Preferences for coastal and marine conservation in Vietnam: Accounting for differences in preferences and choice set formation

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Abstract: This paper has two objectives. The first is to estimate the value of implementing new marine conservation measures in Vietnam, focussing on the relative benefits of water quality improvements, coral conservation and control of marine plastics pollution. The second is to explicitly model heterogeneity in choice set formation alongside preference heterogeneity. The study examines any tendency of respondents to give consideration only, or not at all, to the "opt-out" option in our choice experiment, due to social and cultural norms to be willing to make some contribution to the public good. It further assesses the impact on welfare estimates of failing to account for differences in choice set formation (i.e. processing strategies). Results show that model fit substantially improves traditional multinomial, random parameters and latent class logit models when a probabilistic choice set formation is accounted for. The analysis finds that not accounting for different choice set formation across respondents leads to biased welfare estimates.

1. Introduction

Vietnam has 3,260km of coastline, facing the Gulf of Tonkin and the South China Sea in the east and the Gulf of Thailand in the west. Since 2002 the Vietnamese government has been building a network of marine protected areas (MPAs) as a major tool of environmental policy in the coastal zone. The main objectives of the installation of MPAs are the conservation of biodiversity and improvement of coastal water quality. To achieve this, various different management tools have been applied, such as zoning, activity restrictions and total no-take zones. In addition to these more traditional targets, marine plastic pollution has recently gained interest as an additional major threat to the environmental sustainability of global seas. The seas in Southeast Asia have been shown to exhibit very high amounts of plastic litter: Jambeck et al. (2015) identify Vietnam as number four in the list of the highest emitters of plastics pollution into the ocean, which makes this issue all the more pressing in this case.

Against this background, this study employs a discrete choice experiment (DCE) to assess the preferences of members of the Vietnamese public in the city of Nha Trang regarding different targets of environmental policy in the coastal zone. The study focuses in particular on coastal water quality and conservation of corals as more 'traditional' coastal and marine policy objectives in Vietnam, and measures to curb marine plastic pollution in coastal areas as an example of a more recent policy focus. We are interested in the relative values which citizens attribute to these two different aspects of marine and coastal ecosystems.

On a methodological level, this study serves to further scrutinise the applicability of stated preference valuation in developing countries. These methods have increasingly been used in Europe and North America to value natural capital and support the design of coastal and marine policies (e.g.

Börger et al. 2014, Brouwer et al. 2017, Norton and Hynes 2014, Stefanski and Shimshack 2016, Wattage et al. 2011). However, they have been used to a much lesser extent in developing countries due to a number of reasons, one of which might be the influence of social and cultural norms in survey interviews leading to bias from social desirability and acquiescence (Börger 2013). Given that environmental protection and contributions to such measures are actions which are governed by social and cultural norms, respondents might feel compelled to answer stated choice questions in a way that puts them in a socially and politically positive light. This might affect not only what choice responses are given but also how the information conveyed in the choice cards is processed. Particular emphasis will be on the potential use of choice heuristics of respondents. Conventional choice modelling approaches based on the random utility model (McFadden 1974, Train 2009) assume that respondents takes all presented options into consideration when stating their choice over a set of environmental management options. Yet, responses to both choice and attitudinal questions in the present study give rise to the suspicion that a substantial portion of respondents did not consider all options on offer. In particular, attitudinal statements suggest that these respondents did not consider the no-change option (at no cost) since they perceived a duty to contribute at least a small amount to the proposed environmental management project. Therefore, the study employs the independent availability logit (IAL) model (Campbell and Erdem 2018) to allow for different choice heuristics and so to estimate unbiased preference parameters, while still being able to explore preference heterogeneity across respondents.

In the environmental valuation literature there has recently been some interest in the exploration of choice set formation on the performance of random utility-based discrete choice models and estimation of welfare measures (Li et al. 2015). A substantial part of this literature has considered the role of attribute cut-offs in choice set formation (Campbell et al. 2014, Swait 2001). Another focus of such models has been on choices of visiting recreational (Thiene et al. 2017) or hunting sites (Truong et al. 2018) using revealed preference data. The basic idea of these examinations of choice set formation is to view the choice as a two-step process in which a respondent first scans which options on offer to look at and then find her most preferred alternative in step two. However, while most of this work has looked at applications in transport (Ben-Akiva and Boccara 1995, Swait and Ben-Akiva 1987), marketing (Swait and Erdem 2007) and revealed preference environmental valuation, there is still little insight into the impact of choice set formation and the factors influencing this process in stated preference environmental valuation. Therefore, the present analysis builds on this literature and examines the impact on welfare estimates of simultaneously accounting for preference heterogeneity and choice set formation in an application in a developing country.

The remainder of the paper is structured as follows. Section 2 reviews marine and coastal management as well as previous applications of stated preference valuation in Vietnam. Section 3 introduces the methodology; Section 4 presents the results, which are discussed in Section 5. Section 6 concludes.

2. Objectives of marine and coastal management in Vietnam

2.1. Marine and coastal management in Vietnam

Marine and coastal management in Vietnam has mainly focused on the implementation of integrated coastal zone management (ICZM). With a high concentration of people in coastal areas and ensuing intensive use of coastal resources, ICZM has become an effective framework for environment management and has been introduced in Vietnam in 1990s. The main aim of ICZM strategy in Vietnam is to ensure sustainable economic and social development by protecting coastal natural resources and the environment. ICZM facilitates better coordination between agencies in planning and implementation but still faces challenges, such as conflicts between stakeholders and an ineffective legislation framework supporting it (Nagothu 2005).

