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Valuing mangrove biodiversity and ecosystem services: A deliberative choice experiment in Mida Creek, Kenya

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ABSTRACT

Mangrove degradation threatens the capacity of these important ecosystems to provide goods and services that contribute to human wellbeing. This study uses a deliberative choice experiment to value non-market mangrove ecosystem services (ES) at Mida Creek, Kenya. The attributes assessed include "shoreline erosion protection", "biodiversity richness and abundance", "nursery and breeding ground for fish", and "education and research". Unpaid labour (volunteer time) for mangroves conservation was used as the payment mechanism to estimate willingness to pay (WTP). Results suggest that respondents were willing to volunteer: 5.82 h/month for preserving the mangrove nursery and breeding ground functions to gain an additional metric ton of fish; 21.16 h/month for increasing biodiversity richness and abundance; 10.81 h/month for reducing shoreline erosion by 1 m over 25 years; and 0.14 h/month for gaining 100 student/researcher visits/month. The estimation of WTP for mangrove ES provides valuable insights into the awareness of local communities about the contribution of mangrove forests to ES delivery. This knowledge could assist decision-making for the management and conservation of mangroves in Mida Creek and its environs.

1. Introduction

Over recent decades, marine and coastal ecosystems have been under increasing pressure from overexploitation, pollution and deforestation, (Millennium Ecosystem Assessment, 2005a,b) caused by an increased demand for natural assets and infrastructural development to sustain the growing human population (Liquete et al., 2013). Mangroves and their associated biodiversity provide a range of ecosystem services (ES) including: provisioning services (e.g. food, fuel, and honey), regulating services (e.g. storm protection, erosion control, and climate regulation), cultural services (e.g. spiritual enrichment, recreation and aesthetic features) and supporting services (e.g. nutrient cycling, primary production) (Millennium Ecosystem Assessment, 2005a,b; TEEB, 2010).

The degradation and loss of mangroves globally has raised the concerns of ecologists and economists (Barbier et al., 2011, 2008; Himes-Cornell et al., 2018). This degradation can be human-induced; for example, mangroves have been converted for shrimp production in Asian countries (Barbier and Cox, 2003; Brander et al., 2012). This has led to habitat loss and a deterioration in the regulatory functions of mangroves, thereby reducing marine productivity and increasing coastal vulnerability to natural disasters (Alongi, 2008; Barbier et al., 2011; Bosire et al., 2014)[1]. The reduction of ecosystem capacity to provide ES could in turn affect local livelihoods, more so in developing countries, where most of the population depends on natural resources for their livelihood (Brander et al., 2012; Owuor et al., 2017).

Therefore, there is need to adopt an ecosystem-based approach, which can enable the development of more inclusive strategies in decision-making for the management of critical ecosystems such as mangroves. The current approaches to natural resource management often ignore the benefits communities derive from ecosystems and biodiversity (CBD, 2004; Tallis and Polasky, 2009). As quantitative and monetary estimates are preferred in many decision-making contexts, the application of an ecosystem-based approach should be able to obtain the economic values of different ES (Barbier et al., 2008; Tallis and Polasky, 2009). Thus, if it is possible to obtain accurate economic

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[1] For example, mangroves have reportedly protected communities during natural disasters such as the 2004 Indian Ocean tsunami (Dahdouh-Guebas et al., 2005).

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values for ES, then policy- and decision-makers can use the outcomes of valuation studies to inform the development of strategies for the sustainable use and conservation of natural resources (Barbier, 2007), as well as to determine the financial allocation for the management of these resources (Balmford et al., 2002; Daily, 1997). Indeed, economic valuation studies can estimate the opportunity cost for alternative uses of natural resources in protected areas (Cerda et al., 2013).

Some economic valuation approaches can provide values, even in the absence of market prices, as is the case for most mangrove ES (Polasky, 2011). Despite this need to consider the value of ES for management decisions, there are only a few relevant studies for developing countries (Himes-Cornell et al., 2018). In Kenya, for example, there are several studies on the mangroves by botanists, ecologists and marine scientists (Kairo, 2001; Kairo et al., 2002; Walters et al., 2008), but studies examining the local utilization and valuation of mangroves are scarce (Walters et al., 2008).

Stated preference techniques (SP) such as choice experiments (CE), are recognized as instruments capable of obtaining information about the willingness to pay (WTP) in the environmental field (Hanley et al., 1998; Louviere et al., 2000). CE, like other SP (i.e. contingent valuation), use surveys to obtain statements of value and WTP from respondents (Christie et al., 2012). The use of CE is growing and gaining more recognition due to its ability to estimate values for multiple ES (Cerda et al., 2013).

In this study, a deliberative choice experiment was conducted to determine the economic values that local communities assign to the multiple ES provided by the mangroves of Mida Creek in the Watamu Marine Reserve on the Kenyan coast. Deliberative choice experiments entail the integration of conventional choice experiment techniques with group discussions (deliberations), to facilitate the understanding of preferences for unfamiliar and/or complex ES (Bartkowski, 2017).

The communities' WTP was estimated using volunteer time (i.e. unpaid labour) as the proxy for payment (Vondolia and Navrud, 2018). The main respondents were community members that inhabit Mida Creek, thus benefiting directly or indirectly from mangrove ES. The objectives of the study were to provide knowledge and information on mangrove ES, as well as to obtain the value that the community attaches to these services, and the consequent implications for policy and mangrove management in Kenya. The study will improve the knowledge base related to the economic valuation of mangrove ES in developing countries, and provide information that could be relevant for prioritizing the conservation of mangrove forests as important blue forests (Himes-Cornell et al., 2018).

2. Methodology

2.1. Study site

The study was carried out in the Mida Creek mangrove forest, located on the north coast of Kenya (Fig. 1). Mida Creek is a marine national reserve and part of the Malindi-Watamu complex (Tuda and Omar, 2012) that was designated a UNESCO Biosphere reserve in 1979 (UNESCO, 1979). The Creek covers an area of approximately 31.6 km^2 (Dahdouh-Guebas et al., 2000). Mangroves are the dominant ecosystem occupying an area of 1746 ha (Owuor et al., 2017). Seven of the nine Kenyan mangrove species occur in the Creek: *Rhizophora mucronata*, *Ceriops tagal*, *Avicennia marina*, *Sonneratia alba*, *Xylocarpus granatum*, *Bruguiera gymnorrhiza* and *Lumnitzera racemosa* (Kairo et al., 2002). The biosphere reserve area also includes coral reefs and sea-grass beds (UNESCO, 1979). As a result the Afrotropical, East African mangroves of Mida Creek are a home to many bird species (Sylvia, 2017) and is labelled as an Important Bird Area. In addition, the mangroves provide habitat for many species of crabs, shrimps, fish (over thirty species), snakes, and large mammals (e.g. baboons, monkeys).

