Jurnal Ekonomi Malaysia 52(2) 2018 253 - 266
http://dx.doi.org/10.17576/JEM-2018-5202-20

Aquaculturists Preference Heterogeneity towards Wetland Ecosystem Services: A Latent Class Discrete Choice Model

(Perbezaan Keutamaan Penternak Ikan terhadap Perkhidmatan Ekosistem Tanah Lembap: Model Pilihan Diskret Pengkelasan Pendam)

Roseliza Mat Alipiah
Universiti Malaysia Terengganu

Zuraini Anang
Universiti Malaysia Terengganu

Noorhaslinda Kulub Abdul Rashid
Universiti Malaysia Terengganu

James C. R. Smart
University of Griffith

Wan Noorwatie Wan Ibrahim
Universiti College Bestari

ABSTRACT

The fundamental objective of discrete Choice Experiments (CEs) model or Choice Modelling (CM) is to understand the behavioural processes among individuals which drive the choice decisions based on selected attributes and choice options. Preferences may differ among individuals triggered by their specific characteristics such as socio-demographics, constraints and attitudes. Preferences could also vary among groups and within a particular group by forming different segments of groups or subgroups. The Latent Class (LC) model is a distinctive approach which can accommodate preference heterogeneity where preferences are assumed to be relatively homogenous within the segments, but substantially different between the segments. This LC model was applied to account for preference heterogeneity among aquaculturists in the Setiu Wetlands, Terengganu. Currently, fish cage culture is the main socio-economic activity which imposes considerable impacts on the wetland ecosystem and thus affect its ability to deliver ecosystem service outcomes to other stakeholder groups. This research quantifies the aquaculturists' preferences heterogeneity with regard to the ecosystem impacts under different management scenarios. The existence of sub-divisions of preferences within the stakeholder subgroups was tested. This study revealed three latent classes or segments which show relatively distinct sets of preferences. Segment 1 shows a strong preference for higher harvest rates, a moderately strong preference for higher fisheries income and a moderately strong preference for lower shellfish collections. Segment 2 shows a moderately strong linear preference for higher harvest rates and a very strong preference for retaining the status quo. Segment 3 shows a perplexing set of significant preferences for increasing harvest rates and a modest preference for higher fisheries income. In direct contrast to Segment 2, Segment 3 shows a very strong aversion to retaining the status quo. The results of aquaculturists' preferences for delivery of different ecosystem services in Setiu Wetlands suggest that Latent Class Model (LCM) could be applied successfully in a Malaysian setting. The success of the LC model is evidenced by the high level of fit obtained from the best fitting models. The main finding of this research suggests that a good understanding of the main research objective, familiarity with the research area and carefully designed choice set, as well as employing appropriately trained enumerators are the main factors that particularly contribute to a successful application of the LC model in a developing country setting.

Keywords: Wetland ecosystem; discrete choice model; Latent Class Model; preference heterogeneity

ABSTRAK

Objektif asas model eksperimen pilihan (CE) atau pemodelan pilihan (CM) diskret adalah untuk memahami proses tingkah laku di kalangan individu yang menggerakkan dalam membuat keputusan berdasarkan atribut terpilih dan pilihan alternatif. Keutamaan mungkin berbeza di kalangan individu yang dicetuskan oleh ciri khusus mereka seperti sosio-demografi, kekangan dan sikap. Keutamaan juga boleh berbeza di kalangan kumpulan dan dalam kumpulan tertentu melalui pembentukan segmen kumpulan atau subkumpulan yang berbeza. Model Pengkelasan Pendam (LC) adalah suatu pendekatan tersendiri yang dapat mencungkil kepelbagaian keutamaan di mana keutamaan diandaikan *lebih homogen dalam segmen, tetapi sangat berbeza di antara segmen. Model LC ini digunakan untuk menjelaskan kepelbagaian keutamaan di kalangan pengusaha akuakultur di Tanah Lembap Setiu, Terengganu. Pada masa ini, penternakan ikan sangkar merupakan aktiviti sosio-ekonomi utama yang memberi impak yang agak besar kepada ekosistem tanah lembap seterusnya mempengaruhi keupayaannya untuk membekalkan perkhidmatan ekosistem kepada kumpulan pemegang taruh yang lain. Kajian ini mengukur kepelbagaian keutamaan pengusaha akuakultur terhadap kesan ekosistem di bawah beberapa senario pengurusan yang berbeza. Kewujudan pembahagian keutamaan dalam kumpulan pemegang taruh telah diuji. Kajian ini mendapati terdapat tiga pengkelasan atau segmen dalam kumpulan yang menunjukkan set keutamaan yang agak berbeza. Segmen 1 menunjukkan keutamaan yang tinggi terhadap peningkatan dalam kadar tangkapan, keutamaan yang agak tinggi terhadap peningkatan dalam pendapatan nelayan dan keutamaan yang agak tinggi terhadap kutipan kerangan yang rendah. Segmen 2 menunjukkan keutamaan yang agak tinggi terhadap peningkatan dalam kadar tangkapan dan keutamaan yang sangat tinggi bagi mengekalkan situasi semasa (status quo). Segmen 3 pula menunjukkan kekeliruan dalam keutamaan terhadap peningkatan kadar tangkapan dan keutamaan yang sederhana terhadap peningkatan pendapatan nelayan. Berbeza dengan Segmen 2, Segmen 3 menunjukkan bantahan yang kuat terhadap situasi semasa. Keputusan kajian terhadap kepelbagaian keutamaan oleh pengusaha akuakultur ini menyarankan bahawa Model Pengkelasan Pendam (LCM) juga dapat diaplikasi dengan baik di Malaysia. Kejayaan model LC ini dibuktikan oleh keputusan darjah kepadanan yang tinggi daripada model terbaik yang dihasilkan. Dapatan utama kajian menyarankan bahawa kefahaman terhadap objektif utama kajian, kebiasaan dengan kawasan kajian dan pembentukan set pilihan yang teliti, serta penggunaan penemubual yang terlatih adalah faktor utama yang menyumbang kepada kejayaan aplikasi model LC di negara sedang membangun.*

