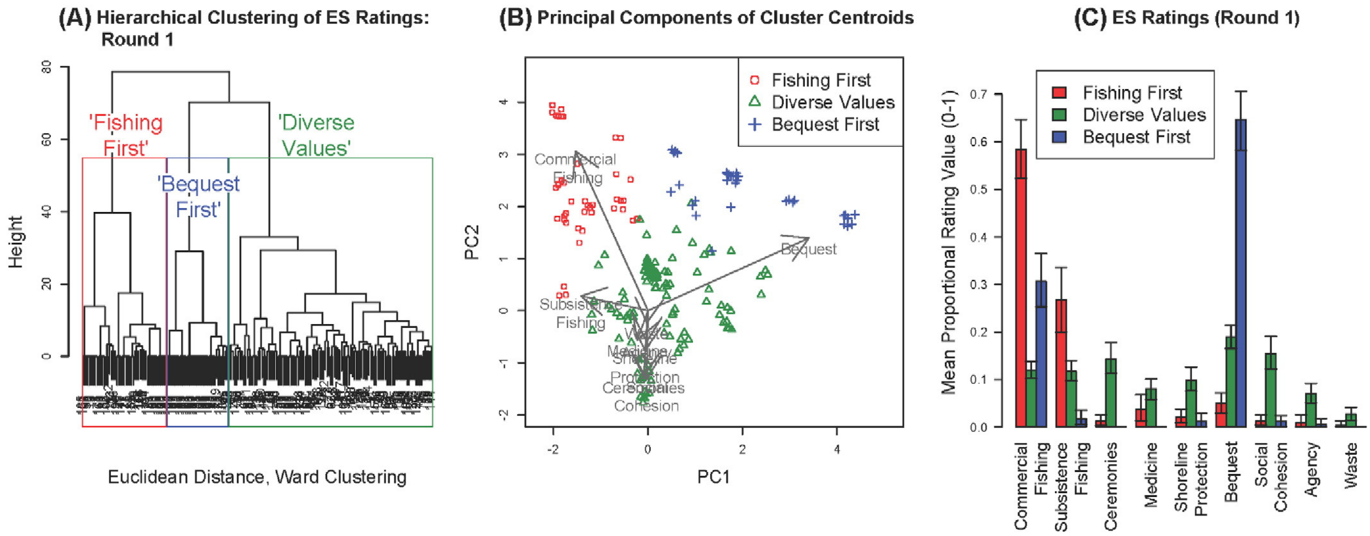

Fig. 3. Hierarchical clustering of ecosystem service (ES) ratings from the first rating round (five beans only). A. Dendrogram of Euclidean distance among each subject's ES ratings, with three major clusters highlighted and named: "Fishing First", "Bequest First", and "Diverse Values". B. Principal components analysis (PCA) biplot of cluster centroids, showing both subject ratings and service loadings along PC1 and PC2. C. Mean ES ratings by cluster, as proportion of total rating value for rating round 1 (i.e., given 5 beans, what average proportion of beans was scored for each ES, according to each cluster). Adapted from Barnes-Mauthe et al., 2014.

level of uncertainty among respondents captured in this analysis. Further, 30% did not think mangroves and reefs are important for protecting their homes from storms. Interestingly, there was no significant interaction with respondents' answers to these questions and the choices they made in the DCE; this might be explained by the absence of trade-offs posed by these questions.

In the initial ranking of all nine ecosystem services we included in the ranking and rating game (ranked in priority order by each respondent before the commencement of the rating), people ranked as first: bequest (32%), commercial fisheries (29%), subsistence fisheries (9%), ceremonies (9%), social cohesion (8%), shoreline protection (6%), medicines (3%), agency (3%), and waste disposal (0%). Turning to the first round of rating, ecosystem service ratings fell into three major clusters (Fig. 3A,B), which we have classified as "Fishing First", "Bequest First", and "Diverse Values", according to the services defining the group. Members of the "Fishing First" cluster divided their ratings between commercial and subsistence fishing, to the near exclusion of other values (Fig. 3C). Members of the "Bequest First" cluster likewise focused their ratings on the bequest value of Vezo identity, leaving some value for commercial (not subsistence) fishing (Fig. 3C). Members of the "Diverse Values" cluster showed no clear favorite among the nine, and instead divided rating values across all services (Fig. 3C). While these trends are clearest in the first rating round, this division among subjects continues throughout the multiple rounds of ratings (Fig. 4). While these clusters appear to indicate real heterogeneity in the ranking and rating responses, a subject's cluster membership showed no significant interaction with choices made in the DCE, suggesting that the DCE overall results are robust to this heterogeneity.