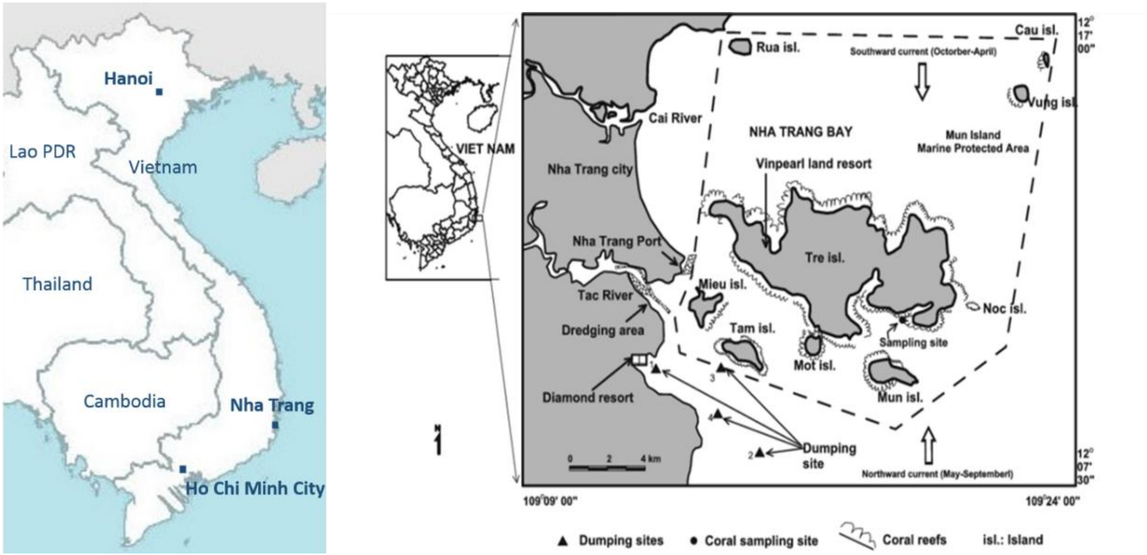
In the evolution of ICZM in Vietnam, the installation of marine protected areas (MPAs) has been recommended as the national strategy for biodiversity conservation in the coastal and marine environment. A network of 16 MPAs with a total area of 270,000 ha from north to south of the country has been approved for establishment (Ngoc 2018). At this point in time, 11 of those approved MPAs have also been established. The main objectives of these MPAs are to conserve biodiversity and to improve the livelihoods of local people. For the objective of biodiversity conservation, six target resources are protected including water quality, seagrass beds, coral reefs, mangroves, sea turtles and reef fish (Walton et al. 2015). A zoning system is often applied as the specific management measure within the MPA. However, conservation outcomes cannot be achieved in some cases due to a lack of sustainable financing and regulatory enforcement (Walton et al. 2015).

Vietnam's National Biodiversity Strategy and Action Plan 2010-2030 (NBSAP) has identified a number of priority programmes and projects aimed at preserving the biodiversity, suggesting specific action plans, which include (1) conducting research; (2) developing guidelines and piloting the economic valuation of biodiversity and ecosystem services; and (3) determining the size, scope and implementation of measures to protect and restore the ecosystems of coral reefs on a national scale, with the aim of restoring at least 15% of degraded critical ecosystems.

Compared to the conservation objectives discussed so far, the focus on marine plastics pollution in Vietnam is more recent. Jambeck et al. (2015) estimate that for Vietnam between 280,000 and 730,000 tons of plastic waste enter the marine environment per year. This makes Vietnam the fourth largest emitter of marine plastic waste and shows that marine plastic pollution has become a real and more serious environmental problem in Vietnam. Such pollution has diverse origins, as it is emitted not only from land but also from marine activities, such as recreational and tourism-related litter, abandoned fishing gear, sewage related debris and shipping waste. The reason that plastic is emitted into the ocean is due to a poor waste management and a lack of public knowledge about the potential consequences of direct littering (UN 2016). The Vietnamese government has acknowledged the seriousness of marine plastic pollution and recently made a big effort to deal with the problem. The National strategy on integrated management of solid waste to 2025, vision to 2050 sets a goal of using environmentally friendly plastic bags at stores and supermarkets by 2025. The government has developed an action plan to mitigate marine litter pollution that focuses on: 1) enhancing the management capacity and improve the policy-making mechanism regarding marine debris control. 2) enhancing the research capacity on the issue of marine debris including factual analysis, trends of marine debris pollution and its impacts on marine life and ecosystem in different perspectives. 3) increasing public awareness, among manufacturers, goods distributors, consumers and others about marine debris. 4) strengthening international cooperation in knowledge and information sharing regarding transboundary issues of marine debris pollution. The National Action Plan is also consistent with the country's Resolution on the Strategy on sustainable development of Vietnam's sea-based economy towards 2030, with a vision to 2045.

The present valuation study focuses on Nha Trang Bay (NTB), a coastal area adjacent to the Vietnamese city of Nha Trang (population 500,000) located on the central southern coast (Figure 1). While up until the 1990s, the main economic sectors of Nha Trang city and its surrounding Khanh Hoa province were forestry, agriculture and fishing, the tourism and industrial sectors have seen rapid development since about the turn of the century. The area has seen growth in the number of infrastructure and other construction projects and Nha Trang has grown into a very popular destination for domestic and international tourists. Ports, roads, hotels and resorts have not only been built in mainland Nha Trang but also on some of the islands located in the Bay.