Kata kunci: Ekosistem tanah lembap; model pilihan diskret; Model Pengkelasan Pendam; kepelbagaian kecenderungan

INTRODUCTION

Wetlands are highly productive and valuable ecosystems (Barbier et al. 1997; Brander et al. 2006; Zhang et al. 2010). Wetlands are defined as "areas of marsh, fen, peatland, or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish, or salty, including areas of marine water the depth of which at low tide does not exceed six metres" (Ramsar 1971). Globally, total wetlands is estimated approximately at up to 21.26 million km^2 (Hu et al. 2017). Meanwhile, the wetlands area in Malaysia is estimated at 5.19 million hectares. Malaysia is blessed with diverse wetland ecosystems particularly for coastal wetlands such as mangroves, mudflats, freshwater swamps, peat swamps, marshes, Nypa swamps, melaleuca swamps, lagoons, river and estuary systems, rocky shores, sandy beaches and coral reefs. Mangroves are among the most important wetland ecosystems in Malaysia with a total area of 641,000 hectares. The diversity of wetland ecosystems in Malaysia is due to the heterogeneity of vegetation structure and composition, unpredictable rainfall patterns and adjacent different surrounding landscapes particularly in the coastal wetland habitats (Rajpar & Zakaria 2014).

The benefits gained by human beings from ecosystems are defined as "ecosystems services". The Millennium Ecosystem Assessment (MEA) mainstreamed the concept of ecosystem services (MEA 2005a, 2005b) and the literature on ecosystem services has grown exponentially from that point onwards (Fisher et al. 2008). This concept provides a convenient and relevant approach to illustrating the diverse ways in which wetland ecosystems contribute to human welfare and distinguishes these welfare contributions into four main ecosystem service categories: regulating, provisioning, supporting and cultural services (MEA 2005a,b; Turner et al. 2000).

The importance of wetland ecosystem services is represented by their values as measured in monetary terms. The value of an ecosystem is expressed as the amount of something that is foregone (the opportunity cost) in order to attain an increase (or retain the status quo) of a good or service (Barbier et al. 1997; Turner et al. 2000; Winkler 2006). The total economic value (TEV) of wetland ecosystems is measured by the total amount of resources that people are willing to forego in order to attain an increased (or preserved) amount of this service (adapted from Turner et al. 2000).

However, it is estimated that about half of wetlands worldwide have depleted since 1900 particularly in temperate countries during the first half of the twentieth century and in tropical and subtropical areas since the 1950s (Barbier 1993, 1994; Dugan 1990; Moser et al. 1996; OECD 1996). The main drivers that contribute to the loss of coastal wetlands are the conversion of wetland ecosystems through drainage, diversion of freshwater flows, nitrogen loading, siltation, species invasions, overexploitation of fish resources and unsustainable aquaculture activity (MEA 2005a).

Due to population growth particularly in the coastal area, pressures from anthropogenic activities on coastal wetlands threaten many of the wetland ecosystem services which are crucial to human well-being. Fish, the most important wetland product, is the main source of protein for one billion people and a source of employment and income for at least 150 million people worldwide. At least two-thirds of the fish that we consume depend on coastal wetlands particularly estuaries and mangroves at some stage in their life cycle. Overexploitation of coastal fisheries (on coastlines, estuaries and coral reefs) have depleted stocks of finfish, crustaceans, and molluscs and consequently reduced the supply of coastal fishery products and incomes for local coastal communities. The diversion of freshwater from rivers feeding estuaries has altered the delivery of water and sediment to nursery areas and fishing grounds in the coastal zone, affecting the livelihood of millions of people who depend on capture fisheries (MEA 2005a).