The mangrove forest ecosystem is surrounded by human settlements in the sub-locations Dabaso, Mida, Matsangoni and Uyombo. Within these sub-locations are the seven settlements Uyombo, Matangeni, Mida, Gede, Sita, Dabaso and Kirepwe, with approximately 6821 households (Republic of Kenya, 2012). Most of the people living around Mida Creek are poor (Government of Kenya, 2009; The Ministry of Planning and Devolution, 2007), with fishing, crop farming, business activities and tourism-related ventures providing the main livelihoods (Owuor et al., 2019). Traditionally, many coastal communities in Kenya have depended on the exploitation of mangrove wood products and fisheries (Government of Kenya, 2009), where the mangroves have supplied timber poles, non-timber resources (e.g. honey[2]) and seafood (UNEP-WCMC, 2011). However, the expanding demand for poles and material for both subsistence and commercial use increases the anthropogenic pressure on mangrove resources.

2.2. Ecosystem services valuation

2.2.1. Research approach

The study combined a deliberative valuation technique (Lo and Spash, 2013; Spash, 2008, 2007) with a choice experiment method (Alpizar et al., 2001; Gunatilake et al., 2012) which culminated in an integrated technique called a deliberative choice experiment (Lienhoop and Volker, 2016). While many different versions of deliberative choice experiments exist, in this study, the participants were asked to complete questionnaires individually (Kenter et al., 2016). The deliberated preference focused on obtaining value at the individual level but also allowed participants to discuss and think about their preferences, with the aim of reducing their cognitive burden (Kenter, 2017; Lo and Spash, 2013). In contrast to Lienhoop and Volker (2016), where the participants were released and later surveyed individually, this study used the procedure by Kenter et al., (2016), where the participants completed the questionnaire on the same day. The values for mangrove ES were obtained with a choice experiment using volunteer time as the payment mode for assessing willingness to pay for ES.

The rationale for adopting a deliberative choice experiment approach, over the conventional choice experiment approaches is that consumers do not always have complete information and perfect structural knowledge about all relevant aspects of a choice/transaction (Chee, 2004; Eckardt, 2007). Many scholars have discussed how consumers in reality are always constrained by incomplete information and limited cognitive capacities, and hence their decisions may also be incomplete (Cummings and Ross, 2013; Englerth, 2015; Luoto, 2017; McCann and Oort, 2009; Scalise, 2015). Deliberative choice experiments aim at bridging these deficiencies by providing the decision-makers (consumers) with the necessary information in a learning environment that improves the robustness of their decisions (Orchard-Webb et al., 2016).

A choice experiment study entails the following steps: (1) identification of ES (Section 2.2.2), (2) selection of priority ES (attributes)_ (Section 2.2.3), (3) experimental design (Section 2.2.4), (4) generation of choice cards (Section 2.2.5), (5) data collection (Section 2.3), and (6) data analysis (Section 2.4). For more details see Holmes et al. (2017) and Janssen et al. (2018).

2.2.2. Identification of ecosystem services

Key informant interviews and literature review identified a total of 20 ES provided by the Mida Creek mangroves. These included: (1) provisioning ecosystem services (e.g. fish, firewood, charcoal, poles, honey, herbal medicine, dyes, fishing gears, wild food); (2) regulating services (e.g. carbon sequestration, nutrient cycling, pollination, sediment regulation, flood protection, water purification, shoreline erosion protection,); (3) supporting services (e.g. nursery and breeding ground

[2] The Mida Creek is considered as an important habitat for honeybees. The area is one of the seven main honey-producing areas of Kenya, with its honey considered to be highly medicinal.

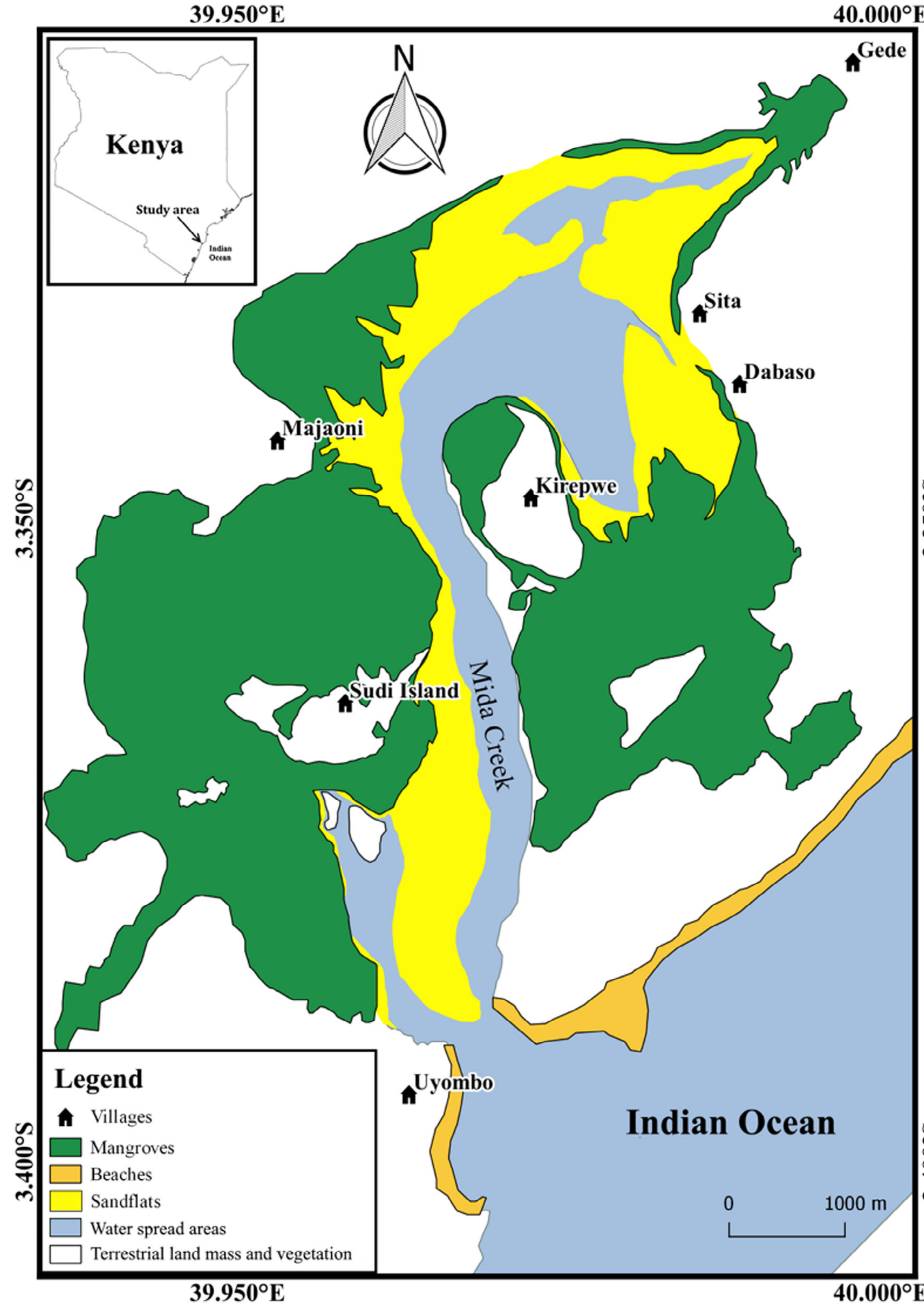

Fig. 1. Map of Mida Creek showing the study villages. Source: Adapted from Kairo (2001) and Owuor et al. (2019).