Figure 1: Location of Nha Trang Bay



NTB hosts one of Vietnam's 11 MPAs, established in 2001 (Nam et al. 2005). The rationale for this MPA is the conservation of seafloor ecosystems, such as coral reefs and seagrass in the Bay and the maintenance and improvement of water quality. The protected areas, however, only covers a small portion of the whole Bay. Coral reefs cover an area of 730ha which amounts to 1.44% of the total Bay area (507km^2). As of 2015, 22.3% of the area suitable for coral growth was actually inhabited by living corals. This is referred to as the level of coral cover.

It has been shown that coral reefs in NTB generate substantial values for the tourism industry (Nam et al. 2005, Xuan et al. 2017), yet it is unclear what value the protection of this ecosystem type generates for the local population. Therefore, the present study assesses the values held by the local population for (i) improvement in coastal water quality; (ii) conservation of coral reefs; and (iii) measures to curb marine plastic pollution in coastal areas.

2.2. Stated preference valuation in Vietnam

Stated preference valuation methods have seen only limited application in support of environmental policy making in Vietnam. Very rarely have survey-based applications sampled from the general public, with most applications focussing on particular user or stakeholder groups. DCE have been employed in Vietnam in health (Cook et al. 2007), terrestrial conservation (Hanley et al. 2018, Shairp et al. 2016) and cultural heritage contexts (Tuan and Navrud 2007). An early example of a DCE in Vietnam is Cook et al. (2007) who elicit WTP for a new generation of cholera and typhoid vaccines in the city of Hue. Tuan and Navrud (2007) compare valuations of a cultural heritage site in central Vietnam based on contingent valuation and choice modelling. The study in Shairp et al. (2016) combine DCE with qualitative interviews to assess demand for illegally-hunted bush meat in Ho Chi Minh City. A similar study is Hanley et al. (2018) who use DCE to elicit of preferences for illegal natural medicinal products based on rhino horn.

The application of stated preference valuation in marine and coastal contexts is even scarcer. Xuan et al. (2017) conduct a DCE among Vietnamese tourists visiting Mon Island in the MPA in NTB. Choice attributes are the level of coral cover, level of waste on shorelines in the MPA and potential job losses for local fishermen resulting from changes in MPA management. Their payment vehicle is an addition to the entrance fee for a boat tour around the MPA. Results show that visitors are willing to pay for improved coral cover and reductions in waste levels, but they have no preference for or against job losses in the fishing sector. In another study, Quynh et al. (2018) conduct a DCE among artisanal fishermen in Thu Tien Hue province in central Vietnam around preferences for a the design of a monitoring scheme to achieve sustainable use of an open-access fishery.

Given this limited number of stated preference applications in Vietnam, particularly in environmental policy contexts, it is worth asking how respondents in the Vietnamese politico-cultural context deal with survey questions in general and discrete choice tasks in particular. Notwithstanding reform efforts over the past 30 years, the political system of the Socialist Republic of Vietnam is markedly hierarchical which includes the field of environmental policy. While ongoing institutional reforms, which include the environmental sector, have produced a larger and more complex network of actors in environmental policy making, decision-making, including on proposals for environmental programmes, is reserved for government and implemented by governmental agencies (Ortmann 2017). In this process, for instance in the conduction of environmental impact assessments, the general public is not routinely consulted (Hostovsky et al. 2010). Consequently many people see the responsibility for environmental protection resting exclusively with the government (Phung 2007). More specifically, it has been found that in surveys asking for willingness to pay for environmental protection respondents from low-income Asian societies, including Vietnam, show higher levels of acquiescence, i.e. the tendency to answer a question in the affirmative irrespective of its content Franzen and Vogl (2013).

In a typical DCE offering a (no-cost) status quo and one or more change options (involving a cost to the respondent), support for the proposed environmental project can be expressed by stating a preference for any one of the change options. If a respondent, because of acquiescence of any other reason, feels compelled to express support for the proposed project whatever its cost, the no-cost status quo option effectively falls out of the consideration set. Similarly, if a respondent objects to the environmental project or the survey method (out of ethical, political or other reasons) and hence systematically ignores the (costly) change options and always only considers the status quo, the set of options offered in the survey and the individual consideration set will differ. Initial analysis of our data suggested a surprisingly-low fraction of respondents chose the no-cost, no-improvement status quo. To allow for such respondent-specific choice set formation, the analysis employs the independent availability logit (IAL) model. This model is introduced in the next section.

3. Methodology

3.1. Development of the survey instrument

The survey instrument and valuation scenario was developed following recent guidelines on stated preference methods (Johnston et al. 2017). A draft questionnaire and valuation scenario was discussed in two focus group meetings with a total $N = 15$ participants. Subsequently, four pilot surveys each with $N = 40$ respondents were conducted to test and refine the survey instrument and inform the experimental design for the main survey. The pilots employed a Bayesian experimental design with zero priors. Based on the responses from the pilot survey the utility coefficients from a multinomial logit model (see next section) were used to generate an efficient design for the main survey. This consists of a set of 12 choice sets separated into two blocks of six. In each choice set, a respondent is offered three options: the status quo option and two potential change options (“Plan A”, “Plan B”).