Aquaculture activity is driven by increasing demand for culture fisheries as an alternative to capture fisheries. This has led to habitat loss, increasing the vulnerability of coastal regions to natural hazards (such as storms, waves, erosion, and floods) and affecting livelihoods (loss of income sources), health (diseases) and security (death). Regionally, the greatest direct threat to coastal wetlands in tropical and subtropical areas is changes in local land use and land cover leading to large-scale losses of supporting services and habitats. For example, in Asia, the loss of mangroves has been attributable mainly to increased aquaculture particularly for shrimp and fish, deforestation and upstream freshwater diversion (MEA 2005a).

In order to assign a value to changes in the delivery of ecosystem services from a wetland, we must identify the physical changes which are expected to arise in the wetland ecosystem and understand how these changes are affected by the human activity and the 'value' of those changes (Bingham et al. 1995; Chopra & Adhikari 2004; Turner et al. 2003). Economic valuation is the process of expressing values for changes in wetland ecosystem services that emphasises human interests (preferences). Economic valuation with regard to wetland ecosystem services is important specifically in developing country settings for the purpose of guiding policymakers for more efficient and sustainable wetland management (Torres & Hanley 2016). According to Torres and Hanley (2016), a high number of studies have focused on valuing services provided by wetlands located in developing countries particularly for regulating and provisioning services.

A range of methods exist for quantifying the economic value of wetland ecosystem services (see for example Barbier 1993; Barbier et al. 1997; Bingham et al. 1995; de Groot et al. 2010; Farber et al. 2002; Turner et al. 2000; Winkler 2006; Torres & Hanley 2016). Survey-based valuation approaches have also been developed for non-market goods and services for valuing, regulating, supporting and cultural services. These stated preference (SP) approaches are based on a simulated market where people are asked (in a survey through questionnaires and or interviews) to express their preferences for increases or decreases in the delivery of a particular environmental good or service (Garrod & Willis 1999). Choice experiments (CEs) were recognised as tools for estimating these non-market environmental values via the stated preferences approach. In early implementations of choice-based stated preferences (SP) methods, consumers' preferences were elicited by choosing the most preferred option from a list of available options characterised by the attributes of the options.

This study will employ choice experiments (CEs) for eliciting relative preferences for the delivery of different wetland ecosystem services among aquaculturists stakeholders affected by wetland management decisions. Individual stakeholders' (respondent) preferences for delivery of different levels of different ecosystem services are examined by observing respondents' preferred choice options when presented with a carefully designed set of hypothetical ecosystem service delivery combinations as a set of choice cards (i.e. the choice set). A choice set comprises a number of separate choice cards. Each choice card comprises a number of choice options delivering different levels of different ecosystem services (attributes) from which respondents are requested to choose their most preferred option.

Respondents' reactions to the options available on the choice cards can be used to estimate their marginal rates of substitution between the various ecosystem services (i.e. the attributes) and thus establish respondents' relative preferences for the delivery of different levels of services. If one of the options on the choice cards is a cost (i.e. involves a monetary payment), then the marginal price of each of the other attributes on the cards can be assessed. And if a status quo or 'do-nothing' option is also included as well as a cost attribute in the choice sets, choice experiments can be utilised to assess the full willingness to pay value for each alternative relative to the status quo baseline (Kanninen 2007). An important advantage of CEs as a stated preference method is that they can address and quantify preferences for different attributes of hypothetical scenarios, i.e. outcomes of management options which may not exist. This allows the method to be used as a stated preference method for environmental valuation to explore relative preferences for outcomes of potential future management scenarios.

This research aims to predict an individual's choice behaviour for aquaculturists stakeholder subgroups by examining their preferences for different characteristics (attributes and attribute levels) of ecosystem goods and services, predicting how they will respond to the levels of these attributes delivered under different management scenarios (options). It then assesses which are their most preferred management options for the wetlands as a whole, as well as identifying which individual-specific characteristics influence their preferences, attributes and options. The Setiu Wetlands which is situated on the east coast of Peninsular Malaysia is chosen as a case study for this research. Setiu Wetlands is classified as a natural coastal wetland ecosystem and consists of a number of inter-connected major habitats including permanent shallow marine waters, marine subtidal aquatic beds (seagrass beds, kelp beds), sandy shores (sand spits, sandbars), estuarine waters, intertidal mudflats, intertidal forested wetlands (mangrove swamps, Nypa swamps, freshwater swamp forests), intertidal marshes (tidal brackish and freshwater marshes) and coastal brackish lagoon (Alipiah 2010).

LITERATURE REVIEW

The fundamental issue in discrete choice study is 'choice'. In order to choose, the quantity of information (details) and the quality of the 'choices' or 'options' characteristics (or attributes) are required in order to make a correct and accurate decision. By examining individuals' choice behaviours, the analyst may be able to understand and relate the decisions made by each person to the characteristics of the person and the characteristics (or attributes) of the options (or alternatives) available to the person.