for fish, habitat for biodiversity) and; (4) cultural services (e.g. tourism and recreation, education and research) (TEEB, 2010; UNEP-WCMC, 2011).

2.2.3. Selection of priority ecosystem services and attributes

The ES identified through the key informant interviews and literature review (Section 2.2.2) were organized into a matrix and presented to stakeholders during focus group discussions (FGD) with community members living around Mida Creek. Each of the mangrove ecosystem services were ranked in order of perceived importance in terms of the benefits provided to the local community. This was done to reduce the number of ES considered during the choice experiment as a means of lowering participant fatigue (Alpizar et al., 2001; Ryan & Gerard, 2003). In addition, the FGD were meant to (a) define and describe the attributes to be valued, (b) establish the attribute levels (especially for the *status quo* scenario, see Section 2.2.5), and (c) determine the appropriate payment system.

A total of 30 participants, with 20 men and 10 women, were invited to participate in three separate workshops. Each workshop comprised 10 participants from various community-based groups such as beach management units, beekeepers' associations, ecotourism operators, and traders. The workshops were held at Dabaso boardwalk, Mida boardwalk and Uyombo beach management unit office.

The FGD encouraged participation and among the issues discussed was education about mangrove ES, and their direct and indirect benefits to the community. This was followed by a quantification exercise of the benefits derived from the mangrove. Participants in this session were presented with a total of 22 ES including biodiversity richness and abundance; although biodiversity is a function of the mangrove ecosystem rather than a service *per se*. The participants were then asked to rank each ES from first to the last and they were encouraged to make individual or personal decisions while carrying out the ranking exercise. The enumerators then summed up the total scores for each service and divided by the total number of participants to obtain the mean score. Out of all different mangrove ES, provisioning services were ranked the highest. However, since it is possible to value provisioning ES using market prices, this study prioritized the non-provisioning ES that were also ranked high.

Identifying the most appropriate payment system for estimating the WTP was a challenging element of the FGD discussions. This is because most of the residents in the case study area engaged in informal employment and were not able to account for their earnings in a simple, clear, and verifiable manner. The residents obtained multiple sources of income from different activities, the majority of which did not entail a direct exchange of money. Therefore, other measures to derive a universal cost measure were explored. Based on the discussions, the enumerators and research team identified that the unpaid time for conserving mangrove ecosystem using volunteer time in hours per month, was a good metric to express the opportunity costs.

Generic policy options were then developed using variations in the levels of ecosystem service delivery. These were tested with the participants to establish the range of attributes and their levels (see Table 1). Community practitioners, experts and managers of key institutions charged with managing the mangrove resources from the area were also interviewed to test the validity of the developed options.

2.2.4. Experimental design

When creating a stated choice experiment, a complete model specification has to be determined with all the parameters to be estimated (ChoiceMetrics, 2014). In this study, five attributes have been considered including; "shoreline erosion protection"; "biodiversity richness and abundance"; "nursery and breeding grounds for fish"; "education and research"; and "volunteer time" as the mechanism for payment. Three policy options were developed to include: two progressive options **A** and **B** that reflect mangrove conservation, with the third option **C** being the *status quo* (see Fig. 2). Studies have shown that having more than four to five attributes in a choice set may affect the quality of the data collected due to task complexity and participant fatigue (Alpizar et al., 2001).

2.2.5. Generation of choice of cards

After selecting the attributes and their levels, the enumerators generated a combination of attributes and levels that would appear in choice cards (Rodrigues et al., 2016). Such choice cards can be generated either through orthogonal or efficient designs. Orthogonal designs are experimental designs that ensure a balance between attributes and their levels, as well as independence between estimates for all parameters (i.e. no correlation). Efficient designs are experimental designs that aim to yield standard errors that are as low as possible during the estimation of parameters, and are currently preferred to orthogonal designs (ChoiceMetrics, 2014). For this study, the choice cards were generated using a multinomial logit model together with D-error measure to select the efficient design (ChoiceMetrics, 2014). During a pilot study to obtain efficient design, 30 respondents were interviewed (n = 30) using orthogonal design choice cards generated with the software package Ngene (ChoiceMetrics, 2014).

The final selection for the full 30 choice cards (Fig. 2) was designed to survey 300 participants with each respondent limited to six choice tasks to avoid fatigue. Choice sets were blocked into five sub-samples to attain the six choice tasks. However, nine of the thirty cards that were generated had dominant alternatives. Johnson and Orme (1996) suggest that it is important to exclude implausible and dominant alternatives by including constraints at the design stage of the choice tasks. These constraints enable information on trade-off preferences as respondents normally prefer a dominant alternative, regardless of their preference (Boxall et al., 1996; Louviere et al., 2000). Trade-offs reflect

Table 1
Summary of the selected attributes and attribute levels.

Attributes	Description	Levels
Nursery and breeding ground for fish	Amount of fish that breed and spent juvenile period in the mangroves harvested per month	16 tonnes/month, 12 tonnes/month, **8 tonnes/month**
Biodiversity richness and abundance	Biodiversity abundance in the mangrove ecosystem. Described as declining, stabilizing, and increasing, and represented by the charismatic species such as mangrove trees, crabs, fish, birds, snakes and monkeys	Increasing biodiversity richness and abundance. Stable biodiversity richness and abundance. **Declining biodiversity richness and abundance**
Shoreline erosion protection	Metres of eroded shoreline. Observed by the local community over time	1 m of shoreline to be lost in 25 years. 5 m of shoreline to be lost in 25 years. **10 m of shoreline to be lost in 25 years**[1]
Education and Research	Number of researchers and students that visit the mangroves for research and educational purposes	500 people/month. 600 people/month. **400 people/month**
Unpaid labour (volunteer time)	Unpaid labour time that respondents will provide towards mangrove restoration activities	4 h/month, 8 h/month, 12 h/month, 16 h/month, 20 h/month, 24 h/month, 28 h/month, 32 h/month, **No additional cost**