The valuation scenario describes a Nha Trang Bay Management Plan. Respondents are informed that the consultation for the elements of such a plan is currently undertaken. Proposed activities include improved treatment of municipal waste water, more stringent regulations for aquaculture operators, heightened protection of coral reefs, more regular collection of plastic waste from beaches and measures to reduce the use of plastic bags in the city. The main consequences of the potential implementation of these measures are then described as the choice attributes (Table 1). The first attribute, water quality in NTB, is affected by the treatment of municipal waste water, aquaculture and tourism in the bay and construction along the coast. Other sources of water pollution are run-off of fertilisers from the agricultural sector and from aquaculture sites. Different chemicals, such as arsenic and heavy metals and coliform bacteria are washed into the sea. Respondents are informed that with the NTB Management Plan the concentration of these chemicals in the water would go down. Therefore, water quality and water clarity could improve.

Table 1: Choice attributes and levels

Attribute	Description	Levels
Water quality	Water quality in Nha Trang Bay is affected a many factors, such as treatment of municipal waste water, aquaculture and tourism in the Bay, construction along the coast. Different chemicals, such as arsenic and heavy metals, and coliform bacteria are washed into the sea. If the activities described above are implemented, the concentration of these chemicals in the water would go down. Water quality and water clarity could improve.	*No improvement*; large improvement
Coral cover	Coral reefs can be found in Nha Trang Bay. At the moment, 20% of the underwater reefs are covered by corals. At the moment, coral reefs are protected in an area around Mun Island. If the above measures are implemented, coral reefs could be protected even outside of that area. The total cover of reefs by corals would increase.	*20%*; 30%; 50%
Plastic waste	Plastic waste can be found all around Nha Trang Bay, on the beaches in Nha Trang and on the islands, and in the open water. This plastic has many sources which are hard to control, but it can be filtered out of small rivers and streams before it reaches the Bay. It is also possible to collect plastic waste from the beaches more regularly and to reduce the use of plastic bags in the city.	*No change*; regular waste collection and filtering; reduce the use of plastic bags in the city
Water fee	Implementing these plans to manage the water and the marine environment in Nha Trang Bay will be costly. The government therefore needs to raise funds through an additional water fee. This fee is payable as an addition to the monthly water bill by all households in Khanh Hoa Province for the next 5 years. If the overall funds people are willing to contribute do not cover the cost of implementing the plan, it cannot be put into action.	*0*; 5,000; 10,000; 15,000; 25,000

Notes: Status quo in italics

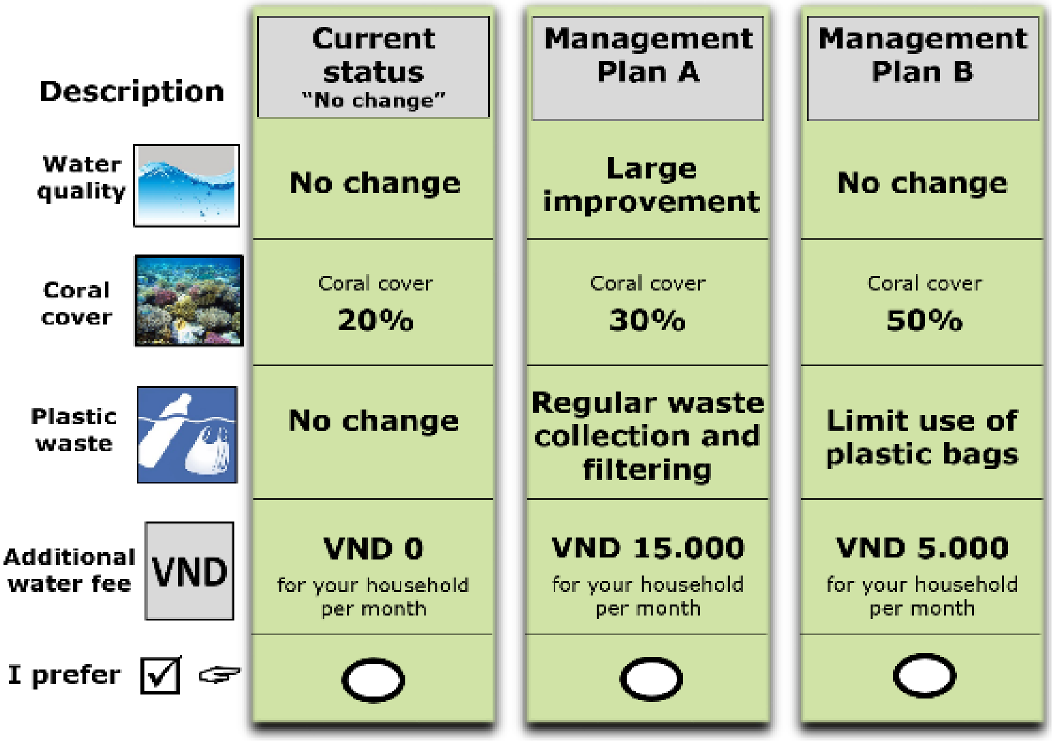
The second attribute concerns coral cover in the bay. At the moment, 20% of the underwater reefs are covered by corals, and coral reefs are protected in areas around some of the islands in the Bay. An increase in the area of Nha Trang Bay covered by corals is in line with Vietnam's national biodiversity strategy which calls for the restoration of 25% of degraded ecosystems by 2030 (MONRE 2013). Respondents are informed that if the Management Plan is implemented, coral reefs could be protected and expand to cover 30% or 50% of the underwater reef area.