Discrete choice study seeks to elucidate the underlying preferences to determine whether preferences, and therefore choices, differ across individuals or between groups of individuals. For the last three decades, the most basic form of discrete choice model specification has been the Multinomial Logit (MNL) specification under the assumption that the error terms in the utility function are independently and identically distributed (IID) (McFadden, 1974). By assuming homogenous utility functions across the respondents, this model does not allow the evaluation of individual preference variation (i.e. respondents with different socio-demographic characteristics such as age, income, and gender are assumed to have the same set of preferences driving their choice decisions).

More advanced models such as the Random Parameters Logit (RPL) model and the Latent Class (LC) model were subsequently introduced to overcome this restriction by introducing individual preference variation through relaxation of the IIA property (see e.g., Birol et al. 2006; Kosenius 2010; Milon & Scrogin 2006; Morey & Greer Rossmann 2003; Morey et al. 2006; Wang et al. 2007; Zhai & Suzuki 2008). The RPL model allows random heterogeneity across individuals by assuming a continuous distribution for individual preferences.

The Latent Class (LC) model is one of a number of alternative approaches in choice experiments which can accommodate preference heterogeneity among the respondents. It evaluates how behaviour functions in the observable attributes of the choices together with latent heterogeneity in respondent characteristics (Heckman & Singer 1984; Louviere et al. 2000; McFadden 1986; McCutcheon 1987). McFadden (1986) emphasises that psychometric data in the form of preferences, attitudes, values and beliefs are vital to quantify the theoretical construct of choice behaviour. The LC model organises the segments of the observed constituent variables within a typology or classification (McCutcheon 1987) where preferences are assumed to be relatively homogenous within the segments, but substantially different between the segments. The latent segments concept was initially applied to understand preferences for beauty aids (Swait 1994) and wilderness recreation park (Boxall & Adamowicz 2002).

Individual choice behaviour is often analysed using discrete choice models. Discrete choice modelling is often attributed to Daniel McFadden whose pioneering work on its theoretical construction won him the Nobel Prize in 2000, however, it was developed earlier by Thurston (1927) in the 20th century in terms of psychological stimuli and expanded by Marchak (1960) who interpreted the stimuli as utility and provided a derivation from utility maximisation (Train, 2003). Lancaster (1966) developed the utility maximisation theory as the theoretical foundation for utility maximisation concept. However, an econometric foundation for the concept was introduced earlier by Luce and Suppes (1965). Lancaster's theory of value postulates that consumers' utility is derived from the consumption of 'composite goods' (goods which comprise the sum of the characteristics or attributes of those goods) instead of the consumption of goods per se (Louviere et al. 2000). For example, an individual's preference for a car can be described in terms of its brand (manufacturer), model, car type, price, age (new or used), performance, engine size, safety, colour, and other characteristics.

McFadden (1974) established choice modelling by applying an econometric approach to random utility theory (RUT). Model estimation for choice modelling combined RUT with statistical specifications of the first form of logit model which is known as the Multinomial Logit (MNL) model. The MNL model was initially employed by marketing researchers to model the choice of telecommunication services during the early 1980s (Louviere et al. 1981; Louviere & Hensher 1982). It was also used to analyse aggregate marketing data (Louviere 1988; Louviere & Hensher 1983; Louviere & Woodworth 1983) where for the first time Louviere and Woodworth (1983) used the term 'choice experiments' (CEs) (Hanley et al. 1998). Later on, the choice experiment technique was widely applied in modelling transportation demand (Ben-Akiva 1985; Hensher et al. 1990).

In environmental valuation, the choice experiment (CE) technique was first applied by Adamowicz et al. (1994) to determine the preference of alternative flow scenarios for the Highwood and Little Bow rivers in Alberta, Canada among recreationalists, followed by Boxall et al. (1996) with an application on moose hunting in the province of Alberta (Hanley et al. 1998). Since then, the application of CEs in environmental studies became widespread (see for example, Adamowicz et al. 1997; Adamowicz et al. 1998; Hanley et al. 1998; Hanley et al. 2001; Layton 2000; Morrison et al. 2002). Other recent studies on the management of environmental and ecological resources were reported by Boxall and Adamowicz (2002), Horne et al. (2005), Kemperman and Timmermans (2006), Zhai and Suzuki (2008) and Kosenius (2010), including investigations of the preferences driving domestic water demand (Bateman et al. 2009; Barton & Bergland 2010; Hoyos 2010; Hensher et al. 2005; Willis et al. 2005).

A number of recent studies which applied CEs specifically focused on the valuation of wetland ecosystem services has increased considerably (see for example, Birol et al. 2006; Carlsson et al. 2003; Do & Bennet 2008; Faccioli et al. 2015; Hanley et al. 2006; Kaffashi et al. 2012; Milon & Scrogin 2006; Nunes et al. 2004; Nunes et al. 2008; Othman et al. 2004; Petrolia et al. 2014; Westerberg et al. 2010). Regarding ecosystem service valuation, researchers have valued regulating, provisioning and cultural services because of the importance of these services especially nitrogen mitigation, coastal protection and stabilisation.