Note: Bold text indicates *status quo* also known as *business as usual.*

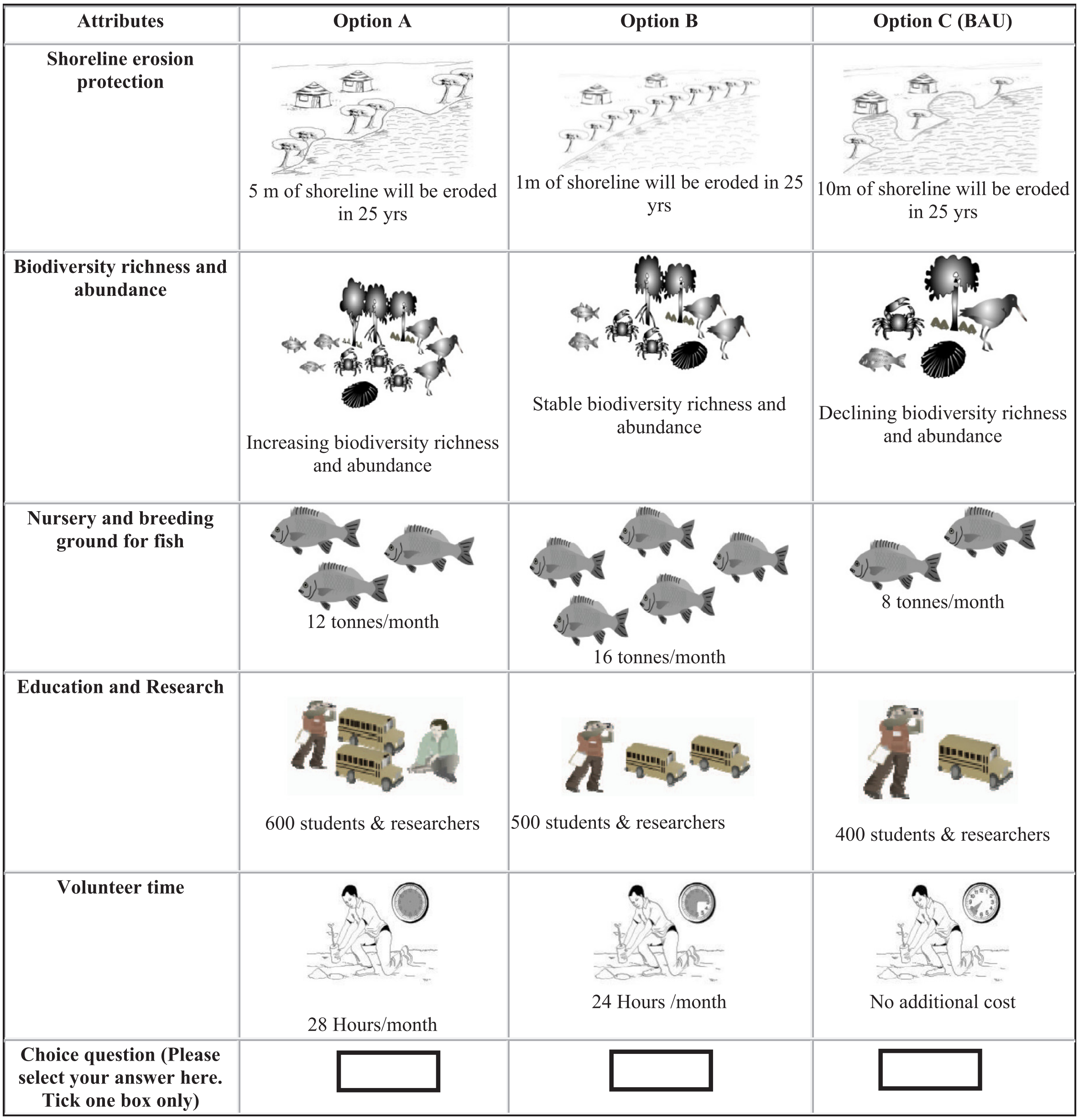

Fig. 2. Sample choice card generated for the study.

an efficient design based on some of the principles associated with the design generation such as orthogonality, level balance, minimal overlap and utility balance (Mühlbacher and Johnson, 2016; Street and Burgess, 2007). However, constraints that exclude implausible combinations or dominant alternatives do introduce some degree of correlation and level imbalance in the experimental design (Johnson et al., 2013). Dominant alternatives also offer a test for measuring respondents' attentiveness to the attribute levels and definitions (Louviere et al., 2000). Consequently, the dominant designs were included in the survey, mainly, to avoid introducing correlation at the data analysis stage and to test participants' level of attentiveness. However, they were not used for data analysis since they do not yield the trade-offs that are required for choice experiment studies (Johnson et al., 2013). Another alternative approach to avoiding dominant choices in the choice cards is to identify the dominant choices in the experimental design and subsequently change the levels of one attribute to avoid dominance. However, this option was not used, although it could have increased the utility of most of the choice cards.

2.3. Data collection

2.3.1. Questionnaire development and sampling

The study questionnaire consisted of four sections. The first section contained the consent form[3]; the second section comprised warm-up questions that ensured familiarity with the mangrove ecosystem and the services it provides; the third section included the choice experiment; and the fourth section contained debriefing questions aimed at establishing the reasoning behind the choices. The questionnaire concluded with questions about the socio-demographic attributes of the participants. The choice experiment was introduced by creating a

[3] The Consent Form informed the respondents about the purpose of the study and sought their permission to engage in the study. It also contained ethical guidelines which informed respondents that participation in the study was not presenting any risk or benefit to them. Respondents were also informed that no personal details such their names would be reported in the study and that only aggregate results would be reported. This information was necessary given that participants were encouraged to provide honest responses.

Table 2
Key demographic characteristics and ecosystem service delivery.

Variables	Percent	Mean	Std. dev.	Min	Max
Fish dependence (1 = yes, 0 = otherwise)	92%	0.919	0.273	0	1
Witnessing of shoreline erosion (1 = yes, 0 = otherwise)	88%	0.875	0.331	0	1
Duration of stay (in years)		28.5	13.21	0.33	64
Shoreline erosion (in metres)		7	8.528	0.25	60
Shoreline erosion in Uyombo (in metres)		12	12.200	1	60
Duration of stay in Uyombo (in years)		27.55	11.809	0.33	56
Importance of biodiversity richness and abundance (1 = yes, 0 = otherwise)	100%				
Status of biodiversity richness and abundance (Increasing = 1; Stable = 0, Decreasing = -1)	Increasing = 20%; Stable = 6%; Decreasing = 74%	−0.545	0.8046	−1	1
Researcher and student sightings (number/year)		4.75	5.391	1	32

Note: Researcher and student sightings are counted on a per group basis, and not on the absolute number of individuals. For example, a group consisting of five individuals will be counted only once.

hypothetical market for the mangrove, and used pictograms to reduce the cognitive burden on participants (Davies et al., 2002).