The third attribute focuses on rising plastic pollution in NTB. While the base level is no additional action to tackle this problem, one of the change options presented is filtering plastic pieces out of small rivers and streams before they reach the Bay, by collecting plastic waste from the beaches more regularly. The other potential improvement level presented is to reduce the use of plastic bags in the city.

The cost attribute is described in terms of a water fee to be paid by all household in Nha Trang. Respondents are informed that in case the management plan is implemented, all households in Khanh Hoa province would have to pay the amount as lump-sum addition to any existing water bill for 5 years. Households in Nha Trang routinely pay fees, for instance, for waste collection and water. Therefore, linking the payment in the stated preference survey to an existing fee was regarded as most realistic payment vehicle. Taxes in particular were ruled out during the focus group meetings.

Different cost vectors were tested in the four pilot surveys as initially cost levels were much too high for the target population, which caused substantial protest responses. Consequently, cost levels were reduced successively in the piloting process. After initially specifying the fee to be paid annually, which respondents found unrealistic, a monthly fee was found to work better. It is worth stressing that the pilot surveys did not yield any indication that the cost vector is too low. If anything it was perceived quite high by most respondents. Figure 2 is the English translation of an example choice card.

Figure 2: Example choice card



3.2. Analysis of stated choice data

The stated choice data are analysed using the random utility model (McFadden 1974). In this model, the utility respondent n expects from option i in choice situation t can be expressed as

$$V_{nit} = \beta_n X_{nit} + \varepsilon_{nit}. \tag{1}$$

β_n is a vector of utility weights to be estimated, X_{nit} is a vector containing the attribute levels of choice option i in situation t. ε_{nit} is an option-specific error term assumed to be independent and identically distributed following a type I extreme value distribution. Assuming that respondent n choses her utility-maximising option in any choice situation t, the probability of that option i being preferred amongst a choice set of options $j = 1, \dots, J$ is

$$P(i|X_{nt}) = \frac{exp(\beta_n X_{nit})}{\sum_{j=1}^{J} exp(\beta_n X_{njt})}. \tag{2}$$

If it is assumed that $\beta_n = \beta$ we have the multinomial logit (MNL) model. This model assumes that there is no heterogeneity in preferences for the choice attributes across respondents and only a vector average utility weights (β) is estimated. One way of allowing inter-respondent preference heterogeneity is to assume for the elements of β_n to be random variables, the mean and standard deviation of which can be estimated. This is the random parameters logit (RPL) model (Revelt and Train 1998). It specifies $\beta_n = \beta + \eta_n$ where η_n is a random variable representing a respondent specific deviation of preference coefficient from the sample mean parameter β.

Another way of exploring preference heterogeneity and instead of assuming a continuous range of preference coefficients distributed around β according to η_n, one can assume there to be a limited number of preference vectors, $\beta = (\beta_1, \beta_2, \dots, \beta_A)$., In this latent class (LC) model, respondent n's choice probability of option i, contingent on belonging to class a, is

$$P(i|X_{nt}, a) = \frac{exp(\beta_a X_{nit})}{\sum_{j=1}^{J} exp(\beta_a X_{njt})}. \tag{3}$$

Since the analyst cannot observe the class that each respondent belongs to, so a class membership function must be used to specify the probability of a respondent n's series of choices as:

$$\pi(a|z_n) = \frac{exp(\delta_a z_n)}{1 + \sum_{l=1}^{A-1} exp(\delta_l z_n)}, \tag{4}$$

where z_n is a vector of respondent-specific variables. It is necessary to normalise the coefficient of the last class to zero for identification. The class membership function can be used to weight equation (3) over classes using the class membership probabilities from (4). This yields the unconditional probability to observe respondent n stating a series of choices $y_n = [i_{n1}, \dots, i_{nT}]$

$$P(y_n|X_{nt}) = \pi(a|z_n) \prod_{t=1}^{T} \frac{exp(\beta_a X_{nit})}{\sum_{j=1}^{J} exp(\beta_a X_{njt})}. \tag{5}$$

All of the models introduced so far (MNL, RPL and LC) assume that all respondents consider all options j in every choice situation t. Yet it is possible that some respondents do not consider all options in the choice set. In a choice situation with three options (i.e. $j = 1,2,3$) a respondent may systematically ignore the first option (e.g. the status quo option), so that for this respondents in fact $j = 2,3$. Yet since the analyst cannot observe this choice behaviour a latent class framework can be used whereby a respondent's choice probability of y_n is conditional on belonging to a certain choice heuristics class $b = 1, \dots, B$:

$$P(y_n|X_{nt}, h) = \prod_{t=1}^{T_n} \frac{exp(\beta X_{nit})}{\sum_{j \in J_b} exp(\beta X_{njt})}. \tag{6}$$

Note that the consideration set J_b is contingent on respondent n belonging to class $b = 1, \dots, B$. Here too, a class membership function can be specified to express the unconditional probability of y_n as

$$P(y_n|X_{nt}) = \pi(h|z_n) \prod_{t=1}^{T_n} \frac{exp(\beta X_{nit})}{\sum_{j \in J_b} exp(\beta X_{njt})}, \tag{7}$$

where $\pi(b|z_n) = exp(\delta_h z_n)/1 + \sum_{m=1}^{B-1} exp(\delta_m z_n)$ is the probability that J_b is the choice set actually considered by respondent n. The analysis considers models with different numbers of classes of two (considering all options and ignoring the status quo) and three different choice heuristics (considering all options, ignoring the status quo, ignoring all change options).