The main issues which underpin interest in studying environmental and resource management issues are the relative scarcity of environmental goods and services and the decline in the environment's ability to provide environmental products due to its competitive use to satisfy a broad range of consumptive demands. In this context, the complex conflict between conservation and development of the environment becomes more apparent; and more information about the choices available and the impact of those choices on the stakeholder community is required (Bennet & Blamey 2001). Since environmental goods and services are not usually traded in conventional markets, choice experiments were recognised as tools for estimating these non-market environmental values via a stated preferences (SP) approach. In early implementations of choice-based stated preferences (SP) methods, consumers' preferences were elicited by using ranking or rating approaches or by choosing the most preferred option from a list of available options characterised by the attributes of the options.

The LC model conceptualises individual preference heterogeneity as a discrete distribution characterized by an endogenous or 'latent' preference segregation or segmentation which is derived from an individual's characteristic. In the LC model, the number of preference segments is finite, and the 'optimum' number of segments is resolved endogenously by the data. Homogenous preferences characterise each LC segment, but segments differ from one another significantly in their preference structure (Birol et al. 2006; Kosenius 2010).

The elicited preferences from the questionnaire for the different stakeholder groups were estimated using Latent Class (LC) discrete choice models. The latent class (LC) model is one of a number of alternative approaches in choice experiments which can accommodate preference heterogeneity among the respondents. Respondents' responses to the options available on the choice cards is a basis for predicting how they will substitute between the various ecosystem services (i.e. the attributes) and thus establish their preferred level of service. If one of the options on the choice cards is a cost (i.e. involves a monetary payment), then the marginal price of the other attributes on the cards can be calculated. And if a status quo or 'do-nothing' option is included as well as a cost attribute in the choice sets, a person's willingness to pay for each alternative can be determined relative to the status quo baseline (Kanninen 2007). An important advantage of CEs as a stated preference method here is that they can address and quantify preferences for different attributes of hypothetical scenarios, i.e. outcomes of management options which may not exist yet. This allows the method to be used as a stated preference method for environmental valuation to explore relative preferences for outcomes of potential future management scenarios.

METHODOLOGY

THEORETICAL BACKGROUND

Preference ordering using preference elicitation for choice options should be consistent with RUT (see, for example, Luce and Suppes 1965; Louviere et al. 2000). Random Utility Theory (RUT) advocates that people think of utility, but it cannot be observed directly by the researcher. As such, it is a latent construct. However, a systematically designed preference elicitation procedure will explain a significant proportion of unobserved utility which is referred to as the deterministic utility (V_{iq}), while leaving the remaining utility (unobserved utility) unexplained (as a random error term). RUT is an expression of deterministic utility (V_{iq}) plus a random error term $_{iq}$), together representing the true utility (U_{iq}) of the i^{th} option for the q^{th} individual *(q=1,…, Q)*;

$$U_{iq}=V_{iq} + \varepsilon_{iq} \quad (1)$$

where;

U_{iq} is the latent, unobserved utility

V_{iq} is the observed (and measured) deterministic utility

ε_{iq} is the random term, capturing the uncertainty surrounding the choice decision.

The basic structure of an individual choice model assumes that individual q will choose an option that delivers the highest utility (option i) if;

$$U_{iq} > U_{jq} \;\forall\; i \neq j \quad (2)$$

By substituting equation (5.1) into equation (2), option i is chosen if

$$(U_{iq} + \varepsilon_{iq}) > (V_{jq} + \varepsilon_{jq}) \quad (3)$$

Equation (3) can be rearranged to group the observable and unobservable utilities together as:

$$(V_{iq} - V_{jq}) > (\varepsilon_{jq} - \varepsilon_{iq}) \quad (4)$$

Since the analyst does not observe $(\varepsilon_{jq} - \varepsilon_{iq})$ we cannot determine precisely if $(V_{iq} - V_{jq}) > (\varepsilon_{jq} - \varepsilon_{iq})$. Only statements about the probability of choice outcomes occurring can be made. The probability *(P)* of individual *q* choosing option *i* can be represented by the following expression;

$$P_{iq} = P[(\varepsilon_{jq} - \varepsilon_{iq}) < (V_{iq} - V_{jq})] \ \forall \ i \neq j \qquad (5)$$

Equation (5) could be defined as the probability of an individual *q* choosing option *i* (P_{iq}) is equal to the probability that the difference in the unobserved sources of utility of option *j* compared to $i[P[(\varepsilon_{jq} - \varepsilon_{iq})]$ is less than the difference in the observed sources of utility of option *i* compared to option $j[P[(V_{iq} - V_{jq})]$ after analysing each and every option in the choice set of *j=1, ...I, ...J* options.

The basic RUT (equation 1 to equation 5) is applicable for modelling individual choice on model estimation (see for example, Louviere et al. 2000; Bennet and Blamey 2001; Hensher et al. 2005).