Prior to actual data collection, pretesting (n = 30) was carried out to test the efficacy and suitability of the choice sets and attribute descriptions. The sampling units in this study were households from across the seven villages (Fig. 1). The sample size was determined using Johnson and Orme (1996) rule of thumb $n \geq \frac{500c}{t \propto}$.where: n is the number of respondents; t is the number of tasks; $\propto$ is the number of alternatives per task not including the none alternative (the status quo was considered as a competitive alternative) (ChoiceMetrics, 2014); c is the number of analysis cells which is equal to the largest number of levels for any one attribute when considering the main effects.

Based on these requirements, the minimum sample size was 250 participants where each participant had to manage six tasks, with two alternatives per task, while the number of analysis cells was 9 as represented by the number of levels for volunteer time (Table 2). In total 300 participants were enrolled for this choice experiment to guarantee an adequate sample size.

Simple random sampling was employed during the recruitment of participants in which ten trained field assistants were assigned villages. In each village, the enumerators made transect walks and approached the household head of every 22nd household given the estimated household population of 6821 (Republic of Kenya, 2012).

2.3.2. Deliberative workshop

Given that deliberation was a central element of the research approach, the randomly selected participants were invited to attend deliberative workshops at predetermined dates and venues across the study area. Each workshop had an average of 20 participants. A total of 14 deliberative workshops were held during May and June 2016. Out of the 300 participants invited, 274 attended the exercise.

The deliberations involved group discussions where the lead facilitator introduced the main issues and information for open discussion between participants. Participants were presented with six major questions and pieces of information which included: (1) Mangrove ES and their importance to humans and ecological balance; (2) Degradation status, trends and threats facing the mangrove ecosystem and implication of such processes for the future availability of mangrove ES; (3) Role of mangroves as a nursery and breeding ground for fish, exploring issues such as, but not limited to, community dependence on these fish for fishermen, traders and fish consumers; (4) Role of mangroves for shoreline protection against erosion drawing from participants' experience, based on age and duration of residence in the creek, and their observations about shoreline erosion over time; (5) Role of mangroves in maintaining biodiversity richness and abundance exploring issues such as, but not limited to, the different animal species found in Mida Creek, the trends and patterns of plants and animal species numbers and diversity over time, and the benefits of biodiversity to the ecosystem and thereby to humans; (6) Role of mangroves in maintaining and promoting education and research with their associated benefits (see S2, Supplementary Electronic Material).

The information session was followed by an open group discussion between participants to generate knowledge on these issues for the benefit of each participant. Discussion on an issue was closed after a consensus was reached following an exhaustive debate. One of the debates that stood out related to biodiversity, and especially on why participants did not hold a high regard for some of the mangrove animal species due to human-wildlife conflict (i.e. loss of crops to monkeys and baboons, snake bites, loss of poultry to raptors, attacks from electric eels). However, the participants were impressed by a deeper analysis of what would be at stake should these complex species interactions be lost.

2.3.3. Preference elicitation

At the end of each deliberation session, participants were provided with individual questionnaires and were guided on how to complete the questionnaires (see S3, Supplementary Electronic Material). The participants were reminded that they represented their households. In this respect, the volunteer time they were required to donate would have had to come from their valuable time used to earn a living, rather than from their free time. A team of five facilitators guided the respondents because of low literacy levels. The questionnaires were designed in English, but the copies used by the facilitators were translated into Kiswahili (local dialect) to improve understanding.

2.4. Data analysis

The Lancaster theory of value (Lancaster, 1966) and the McFadden's random utility theory (McFadden, 1974) form the theoretical basis for the analysis of the participants stated choices. In modelling these discrete choices, the conditional logit (CL) model is used (Hensher et al., 2005). The CL model assumes that the error terms are independently and identically distributed (IID) over alternatives and individuals. This means that irrelevant alternatives with non-zero probability are independent of each other, and are thus unaffected by the introduction or removal of additional alternatives in the choice set (Louviere et al., 2000). Though computationally convenient, the IID is unlikely to hold if there is unobserved preferences heterogeneity among respondents (Louviere et al., 2000). In this case, the use of CL will lead to biased estimates. Therefore, there is a need to use a model that avoids the IID assumption such as the mixed logit (ML). Given a decision-maker who faces a choice among J alternatives, the utility of person i from alternative j is specified as;

$$U_{ij} = \beta_i' x_{ij} + \varepsilon_{ij} \quad (1)$$

where x_{ij} are the observed variables that relate to the alternative and decision maker, β_i is a vector of the coefficients, and ε_{ij} is the random error term. According to Hensher et al. (2005), these coefficients vary among the population with density function $f(\beta_i|\theta)$. The density function represents the individual preference heterogeneity in the sampled

Table 3
Attributes for conditional logit (CL), Alternative Conditional logit (ACL) and mixed logit (MXL) models.

Variable	CL Model	ACL Model	MXL Model
Nursery and breeding ground for fish	0.126**	0.150**	0.150**
Biodiversity richness and abundance	0.457**	0.498**	0.617**
Shoreline erosion protection	−0.234**	−0.246**	−0.278**
Education and research	0.003**	0.004**	0.005**
Unpaid labour (Price/Cost)	−0.022**	−0.023**	−0.025**
AIC[a]	1566.23	1559.906	1553.068
BIC[b]	1597.025	1603.020	1608.500
Log likelihood	−778.111	−772.953	−767.534
Number of observations	3495	3495	3495
Respondents	262	262	262

Note: **$p < 0.05$.
[a] Alternative Specific Constant.
[b] Bayesian Information Criterion.

population. The vector θ comprises parameters characterizing the density function that captures individual deviations from the mean (Hensher et al., 2005). The decision-maker knows the value of his/her own β_i and ε_{ij}'s for all j and chooses alternative m if and only if $U_{im} > U_{ij}\ \forall j \neq m$. The researcher does not know β_i and therefore cannot condition β. Therefore, the unconditional choice probability over all possible β_i i.e. mixed logit probability is given by;

$$P_{im} = \int_{i=1}^{N} \left(\frac{e^{\beta_i' x_{im}}}{\sum_j e^{\beta_i' x_{ij}}} \right) f(\beta) d(\beta) \tag{2}$$

Several distributions for the coefficients can be assumed, e.g. normal, lognormal, uniform or triangular (Hensher et al., 2005), which should be specified during the analysis. If the analyst intends to constrain the parameter estimates to some specific sign (positive or negative), a triangular distribution with the standard deviation restricted to equal the mean, or lognormal distribution can be used. The challenge with lognormal distribution is the asymptotic nature of the tails, which could be problematic in WTP estimations. There is an assumption that normal distribution will not constrain the parameter estimates to any specific sign, which might lead to counter intuitive results such as a positive sign for the cost attribute (Hensher et al., 2005; Kragt and Bennett, 2011).