This type of independent availability logit can be combined with the preference heterogeneity LC model in (3) to account for two types of heterogeneity: preference and processing heterogeneity. More than one type of heterogeneity are not routinely examined in stated preference studies in the environmental field. Among the exceptions is Campbell et al. (2018), on which the model in the present analysis is based. This model has $C = A \times B$ classes and can be specified using equality constraints (Scarpa et al. 2009).

4. Results

4.1. Sample characteristics

The survey was conducted in September and October 2018 using in-person household interviews. Students at the Economic Department of Nha Trang University were trained as interviewers and conducted the survey throughout 17 of the 19 urban wards and 6 out of 8 suburban communes of Nha Trang city. A sample of $N = 422$ completed questionnaires was obtained. Sample characteristics are reported in Table 2.

Table 2: Sample characteristics

Variable	Unit	Mean	Std. dev.	Min.	Max.
FEMALE	Share	0.53	0.50	0	1
AGE	Years	37.90	13.05	18	79
UNI[a]	Share	0.43	0.50	0	1
LIFE[b]	Share	0.44	0.50	0	1
MIDINC[c]	million VND	6.22	3.32	1	12

Notes: [a] Respondents with at least a university degree. [b] Respondents who have lived their whole life in Nha Trang. [c] based on midpoints of income brackets.

Further descriptive statistics of choice and attitudinal responses show that 75% of respondents never chose the status quo alternative (Figure 2), whilst 74% of respondents (strongly) agree with the statement "I think it is my duty to contribute at least a small amount to the NTB management plan". Agreement to this statement might indicate that a substantial portion of respondents did not actually consider the status quo as a viable response option. It is therefore likely that choice heuristics which reduce the consideration set affected the choices of a majority of respondents. The next section will look at a series of models, which successively take into account (1) preference heterogeneity and (2) heterogeneity of choice heuristics expressed by respondents operating with differing consideration sets.

4.2. Preferences for coastal management objectives

Table 3 presents a MNL model as a baseline for analysis. On average, large improvements in water quality (WATER1), coral cover (CORAL30 and CORAL50) as well as measures to address plastic pollution in coastal waters (PLASTIC1 and PLASTIC2) affect choice probabilities positively. The coefficient of the cost attribute is negative and significant. The coefficient of the alternative-specific constant for the two change options (ASC_CHANGE) is positive and significant indicating that on average there is a strong preference for the NTB Management Plan which is not explained by its other characteristics.

A random parameters logit model with correlated, normally distributed coefficients of the non-monetary attributes and a non-random cost coefficient (Table 3) confirms the findings of the MNL model.[1] Only the improvement to 50% of coral cover (CORAL50) is not significant in this model. Similar to the MNL, the RPL model also yields a coefficient of the ASC_CHANGE which is several times larger than the other coefficient estimates. This indicates that considerations other than the level of the choice attributes might have led respondents to prefer any of the change options over the current status. In such a situation where there might be a strong and unexplained dislike for any one of the options, an IAL model might be more appropriate (Campbell and Erdem 2018).

Finally, estimates of the standard deviation of the random coefficients are mostly much larger than their respective mean estimates, which indicates a very high level of preference heterogeneity

[1] This model is run using the user-written Matlab routine in Czajkowski et al. (2017) which is available under the Creative Commons BY 4.0 license at github.com/czaj/DCE.

with respect to the choice attributes. To capture and further explore this heterogeneity, the subsequent analysis employs as series of latent class models. With respect to preference classes, simple LC models with different numbers of classes were run. A 3-class model produces better fit than a 2-class model. Models with more than 3 classes produce classes with unreasonable preference coefficients or classes with membership probability <1% or both. Therefore a 3-class model is used (Table 4). Subsequently, the model is extended to also account for different choice heuristics, namely respondents having different consideration sets.

Table 3: Multinomial and random parameters logit models

	MNL		**RPL**[a]			
	Coef.	**s.e.**	**Coef.**	**s.e.**	**SD**	**s.e.**
ASC_CHANGE	1.146 ***	(0.103)	5.587 ***	(0.754)	5.998 ***	(0.710)
WATER1	0.375 ***	(0.054)	1.296 ***	(0.184)	1.923 ***	(0.317)
CORAL30	0.336 ***	(0.065)	0.661 ***	(0.161)	1.463 ***	(0.239)
CORAL50	0.264 ***	(0.077)	0.148	(0.353)	5.637 ***	(0.511)
PLASTIC1	0.415 ***	(0.091)	0.808 ***	(0.280)	3.942 ***	(0.413)
PLASTIC2	0.371 ***	(0.079)	0.887 ***	(0.199)	2.218 ***	(0.473)
COST	-0.041 ***	(0.004)	-0.100 ***	(0.010)		
LL_0	-2,477		-2,477			
LL	-2,395		-1,712			
Choice sets	2,532		2,532			
Respondents	422		422			
Parameters	7		28			
MF R-sq	0.033		0.309			
BIC	4,846		3,644			
Sobol draws	-		10,000			

Notes: *** indicates significance at the 1%-level of confidence. [a] All but the cost coefficient are assumed to follow a normal distribution and be correlated.