USE OF CHOICE EXPERIMENTS TO ELUCIDATE RELATIVE PREFERENCES

Choice experiments are samples of choice sets or choice scenarios systematically designed *a priori* to satisfy the estimation requirements of different forms of discrete choice models. The implementation of CEs generally involves four main elements as follows:

1) Set-up of CEs

Aquaculturists were identified as a focal stakeholder group in the present study because of the considerable impacts aquaculture imposes on the wetland ecosystem. The next stages of the research design are; (a) Identify the management scenario options which will be explored and (b) Produce a list of attributes and attribute levels through which the consequences of the various management scenarios can be depicted on the choice cards.

The list of attributes and attribute levels for the CEs was produced by using the BBN cause-effect model to predict likely levels of ecosystem service delivery under the four chosen management scenarios (refer to Table 1). This model identified four management scenarios: (a) the current situation (Status quo scenario) and three hypothetical future scenarios focusing on (b) Intensive aquaculture, (c) Conservation, and (d) Ecotourism. Details of the selection of attributes and scenarios can be referred in Alipiah et al. (2018) and Alipiah (2010).

2) Experimental design

The experimental design for a CE assigns the combinations of attributes and levels which will be presented in each choice option on each of the choice cards and the number of choice cards in the CE. Table 2 shows the choice card design developed for this study which used an optimal orthogonal in differences (OOD) approach, as developed by Street and Burgess (2007).

Orme (1998) recommends that the number of respondents interviewed *n* should be sufficient to ensure that:

$$\frac{nta}{c} > 500$$

Where:

t = number of choice tasks completed by each respondent [6]

a = number of alternatives per choice task (not including a status quo) [3]

c = number of levels of the attribute with the largest number of levels [3]

Orme's sample size requirement, therefore, suggests that at least 84 respondents should be interviewed for the Setiu CE surveys. Orme's recommendations are often, although not always, adhered to in practice. With this in mind, target sample sizes of 85 respondents in the

TABLE 1. Ecosystem service attributes chosen to represent BBN nodes (and the states of nodes) and CE attributes (and the levels of those attributes)

BBN Variables	BBN Variable States	CE Attributes	CE Attribute Levels [coding]
1. Aquaculture production	a. Low b. Medium c. High	1. Harvest rate (%) [HR]	a. 30 % [0] b. 40 % [1] c. 50 % [2]
2. Sediment invertebrates	a. Normal b. Elevated c. Reduced	2. Shellfish collection [SC]	a. 10kg/day [0] b. 20kg/day [1] c. 30kg/day [2]
3. Fisheries income	a. Low b. Medium c. High	3. Fisheries income [FI]	a. RM500/month [0] b. RM700/month [1] c. RM1000/month [2]
-	-	4. Annual licence fee [F]	a. RM1/cage [0] b. RM1.50/cage [1] c. RM2/cage [2] d. RM10/year*

TABLE 2. Choice card design for the attributes and levels used in the CEs stakeholder group.

	Option 1				Option 2				Option 3				Status Quo			
Attribute	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Card 1	1	1	2	1	2	2	0	2	0	0	1	0				
Card 2	0	0	2	2	1	1	0	0	2	2	1	1	as appropriate			
Card 3	2	0	0	1	0	1	1	2	1	2	2	0				
Card 4	2	1	1	0	0	2	2	1	1	0	0	2				
Card 5	1	2	1	2	2	0	2	0	0	1	0	1				
Card 6	0	2	0	0	1	0	1	1	2	1	2	2				

Setiu CE would be recommended if sufficient time and resources were available.

3) Questionnaire development

Overall, the questionnaire was structured into three main sections; research scenario/problem statements, a series of choice sets with a number of attributes and attribute levels (refer to Appendix A), and other questions to quantify respondents' background and attitudes.

4) Survey design and sampling methodology

The questionnaire survey was conducted by personal face-to-face interviews instead of self-administered methods. In stated preference valuation studies, face-to-face interviews are widely implemented compared to self-administered methods. According to Snowball and Willis (2011), the National Oceanic and Atmospheric Administration (NOAA) panel on Contingent Valuation's (CV) recommendation to use willingness to pay (WTP) for data collected using face-to-face interviews, the majority of CE studies have used face-to-face interviews to administer questionnaires. Despite the advantages of using face-to-face interview such as more data could be collected, extra information can be provided during the interviewing session, high response rate, low cognitive burden, etc.; this method also has drawbacks such as being costly and time-consuming, less time for respondents to think about the options offered in the choice cards, interviewer bias and the 'warm glow' effect.