3. Results

3.1. Community perceptions of mangrove ecosystem services

The mean respondent age was 36.5 years. Fifty seven percent of the respondents were men and 43% were women. Most of the respondents attained primary level of education. With respect to membership of environmental groups, 55% of respondents were members of such organisations. The mean number of children per household was 8, indicating that respondents generally had large household sizes with a substantial number of dependants

All participants (100%) believed that mangroves were important as nursery and breeding grounds, while 99% of respondents indicated that they were important sites for research and education. Approximately 95% of respondents believed that mangroves were important for shoreline protection and in sustaining biodiversity.

As this study sought to establish whether the respondents benefited, attached importance, or interacted with the identified mangrove ES they were asked as series of relevant questions. In particular, respondents were asked to name some of the fish species that bred or inhabited the mangrove environment during their juvenile stages. This question was also used to assess whether the communities depended on these fish species, either through fishing or buying from the local market. Ninety-two percent of the respondents reported that indeed they derived benefits from mangrove fish. The respondents were also asked if they had witnessed/experienced shoreline erosion in the area where they lived, with 88% responding positively. Respondents were also asked to estimate the extent of shoreline erosion that they had witnessed. Most respondents had lived in their current location for an average of 28.5 years and reported on average 7 meters of beach erosion during that period. Among the four study locations, participants from Uyombo reported the most extensive shoreline loss due to erosion (12 meters for an average length of stay of 28 years).

Regarding the status of biodiversity richness and abundance, 74% of the respondents reported a decline, 20% reported an increase, and 6% reported stability. Participants also reported that they often observed researchers and students visiting the mangroves. The mean number of group sightings per year was five, although this varied by sub-location. Participants residing in Dabaso and Mida Majaoni reported a higher frequency of researcher/student visits as a mangrove boardwalk had been constructed for visitors in that area (see Table 2).

3.2. Regression analysis

3.2.1. Willingness to Pay (WTP)

The most important non-market mangrove ES were valued through a deliberative choice experiment with volunteer time being the cost (price) for estimating the WTP. Table 3 presents the results of attributes only for conditional, alternative specific conditional and mixed logits models.

As expected, the utility of mangrove conservation alternatives is positively related to the nursery and breeding ground for fish, education and research, and biodiversity richness and abundance attributes. However, the coefficient for shoreline erosion protection is negative because respondents preferred alternative scenarios that had few meters (1 m) of shoreline eroded after 25 years as opposed to several meters (10 m). Volunteer time also had a negative coefficient, an indication that respondents preferred to spend less volunteer time on mangrove conservation.

Table 4 contains the results of the respondents WTP. For nursery and breeding ground for fish, the average respondent was willing to spend 6.10 h per month to gain an additional 1 tonne of fish, 25.05 h per month for increased biodiversity richness and abundance, 11.29 h per month for reduced loss of shoreline by 1 m in 25 years, and around 0.2 h per month for gains of 100 students and researcher visits per month. Volunteer time was translated to monetary equivalent using the average salary of a casual labourer (Kshs. 600 for six hours of work per day, exchange rate USD 1 dollar = Kshs 95). This value was used as the

Table 4
Marginal Willingness to Pay for mangrove ecosystem services.

Ecosystem Service	WTP (h/month)		WTP (USD)	
	CL	MXL	CL	MXL
Nursery and breeding ground for fish (1 tonne of fish)	5.82	6.10	6.13	6.42
Biodiversity richness and abundance (increase)	21.16	25.05	23.27	26.37
Shoreline erosion protection (1 m of reduced loss in 25 yrs.)	10.81	11.29	11.38	11.88
Education and research (additional 100 researchers/students per month)	0.14	0.17	0.15	0.18

Table 5
Willingness to Pay for individual households, entire community and unit area.

Ecosystem services	Household WTP (USD/Mon)	Household WTP (USD/Yr)	Community WTP (USD/Yr)	Average WTP (USD/Ha/Yr)
Nursery and breeding ground for fish	6.42	77.04	525,489.8	164.22
Biodiversity richness and abundance	26.37	316.44	2, 158,437	674.51
Shoreline erosion protection	11.88	142.56	972,401.8	303.88
Education and research	0.18	2.16	14,733.36	4.60
Total Indirect Use Value	**44.85**	**538.2**	**3,671,062**	**1,147.21**

Table 6
Influence of socio-demographic characteristics on respondent preferences.

Variable	Conditional logit with interactions	Mixed logit interactions
ASC (status quo)	−0.020	−0.045
Attribute Variables		
Nursery and breeding ground for fish	0.150**	0.150**
Biodiversity richness and abundance	0.498**	0.617**
Shoreline erosion protection	−0.246**	−0.278**
Education and research	0.004**	0.005**
Payment system (Time)	−0.023**	−0.025**
ASC Interactions with socio-demographic characteristics		
ASC*Environmental group membership	−0.278	−0.345*
ASC*Fishing	−0.471**	−0.550**
Payment system interactions with socio-demographic characteristics		
Time*Fishermen	−0.068***	−0.076
Time*Crop farmers	−0.079***	−0.095*
Time*Cattle keepers	−0.077***	−0.095*
Time*Business people	−0.057***	−0.068
Time*Salaried people	−0.076***	−0.085*
Time*Non salaried workers	−0.057***	−0.063
Attributes interactions with socio-demographic characteristics		
Nursery and breeding ground for fish*Fishing	0.029**	0.032*
Research and education*Dabaso sub-location	0.005**	0.005*
Biodiversity richness and abundance*Age	0.014**	0.014**
Biodiversity richness and abundance*membership to environmental group	−0.806***	−0.740***
Shoreline erosion protection*Education	−0.0620**	−0.063***
AIC	1559.906	1553.068
BIC	1603.020	1608.500
Log likelihood	−772.953	−767.534
Number of observations	3495	3495
Respondents	262	262

opportunity cost for the volunteer time (see Tables 5 and 6).

3.2.2. Estimation of community welfare

Using the mean marginal WTP estimated from the mixed logit model, a societal (community) welfare analysis was conducted on the total population in the study area using the per hectare estimates on annual accrual. Table 5 summarises (a) the marginal WTP for respondents per attribute per month, (b) the marginal WTP per household per year, and (c) the WTP of the surveyed households. Table 5 contains household WTP estimated by translating the monthly WTP to annual equivalents, assuming constant returns to scale of the mangrove ecosystem values. The annual household values were then expressed to cover the selected sample and the total number of people benefiting from the mangrove ecosystem. Therefore, based on a final sample size of 262 households, the annual WTP was calculated (Table 5).