According to the LC model, respondents in the largest class (class 1), have positive preferences for improvements in corals and for reductions in marine plastic pollution. These respondents, however, have preferences *against* improvements in water quality. The second class which comprises approximately 28% of respondents shows a positive cost coefficient. This counterintuitive finding might be the result of respondents systematically ignoring the status quo. This would mean that in all classes respondents appear less sensitive to cost and in some classes even preferring cost, even though this is a result of them systematically choosing a costly choice option over the status quo. Respondents in class 2 are indifferent regarding plastic pollution, but value water quality improvements very strongly. These respondents prefer larger expansions of coral cover to smaller expansion. Finally respondents in class 3 (17.9%) are extremely sensitive to cost. They too, are indifferent when it comes to measures against plastic pollution but have strong preferences for the higher level of expansion of coral cover.

Both the earlier finding of a high share of respondents who never choose the status quo and the positive and significant cost coefficient in class 2 of this model make these results problematic. Therefore the LC models in Tables 5 and 6 allow for preference heterogeneity and respondents with different consideration sets. The model in Table 5 also has three preference classes and within each preference class allows for two choice strategies, namely to consider all three options (SQ, A and B) and only the two change options (A and B). Consequently this model has six classes in total ($C = 3 \times 2 = 6$), whereby classes 1 and 2, 3 and 4, and 5 and 6, respectively, share the same preference coefficients. The model in Table 6 has three preference classes and three processing classes: considering all options, ignoring the status quo (only look at A and B) and ignoring the change options (only consider the SQ). This model has nine classes ($C = 3 \times 9 = 9$), with classes 1, 2 and 3 sharing one preference structure, 4, 5 and 6 another, and 7, 8 and 9 the third preference pattern.

Table 4: Latent class logit with three preference classes

var.	Class 1 Coef.		s.e.	Class 2 Coef.		s.e.	Class 3 Coef.		s.e.
ASC	3.237	***	(0.261)	1.100		(0.715)	0.875	**	(0.397)
WATER	-0.386	***	(0.087)	2.765	***	(0.365)	0.795	***	(0.252)
CORAL30	0.494	***	(0.099)	0.525	**	(0.235)	0.580	*	(0.298)
CORAL50	0.441	***	(0.164)	0.927	**	(0.402)	1.373	***	(0.374)
PLASTIC1	1.336	***	(0.187)	-0.772		(0.513)	-0.282		(0.327)
PLASTIC2	0.838	***	(0.129)	0.382		(0.279)	0.090		(0.282)
COST	-0.075	***	(0.009)	0.047	*	(0.025)	-0.308	***	(0.046)
Class probability	0.526			0.295			0.179		
LL_0	-2,478								
LL	-1,801								
e(k)	23								
MF R-sq	0.264								
BIC	3,741								

Notes: 422 respondents and 2,532 choice sets. ***, **, * indicate significance at the 1%-, 5%-, 10%-level of confidence.

In Table 5, class 1 is still the largest class, but has only 35.5% of respondents. The pattern of preferences is similar to that in Class 1 in Table 4. Respondents have preference against improvements in water quality, but clear preferences for expansion of coral cover and both types of measures to curb marine plastics. In Class 2, the cost coefficient is still positive but now insignificant. Respondents in this class (about 32%) value water quality improvements very strongly, and they prefer expansion of coral cover. Respondents in Class 3 (about 31.5%) are extremely cost-sensitive and only care about water quality improvements. These respondents are indifferent towards coral cover and marine plastics pollution. Looking at the probabilities of being in different choice strategy classes conditional on being in each preference class reveals that in all preference classes (i.e. columns) more than half of respondents ignore the status quo option. This share differs between classes, in the third preference class (class 5/6), 41% of respondents consider all three options, but in the second preference class (class 3/4) only 14% look at all options. The latter findings might explain the positive and insignificant cost coefficient in that preference class.

Table 5: LC model with three preference classes and one choice heuristics classes (6 classes in total)

var.	Class 1/2 Coef.		s.e.	Class 3/4 Coef.		s.e.	Class 5/6 Coef.		s.e.
ASC	-0.403		(0.304)	-1.961	***	(0.555)	1.878	***	(0.398)
WATER	-0.384	***	(0.118)	2.561	***	(0.302)	0.765	***	(0.246)
CORAL30	0.422	***	(0.130)	0.432	**	(0.197)	0.344		(0.237)
CORAL50	1.183	***	(0.215)	0.870	***	(0.317)	-0.292		(0.319)
PLASTIC1	1.908	***	(0.234)	-0.419		(0.328)	0.096		(0.378)
PLASTIC2	1.080	***	(0.162)	0.443	*	(0.265)	0.498		(0.309)
COST	-0.041	***	(0.010)	0.011		(0.017)	-0.496	***	(0.059)
Prob(SQ-A-B)	0.092	26%		0.044	14%		0.134	41%	
Prob(A-B)	0.263	74%		0.275	86%		0.191	59%	
LL_0	-2,478								
LL	-1,735								
e(k)	26								
MF R-sq	0.289								

BIC	3,628

Notes: 422 respondents and 2,532 choice sets. ***, **, * indicate significance at the 1%-, 5%-, 10%-level of confidence.

Moving from two to three processing strategies, i.e. moving from Table 5 to 6, the model fit improves substantially. The model with three processing strategies finds a very similar preference pattern in all three preference classes, yet identifies a small share of respondents in each preference class who are most likely to only look at the status quo option (between 4% and 7% of respondents in each preference class).