6. Discussion

The premise that the poor are too preoccupied with immediate livelihood concerns to recognize long-term benefits from conserving environmental resources has led researchers to largely ignore non-use values such as bequest (see Martinez-Alier, 1995). However, through all of our inquiries bequest emerged as having the highest priority, even when respondents were forced to make difficult trade-offs among other provisioning and regulating ecosystem services supporting their livelihoods and well-being. Bequest had the highest marginal utility value in our DCE. Nearly all respondents agreed that maintaining the Vezo identity was either important or very important, and 70% of respondents stated that bequest was their primary motivation when making trade-off choices in the DCE. In our ranking and rating game, where respondents were less restricted in their choices and were not confined to making trade-offs, bequest was prioritized (Figs. 3C, 4) to a greater or lesser extent by all groups (Fig. 3A,B). Mean individual WTP for one

Table 4
Average WTP per spring tide for bequest, social cohesion, shoreline protection and commercial fisheries (000 MGA)[a] with 95% confidence intervals. WTP is relative to the base level of each attribute (status quo).

Attributes levels	Description	WTP per individual	Lower confidence interval	Upper confidence interval
Bequest low[b]	**1 generation**	–	–	–
Bequest medium	**2 generations**	**24.42**	**14.26**	**58.96**
Bequest high	**5 generations**	**56.78**	**34.37**	**143.22**
Social cohesion low[b]	2 people/village	–	–	–
Social cohesion medium	4 people/village	3.07	−3.27	12.17
Social cohesion high	6 people/village	14.99	7.42	38.88
Shoreline protection low[b]	1×/3 years	–	–	–
Shoreline protection medium	1×/4 years	4.13	−2.62	14.39
Shoreline protection high	1×/5 years	14.99	7.12	38.61
Commercial fisheries low[b]	60 k MGA	–	–	–
Commercial fisheries medium	70 k MGA	6.18	0.18	20.21
Commercial fisheries high	80 k MGA	14.05	5.71	41.85

[a] 1 MGA = 2090 USD, 2010.
[b] Omitted base level.

Table 5
Results from Likert-scale questions on bequest, income trade-offs, environmental awareness, and management perceptions.

	Strongly agree	Agree	Unsure	Disagree	Strongly disagree
Bequest					
I'm proud to say that I am from Velondriake.	43%	56%	1%	0%	0%
It is important to protect the sea to ensure that future generations can live as Vezo.	45%	54%	1%	0%	0%
Income trade-offs					
I wouldn't like it if my income from marine resource sales decreases this year even if it will increase next year.	4%	22%	1%	70%	3%
Environmental awareness					
Mangroves and reefs are not important to protect my house from storm damages.	10%	20%	8%	55%	7%
Ecosystem management					
The management of marine resources within Velondriake area decreases my catch.	3%	6%	1%	79%	11%
There is nothing to do to change the quantity of the fish in the sea.	1%	8%	16%	65%	10%

additional generation to live as Vezo was estimated at ~24 k MGA per spring tide (Table 4), which is equal to an annual value of 624 k MGA per person, or 75–95% of the estimated annual average per capita income in the region in 2010.[7] The considerable value placed on bequest, representing a majority of *all* income generated in the region, challenges the assumption that the Vezo live solely in the present or are too poor to consider the long-term benefits of conservation. Our results reflect the overwhelming importance the Vezo place on cultural bequest in comparison to other direct and indirect use ecosystem services. We suspect that the Vezo are not unique, and that other poor, resource-dependent communities may have similar bequest values that remain understudied, and which could directly inform management. Our results, coupled with that of Casey et al. (2008) and O'Garra (2009) (the only other studies we are aware of that explicitly quantify bequest values from ecosystems in low income groups), suggest that cultural ecosystem services, and bequest values in particular, should be more readily accounted for in environmental valuations and incorporated into policy and management in all socioeconomic conditions.