Furthermore, the total indirect use value for mangroves in Mida Creek (Table 5) is derived by multiplying the number of households in the area[4] with the average WTP. The estimate of community WTP (Table 5) is then converted to monetary values per hectare, by dividing with the total of the Creek (3,200 ha). The total average welfare value of the Mida Creek mangrove ecosystem services is estimated at 1147.21 USD/ha/year (Table 5).

3.2.3. Effects of socio-demographic characteristics on preferences

Table 6 outlines the influence of socio-demographic characteristics on the respondents' preferences, through the interaction with alternative specific constant (ASC) of the *status quo*, the attributes (mangroves ecosystem services), and the payment system.

The negative coefficients of the *status quo* ASC are an indication that respondents prefer the mangrove conservation policy options compared to the *status quo* situation. The ASC was not statistically significant suggesting that there was no systematic bias of respondents towards the *status quo* alternative. Members of an environmental group were more inclined to the policy options favouring mangrove conservation. The lack of statistical significance in their preference suggests that there was no major difference in preferences between members and non-members of environmental groups. Fishermen or fish traders had a statistically significant preference towards improved mangrove conservation policies compared to the *status quo*.

4. Discussion

4.1. Synthesis of findings and policy relevance

The Western Indian Ocean region, of which Kenya is a member state (WIO-region), has relatively pristine coastal and marine ecosystems, mainly due to the current low levels of industrialization and economic development (ASCLME/SWIOFP, 2012; UNEP-Nairobi Convention and WIOMSA, 2015). However, as the economic conditions of many countries in the region improve, the number of development projects is expected to increase rapidly to promote the much-needed economic development for the region (UNEP-WCMC, 2011). The benefits of development and the effort to transition to Blue Economies will likely pose additional threats to ecosystems and species and increase the risk of negative feedbacks on environmental quality and traditional living resources. In such a context the economic values of ES can serve as a means of identifying potential winners and losers in such endeavours (United Nations Development Programme, 2018; United Nations Economic Commission for Africa, 2016).

Most of the Kenyan policy and management documents, especially for coastal and marine contexts, lack robust scientific evidence about the economic importance of natural resources. Therefore, coastal and marine resources in Kenya, and other parts of Eastern Africa, are rapidly converted to apparently more economically viable projects (NEMA, 2011). For example, in Kenya mangroves will be depleted by extensive coastal infrastructure development of ports and railways for cargo transport (NEMA, 2017). However, robust valuations of coastal and marine natural resources would provide evidence that relevant authorities can use to design appropriate strategies for prioritizing

[4] According to the 2009 national census the area contained 5448 households (Republic of Kenya, 2012). By using an annual household growth of 3.6%, the current number of households is estimated at 6821.

management and conservation options, as a means to contributing to relevant Sustainable Development Goals (SDGs), such as SDG 14 (Life Below Water) and SDG 15 (Life On Land).

Recognizing the links between ES and development goals can enhance the effectiveness of strategies, and minimising the possibility of failing to identify important consequences for ES (WRI, 2008). In this sense, an improved ability to assess and value ES, can help decision-makers understand how possible interventions depend on and might impact these services, and thereby encourage the selection of policies that sustain such services. Below we discuss further the most relevant findings for policy from the study. However, as most of the previous studies along the Kenyan Coast have focused on benefit transfer, market-based, replacement and production function valuation approaches, it is not easy to compare the current findings with these existing economic valuations (UNEP, 2011).

To establish the importance of the Mida Creek mangrove forest as a nursery and breeding ground for fish used by local communities, respondents identified 22 fish species that rely on the mangroves for at least one, or more, stages of their life. This is a good representation of the 27 species identified professionally from the same ecosystem in another study (Gajdzik et al., 2014). Practically all community respondents appreciated the importance of mangroves as nursery and breeding grounds for fish as was evident in the descriptive analysis. Respondents that engage in fishing as their most significant source of livelihood have a statistically significant preference for nursery and breeding ground of fish compared to other services (Table 6). This reflects many other studies that have identified mangroves as important nursery and breeding grounds for fish (Abdullah-Al-Mamun et al., 2017; Reddy et al., 2008). In addition, Barbier (2017) argues that coastal wetlands provide multiple benefits for local coastal communities including storm protection, support for fisheries, provision of wood and non-wood products, and tourism opportunities. The “nursery and breeding ground for fish” ES has a local value of USD 164.22 per ha/year (Table 5), which is slightly lower compared to the USD 243 per ha/year estimated for a mangrove site in the Philippines (Samonte-Tan et al., 2007).

The mangrove ecosystem is also an important habitat for many other wild species such as monkeys, baboons, snakes, raptors, electric eels, birds among others, as identified by the respondents. More than two thirds of the respondents (74%) also noted that the wild fauna is declining in the area. Furthermore, many community respondents pointed to the detrimental role of some wild species, with, for example, baboons and monkeys associated with crop destruction, raptors with poultry preying, and snakes with bites. To reduce these incidents, snakes from the surrounding area are captured and kept in a snake park established within the community.

However, during the deliberation participants were informed about the complex web of interactions between wild species, and the negative effect that the loss of all (or some) of these animals may have for ecosystem functioning and eventually community livelihoods. Respondents were, for instance, informed that both the baboons and raptors are responsible for the regulation of snake population, which also acts as their alternative prey to poultry. Thus, the local economic value of this ecosystem function was estimated at USD 674.51 per ha/year, which is the highest among the attributes that were assessed (Table 5). Paradoxically, during the FGD the participants were asked to rank the attributes in order of importance, with “biodiversity richness and abundance” being ranked third behind “nursery and breeding ground for fish” and “shoreline erosion protection”, respectively. This shift in perception could have been influenced by the extensive discussions during the deliberative workshops in which the ecological interactions between mangrove animal species were a major theme. To validate this finding, it would be important to follow up this exercise with knowledge, attitude and/or practice surveys to investigate whether the local community retains any positive attitudes towards these animals after the deliberation workshops.

Model results suggest that older people tend to assign higher values to “biodiversity richness and abundance”, compared to the younger respondents (Table 6). An unexpected finding of the study is that the members of environmental groups have a lower preference for biodiversity richness and abundance compared to community members not belonging to environmental groups. Considering the negative impacts of some animal species, as discussed above, the importance of biodiversity for ecosystem functioning and community livelihoods can only be popularized through community education. For this it might be important to mobilise the different environmental groups to convey better the importance of biodiversity to the local community through appropriate education and biodiversity conservation actions.