Table 6: LC model with three preference classes and three choice-heuristics classes (9 classes in total)

	Class 1/2/3			Class 4/5/6			Class 6/7/8		
var.	**Coef.**		**s.e.**	**Coef.**		**s.e.**	**Coef.**		**s.e.**
ASC	-0.486	*	(0.271)	-2.024	***	(0.553)	4.611	***	(1.028)
WATER	-0.416	***	(0.115)	2.578	***	(0.312)	1.918	***	(0.446)
CORAL30	0.418	***	(0.128)	0.435	**	(0.200)	0.661		(0.422)
CORAL50	1.147	***	(0.207)	0.862	**	(0.339)	-0.174		(0.385)
PLASTIC1	1.819	***	(0.225)	-0.450		(0.373)	-0.004		(0.851)
PLASTIC2	1.041	***	(0.156)	0.442		(0.270)	0.264		(0.706)
COST	-0.041	***	(0.010)	0.013		(0.019)	-0.721	***	(0.104)
Prob(SQ-A-B)	0.092	24%		0.043	13%		0.080	28%	
Prob(A-B)	0.272	71%		0.275	82%		0.187	65%	
Prob(SQ)	0.016	4%		0.016	5%		0.019	7%	
LL_0	-2,478								
LL	-1,683								
e(k)	26								
MF R-sq	0.310								
BIC	3,524								

Notes: 422 respondents and 2,532 choice sets. ***, **, * indicate significance at the 1%-, 5%-, 10%-level of confidence.

Table 7 shows marginal WTP estimates for the three different LC models based on the models in Tables 4 to 6. Estimates of marginal WTP in preference classes with an insignificant cost coefficient are set to zero. As the table again shows, allowing for different choice strategies, the only class with meaningful marginal WTP is diminished (from 56% to 40% and further to 38% of respondents) but the marginal WTP estimates are higher. So accounting for processing heterogeneity finds that a smaller number of respondents are willing to pay for coral cover expansion and measures to reduce plastic pollution, but that the WTP estimates of this group are substantially larger.

The implausible negative WTP for water quality improvements and coral cover expansion in Class 2 in the traditional LC model disappears in the second and third models when alternative choice strategies are taken into account. Consequently, marginal WTP estimates of about 30% of respondents are zero because these respondents do not react to the cost attribute.

Differences between WTP estimates based on the different models can also be found in the third preference class. While without accounting for processing heterogeneity there is significant WTP for expansion of coral cover, this disappears in the bottom two models. After accounting for both types of heterogeneity (preference and processing), respondents in this preference class have only a modest WTP for an improvement of water quality (due to the very high sensitivity to the cost attribute).

Table 7: Marginal WTP for changes in choice attributes (from all three LC models)

	Traditional LC model (Table 4)		
	Cl.1	**Cl.2**	**Cl.3**
WATER	-5.22	-62.22	2.73
CORAL30	6.62	-12.08	1.65
CORAL50	5.81	-22.55	4.43
PLASTIC1	17.45	15.77	-0.68
PLASTIC2	11.00	-8.41	0.31
Class probability	0.56	0.29	0.16

	LC model allowing for two choice strategies (Table 5)		
	Cl.1/2	**Cl.3/4**	**Cl.5/6**
WATER	-7.99	0.00	1.61
CORAL30	10.56	0.00	0.61
CORAL50	26.89	0.00	-0.79
PLASTIC1	43.54	0.00	0.23
PLASTIC2	25.55	0.00	0.98
Class probability	0.40	0.30	0.30

	LC model allowing for two choice strategies (Table 6)		
	Cl.1/2	**Cl.3/4**	**Cl.5/6**
WATER	-10.24	0.00	2.66
CORAL30	10.29	0.00	0.92
CORAL50	28.23	0.00	-0.24
PLASTIC1	44.79	0.00	-0.01
PLASTIC2	25.64	0.00	0.37
Class probability	0.38	0.33	0.29

Notes: In 1,000 VND (0.033 GBP)

5. Discussion and conclusions

This study demonstrates the effect of accounting for heterogeneity in preferences and processing strategies on the performance of the random utility model and the welfare estimates for changes in the coastal zone in Nha Trang Bay, Vietnam. The analysis shows that, when different processing strategies are explicitly modelled, only a share of approximately 40% of respondents are willing to pay for different levels of expansion of coral cover and measures to reduce marine plastic pollution in Nha Trang Bay. Marginal WTP estimates for reducing plastic pollution are, on average, substantially higher than WTP for increasing the coral cover in the Bay. Regular waste collection on beaches and filtering of water from streams and rivers (PLASTIC1), in particular has the highest WTP.

The biggest change in preference coefficients (and marginal WTP estimates) can be seen when introducing probabilistic choice set formation with two processing strategies, i.e. moving from Table 4 to Table 5. Allowing for a third processing strategy to capture potential protesting behaviour of respondents who (for some reason) only ever consider the status quo option, does not change the results very much.

This analysis further shows the potential for biased welfare estimates when choice set formation (i.e. processing heterogeneity) is not accounted for. While this has been shown in simulation (Li et al. 2015) and for revealed preference data (von Haefen et al. 2008), this is a new insight in applied stated preference valuation. Comparing these model fit (BIC) of the MNL and RPL models, and the different LC models it becomes apparent the two models accounting for preference and processing heterogeneity outperform all other specifications.

The results of this study further highlight the importance of accounting for choice set formation in the modelling to avoid the derivation of biased welfare estimates. While choice set formation has been studied a lot more in transport, marketing and revealed preference valuation, there is a case to investigate this issue in stated preference valuation studies as well. This is especially the case when stated preference studies are conducted in developing countries where social and cultural norms might influence how respondents approach the choice tasks.

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