Understanding the importance local communities (and potential subgroups within the community) place on cultural ecosystem services can help ensure that resource governance institutions are appropriately designed and targeted, thereby improving both livelihoods and environmental sustainability. For example, in our study site, the importance of the Vezo identity and its intimate connection with the marine environment formed the basis of a social marketing campaign that sought to change behavior and improve local ecological conditions. The campaign, whose slogan was "Vezo aho" (I am Vezo), sought to stem the use of destructive fishing practices in the region, in part by speaking to the Vezo heritage of being skilled fishers who do not need or use poison or destructive beach seines (Andriamalala et al., 2013). The campaign, broadly considered a success, directly connected responsible fishing with the importance of maintaining ecological integrity for future generations, with a campaign by-line that read "the sea is my heritage and that of my descendants" (Andriamalala et al., 2013). Although the way in which the importance of cultural ecosystem services can be incorporated into management and policy initiatives will vary with context, this example demonstrates the power of understanding and linking cultural ecosystem service values with motivating stewardship.

Another general premise in the policy realm is that poor, resource-dependent communities exhibit a strong preference for pay-offs now over those in the future. This is worrisome, as present bias can lead to resource overexploitation (Sumaila and Walters, 2005) and higher violations of rules governing resources (Akpalu, 2008), thus hampering efforts to solve the tragedy of the commons. Previous ethnographic research has characterized the Vezo as present-oriented with short time horizons and a poor capacity for, and disinterest in, forward thinking (Astuti, 1995; Tucker, 2012). Past choice experiments focused on food security found very high discount rates among the Vezo (30–49% monthly) (Tucker, 2012). The local cultural narrative confirms this: we observed people teasing each other for being "un-Vezo" when they discussed long-term plans. Our results offer some evidence to the contrary, however, suggesting that despite their struggle with poverty and focus on daily activities, the Vezo do not necessarily highly discount the future. As already discussed, they are willing to make trade-offs to ensure the long-term bequest value. Similarly, nearly 75% of respondents were willing to give up short-term income from fishing in exchange for long-term gains in commercial fisheries catches (Table 5), the trade-off that also underlies our calculated annual discount rate of 62%. Moreover, though our calculated annual discount rate does imply that the Vezo exhibit a present bias, it is on the low end of the broad range of rates found for small-scale fishers elsewhere. Teh et al. (2014) found that small-scale fishers in Fiji and Malaysia held very high (over 200%) discount rates, even when the fishery was collectively managed. Akpalu (2008) reported rates about half that (130%) for Ghanian fishers, while Johnson and Saunders (2014) found that fishers in Bonaire and Curaçao were far less present-biased (22%). These studies should be compared with caution, however, as different methods were used in each (Cardenas and Carpenter, 2008), and estimated discount rates are highly dependent on elicitation methods and context (Kühberger et al., 1999).

Many drivers influence individual time preferences, including socioeconomic conditions, psychological handling of uncertainty and risk, and ethical perspectives on, for instance, intergenerational justice (Sumaila and Walters, 2005; Teh et al., 2014). Resource condition and ownership, experience with management, and other variables of the managed system may also play a significant role. Across methods, contexts, and derived rates, however, recent research on time preferences suggests that solving the open access nature of resources may not be enough to ensure sustainable behavior. Managers need to develop a nuanced understanding of what is driving present bias to design multi-faceted management schemes targeted to specific groups that effectively incentivizes behavior change (Johnson and Saunders, 2014; Teh et al., 2014).

7. Conclusion

Though cultural ecosystem services such as bequest are increasingly recognized as one of the most compelling reasons for conserving ecosystems (Satterfield et al., 2013), they are challenging to measure and thus are typically omitted from economic valuations, making it difficult to formally incorporate them in many environmental policy and management decision making processes. Choice experiments offer a useful method for quantifying these difficult to value services and for considering trade-offs with other, more tangible ecosystem services, thereby improving capacity for sound environmental decision-making. Choice

[7] Using data collected in our household survey, where respondents were asked to report their average weekly income and the number of individuals supported by this income, average annual per capita income was estimated at 656 k MGA. Average per capita income in 2010 was also estimated by Barnes-Mauthe et al. (2013) in the same site using a fisher survey: 2.3 k MGA per day, or 837 k MGA per year. Annual per capita income likely falls within this range of values (656–837 k MGA).