Marine ecosystems have an important role in protecting coastal populations and property from flood and wind damage from periodic storms (Barbier, 2016). A large majority of community respondents (95%) view mangrove ecosystems as a defence against the erosion of the ocean shoreline from storms and waves. The community members reported the mean loss of 7 m of shoreline in areas not protected by the mangrove forests in a 28-year period. Uyombo residents that live closer to areas with lower mangrove cover (i.e. where the creek joins the open ocean) reported higher erosion on average (12 m) compared to other sub-locations (Section 3.1). This erosion rate is comparable to rates from a study in Mozambique, which reports coastal retreat rates of between 0.4 m and 1 m per year (or 11.2 m and 28 meters in 28 years) (Palalane et al., 2016). Our hypothesis was that sublocations further from the shoreline would report significantly different erosion rates. However, results did not reveal any statistically significant difference in erosion rates between the sub-locations (see S1, Supplementary Electronic Material). Community members residing far from the mangroves may have less interaction with the mangroves, and may not be aware of the importance of mangoves role for erosion control or to the local community. This was confirmed by a study in the Tana delta which found that the local importance of this mangrove ecosystem service declined with an increasing distance from the mangrove forest (Otieno, 2015). However, this is possibly a knowledge gap that can be overcome through the deliberative approach so that all respondents, whatever their respective distance from mangroves, would have the same level of information. The results from this study appear to confirm this idea, as distance from the mangroves did not yield any statistically significant result (Section 3.2.3). Furthermore, community members with higher education levels selected lower levels for shoreline erosion, compared to community members with lower education (Table 6). The economic value for this service was estimated at USD 303.88 per ha/year. A study at the nearby mangrove site of Gazi bay produced an estimate of USD 91.7 per ha/year, showing great disparity in the values that these two Kenyan coastal communities attach to this service (UNEP, 2011). Nonetheless, a study on the mangrove ecosystems of Vanga, Gazi, Funzi and Mwache produced an average estimate of USD 395 per ha/year, which is comparable to the value obtained for the Mida study (Huxham et al., 2015). In the case of mangroves in Philiphines, the estimated value of USD 672 per ha/year was much higher than for Kenya, perhaps because the Philipinnes are much more vulnerable to typhoons and tsunamis (Samonte-Tan et al., 2007).

A large fraction of respondents (95%) considered that education and research to be an important cultural ecosystem service provided by the mangrove forest. Community members reported that most visits take place in Dabaso and Mida Majaoni, where visitors can use boardwalks to access the mangroves and the open water within the creek. Many studies have shown that mangroves attract globally many researchers, students and schools to study and learn about this system (UNEP, 2011). For example, 16% of the ecological research on marine protected areas in Kenya between 1968 and 2010 has focused on mangrove forests (Muthiga and Kawaka, 2010), with Mida Creek attracting the attention of many local and international scientists. Education and research was valued locally at USD 4.60 per ha/year, with this being the lowest ES value. This indicates that it is the least preferred ES among the four assessed services, which is consistent with rankings obtained during the FGD. In most studies, education and research is usually categorized under cultural services together with tourism and other cultural services, thus masking its value. This could be due to the perception of the communities benefiting from mangrove and other ecosystem that it is not a priority service. For instance, this service has been combined with tourism by Huxham et al. (2015), with the total value estimated at USD 41 per ha/year.

Finally, it is worth pointing that the deliberative exercise was meant to eliminate information asymmetry and ensure that individual/specific variables such as distance, education, membership of environmental groups, and location of residence do not influence the individual preferences. The Model 2 results suggest that this was fully achieved for distance, but partially achieved for membership of environmental groups, education, and location (Table 6).

4.2. Limitations of the study

Despite its strength for acquiring economic values for non-market ecosystem services and ecological functions, the deliberative choice experiment has some shortcomings related to the (a) payment mechanism, (b) assumption of constant ES delivery throughout the forest, and (c) co-generation of ES.

During the design stage of the choice experiment for the selection of attributes, the researchers presented FGD participants with three types of numeraires as potential payment mechanisms. This included money, volunteer labour, and the donation of commodities, with volunteer labour emerging as the most acceptable metric for measuring the WTP for mangrove ES. Several studies have considered volunteer labour as an acceptable mechanism for payment (Birol, 1998; O'Garra, 2009; Vondolia et al., 2014). However, non-monetary payment mechanisms are often more uncertain compared to monetary mechanisms (Vondolia and Navrud, 2018), and thus more robust sensitivity analysis should be conducted. For the current study, the welfare estimates are more uncertain as a sensitivity analysis has not been implemented. Thus, caution should be exercised when using the results for benefit transfer studies.

One of the key outputs of ES valuation studies are estimates of societal welfare benefits obtained from ecosystems (Liekens and De Nocker, 2013). Such welfare estimates can be expressed in various metrics such as WTP per household/year, capitalized values, or marginal value per unit area, among others (Brander et al., 2006). In this study, the welfare benefits of the Mida Creek mangroves are expressed in a per unit area basis, by assuming that each hectare of the Mida Creek mangroves contributes uniformly to the economic values. However, such constant delivery of ecosystem services per unit area may not always reflect the actual situation (Liekens and De Nocker, 2013). To increase the explanatory power of the analysis, it would be important to link the estimates from this study with more accurate ES mapping exercises.

Some of the mangrove ES appear to be co-generated, in the sense that a specific area might provide multiple ES simultaneously. Thus, mangrove conservation efforts will most likely lead to the simultaneous enhancement of multiple services related to nursery and breeding ground for fish, shoreline erosion protection, and biodiversity richness and abundance. Yet all these services provide separate benefits and functions to local communities, hence their values should be equally visible. An important question therefore is to ask whether it is reasonable to separate the WTP, when the conservation investment will simultaneously generate multiple benefits. One alternative option would be to estimate the same services using Contingent Valuation Method (CVM), by asking respondents to report their WTP for the preservation of mangrove ecosystems, without dividing between individual attributes. This would enable a comparison between different valuation methods, offering more nuanced information to guide conservation action.

5. Conclusion

The study established the monetary values that local communities attach to the multiple ES provided by the Mida Creek mangrove forest in Kenya. The study used a deliberative choice experiment to elicit these individual values or preferences by ensuring through FGD between community members that respondents have adequate knowledge of the mangrove ecosystem services. This deliberative exercise sought to ensure that information asymmetry would not have any statistical influence on the respondents' preferences, with relevant variables including distance to mangrove forest, education, membership to environmental groups and sub-locations.

Overall the community's level of understanding for mangrove ES is generally high, although they do not fully understand the complex functioning and interactions of the mangrove. Community members draw many benefits but also face many challenges in relation to the ecosystem and its services and would be willing to invest resources to safeguard the benefits they derive. In this sense, the study proposes that community members should be educated to understand and appreciate the species-habitat interactions and why such interactions are important for ES delivery and their wellbeing.

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Appendix A. Supplementary data

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