The survey was administrated in June and July 2009. A random sampling approach was used to select respondents. However, only 50 culturists were interviewed, as this represented almost the entire population of local aquaculturists. The reason for the smaller than intended sample of aquaculturists is a reduction in the number of culturists operating in the Setiu Lagoon which has occurred since 2008 due to high mortality rates for caged fish. Some culturists discontinued their operations when the potential profit became very low due to an extremely high fish mortality rate. As a result, the enumerators had to look for aquaculturists from other cage culture locations which were outside the main site (Gong Batu) such as Limau Nipis, Fikri and Penarik. Most of the aquaculturists were interviewed at the jetty where the harvested fish from the lagoon were landed, although some of them were interviewed at their homes, particularly on weekends.

LATENT CLASS MODEL ESTIMATION

The LC model is fundamentally rooted in this random utility theory. The difference between the CL and LC approaches to model estimation comes from segmentation of the population where (in the LC model) individual n is estimated to have a particular probability of belonging to segment s $(s = 1, \ldots, S)$. The existence of this segmentation is shown in the utility function as follows;

$$U_{iq/s} = \beta_s X_{iq} + \varepsilon_{iq/s}, \qquad (6)$$

Where,

$(U_{iq/s})$ is the utility which respondent q would derive from choosing option i, given that respondent q were to belong to a particular segment s.

X_i is a vector of attributes associated with option i

β_s is a *segment-specific* vector of preference parameters associated with the attributes *(X),* and

$\varepsilon_{iq/s}$ are the error components.

Assuming the error terms ($\varepsilon_{iq/s}$) are independently and identically distributed and follow a Type I (or Gumbel) distribution, the probability of individual q in segment s choosing option i in order to maximise his/her utility (U_{iq}) can be represented by the following expression;

$$U_{iq/s} = \frac{\exp(\beta_s x_{iq})}{\Sigma_{i=1}^{S}\exp(\beta_s x_{iq})} \qquad (7)$$

According to (Swait 1994), a latent or unobservable membership likelihood function (M^*) which categories an individual into one of the segments, and which is driven by individual-specific characteristics such as socio-economic characteristics, attitudes and perceptions, can be expressed at individual level (q) as;

$$M^*_{qs} = \lambda_s Z_q + \xi_{iq}, \qquad s = 1, \ldots, S \qquad (8)$$

Where Z_q is the observed individual-specific characteristics for individual q, λ_s is a vector of parameters linking these individual-specific characteristics to the probability of segment membership and ξ_{iq} is the error terms.

By assuming the error terms in the membership likelihood function are independently and identically distributed across individuals and segments with Type I extreme value distribution and scale factor α (Gupta & Chintagunta 1994; Kamakura & Russell 1989; Swait 1994); the probability of individual q being a member of segment s can be expressed as;

$$U_{qs} = \frac{\exp(\lambda_s + Z_i)}{\Sigma_{i=1}^{S}\exp(\lambda_s + z_i)} \qquad (9)$$

Where λ_k (k = 1, 2, …, S) are the segment-specific parameters to be determined and P_{qs} sums to one across the S latent segments ($0 \leq P_{qs} \leq 1$). Bringing together equation 7 and equation 9 allows the analyst to derive the probability that individual q pertains to segment s and chooses option i, as represented by the following equation;

$$P_{iq/s} = (P_{iq/s}) * (P_{is}) = \left[\frac{\exp(\beta_s x_{iq})}{\Sigma_{i=1}^{S}\exp(\beta_s x_{iq})}\right] * \left[\frac{\exp(\lambda_s + Z_i)}{\Sigma_{i=1}^{S}\exp(\lambda_s + z_i)}\right] \qquad (10)$$

The optimal number of segments (S) in the LC model is not defined automatically and must be determined by using a number of statistical criteria. Two statistical criteria commonly used to determine the optimal number of segments; the minimum Akaike Information Criterion (AIC) and the minimum Bayesian Information Criterion (BIC) (Allenby 1990; Gupta & Chintagunta 1994; Kamakura & Russell 1989; Swait 1994). The process of determining the optimal number of segments involves balancing the improvement in the log-likelihood values as additional segments are added with the additional complexity incurred.

The AIC and BIC measures of model fit effectively apply penalties for the increasing number of parameters added due to the inclusion of additional segments (Boxall & Macnab 2000). However, these statistical fit criteria should be used as a guide only as rigid rules for determining the optimum numbers of LC segments do not exist. As well as the AIC and BIC statistical criteria, the significance of the parameter estimates, interpretability of the model, analyst's judgement, simplicity and the overall "parsimony" of the model are also taken into account for the final selection of the number of segments (Boxall & Adamowicz 2002; Kosenius 2010; Swait 1994).

The estimated LC models were derived from the choice card set in which each card presents four different options comprising four attributes present in three levels. The LC estimation equations can be interpreted as the estimated conditional indirect utilities derived from the different choice options present on the cards (V_Q, V_A, V_B and V_C).