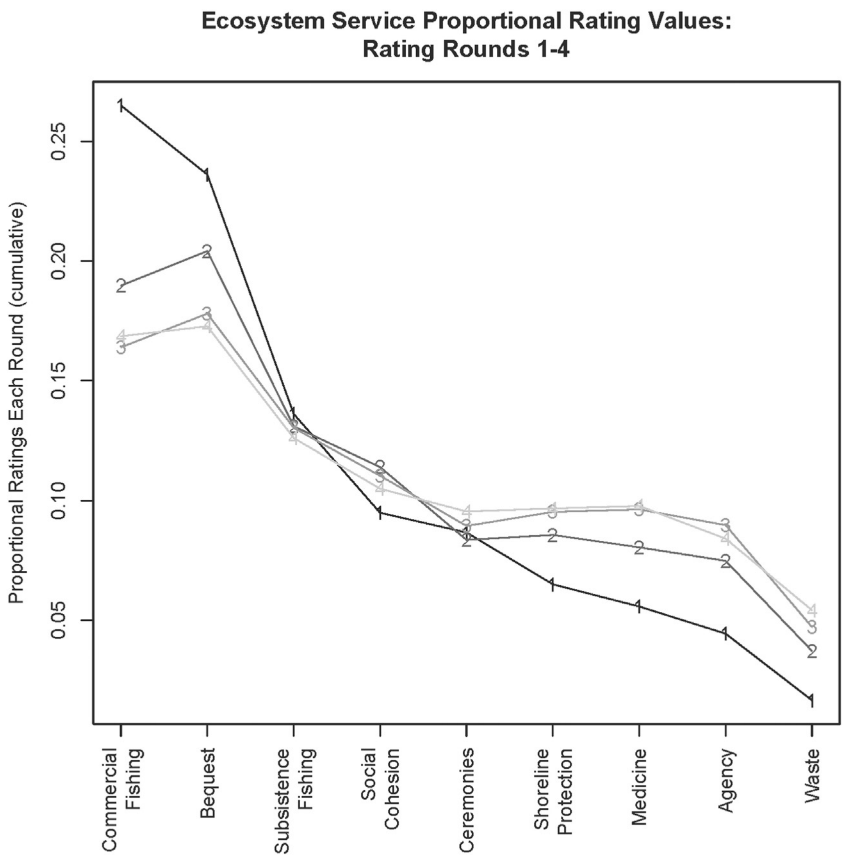

Fig. 4. Mean cumulative proportional ratings of each ecosystem service (ES) in the ranking and rating game across four rounds. Each line represents the cumulative total score proportional to the total beans scored from a different round (1–4; 5 beans each round). . The results from the first round are highlighted, and are the same as presented in Fig. 3. This demonstrates the relative importance of bequest. Adapted from Barnes-Mauthe et al., 2014.

experiments may also offer a means to estimate time preferences, which have deep implications for management and policy design, particularly in resource-dependent communities.

In line with recently developed guidelines for applying choice experiments in developing countries, here we employed a DCE to determine indigenous fishers' preferences and WTP for bequest gains from local management actions in a locally managed marine area in Madagascar. A careful design helped ensure appropriateness for the context, broad comprehension by a majority of respondents, and overall reliability of our results. Our design and implementation benefited from focus groups, key informant interviews, the use of pictograms to display attributes and levels, a pilot experiment, and well trained local surveyors. By applying an additional variety of mixed methods, we further ensured the validity of our results.

Our results reflect the overwhelming importance of cultural bequest in comparison to other direct and indirect use ecosystem services, suggesting management actions that entail short-term sacrifices to improve ecological structures and functions that may be more acceptable to the local community in our study site than previous research suggests. Though they remain vastly under-studied, we suspect that similar bequest values may exist in other poor, resource-dependent communities. Information on the value of bequest in comparison to other ecosystem service benefits can play a crucial role in resource policy and management, and can be leveraged to help ensure long-term ecological and socio-cultural sustainability, e.g., by encouraging resource stewardship. Our empirical approach and methods for validation provide one way of better quantifying intrinsically difficult to value services, and it is our hope that this study serves as a tool for better quantifying bequest and other cultural ecosystem services on a global scale.

Acknowledgements

This research was funded by the John D. and Catherine T. MacArthur Foundation Grant 07-89632-00-GSS, the Waterloo Foundation Grant 449-547, the Network for Social Change, and United States National Science Foundation Grant OISE-0853086. Our ranking and rating adapted a method developed by Dr. C. Hicks; and Dr. D. Gill provided statistical advice. We thank the Madagascar-based ground staff of Blue Ventures Conservation and all of our survey respondents, key informants, focus group discussants, interviewees, and research assistants. We also thank three anonymous reviewers for their constructive comments.

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