Empirical Results The results of LC models revealed that the three-segment model is the best model with three optimal number of classes based on the statistical criteria of model fit, specifically the BIC and AIC, as well as the Pseudo R2 and log-likelihood statistics. Relevant statistical criteria for choosing the number of segments in the aquaculturists' LC model are shown in Table 3. Log-likelihood value decreases and Pseudo R^2 improves very substantially as the number of segments increases up to three. A significant improvement in Pseudo R^2 (49 %) is evident when moving from the two-segment to the three-segment LC model. The change in log-likelihood between the two-segment and the three-segment LC models is sufficient to justify the inclusion of the seven extra parameters in the three-segment model ($-2 \times (-241.689 - (-298.348)) = 113.318 > \chi^2$ 5 % critical value for 7 degrees of freedom).

The AIC statistics decrease with a slightly larger reduction reported between one and two segments (18%) than between two and three segments (16%). The BIC criterion also improves from two segments to three segments, suggesting that the three-segment model is the best solution. Besides these statistical criteria, the significance of the estimated parameters, researcher's judgement, the explicability of the model and the overall representativeness of the segmentation may also need be considered when selecting the number of segments (Swait 1994). Considering all of these aspects collectively, the three-segment LC model appears to provide the most appropriate fit to the CE data.

Results from the three-segment LC model are reported in Table 4. This model classifies the sample into three fairly evenly-sized segments[1]; 41 % in Segment 1, 28 % in Segment 2, and 32 % in Segment 3. The three segments show relatively distinct sets of preferences. Segment 1, the largest segment, strongly associated with

TABLE 3. Statistical criteria for determining the optimal number of segments in a Latent Class Model.

No. of Segments	Log-Likelihood	Pseudo R^2	AIC	BIC	Number of Parameters	Respondents Association with Segments*
1	–373.2211	0.098	2.5281	2.6022	6	-
2	–298.3476	0.279	2.0757	2.2362	13	98 %
3	–241.6894	0.416	1.7446	1.9915	20	96 %

* Respondents are regarded as being strongly associated with a particular segment if their individual-specific probability of segment membership for that segment is ≥ 90 %.

around 40 % of respondents, shows a highly significant and very strong non-linear increase in preference for higher harvest rates. This segment also shows a highly significant and moderately strong preference for higher fisheries income but also a significant and moderately strong preference for lower shellfish collections. Segment 1 shows no significant response to the fee attribute.

The three-segment LC model has been unable to resolve Segment 1's preference for the status quo ASC. Subsequent investigation of the choices made by respondents strongly associated with Segment 1 showed that none of these respondents chose the status quo option on any of the choice cards. The status quo dummy variable would therefore never have been set to '1' for this Segment, and this prevented estimation of the status quo ASC parameter for Segment 1. This is the discrete choice modelling equivalent of the 'complete separation' which prevents parameter estimation in binary logit or binary probit models (Long 1997). The polarity of the coefficient estimates for the status quo ASC confirms the intuitive interpretation of Segment 1's observed choice behaviour– Segment 1 respondents show very strong aversion to retaining the status quo, *ceteris paribus*. However, the complete absence of the status quo options in the choices made by these respondents prevents the model from providing statistical confirmation of this preference.

Segment 2, the smallest segment, strongly associated with around 28 % of respondents, shows a moderately strong linear preference for higher harvest rates which is significant at the 10 % level. Segment 2 also shows a very strong and highly significant preference for retaining the status quo. This segment shows no significant preference for the shellfish collection, fisheries income or fee attributes.

Segment 3, strongly associated with around 32% of respondents, shows a perplexing set of significant preferences for increasing harvest rates. The segment shows a moderate preference for the current 40 % harvest rate compared to the lower 30% harvest rate but appears to strongly prefer the current 40% harvest rate to an alternative, higher harvest rate of 50%. Segment 3 also shows a modest preference for higher fisheries income, significant at the 10% level. In direct contrast to Segment 2, Segment 3 shows a highly significant and very strong aversion to retaining the status quo.

DISCUSSION

The three-segment latent class model provides a good fit to aquaculturists' observed choice predictions. The preferences portrayed for Segment 1 (around 41% of the sample) appear largely consistent with those which might be expected from individuals operating intensive aquaculture in Setiu Lagoon, showing a strong preference for the highest level of aquaculture harvest rate, a preference for increased fisheries income and an aversion to increased shellfish collection. Segment 1 respondents did not select the status quo option on any choice occasion, preventing the model from quantifying the status quo preference for this segment, although it seems reasonable to infer from this behaviour that Segment 1 aquaculturists are highly averse to retaining the status quo if alternatives offering higher aquaculture harvests are available.

TABLE 4. The 3-segment Latent Class Model

Attributes	Latent Class Model (3 Segments)					
	Segment 1		Segment 2		Segment 3	
	Coefficient	Std. Err	Coefficient	Std. Err	Coefficient	Std. Err
Harvest rate 1	–0.7324**	0.3487	0.1683	0.4428	0.2730***	0.0980
Harvest rate 2	2.6340***	0.4232	0.7835*	0.4306	–0.2715**	0.1264
Shellfish collection	–0.7510**	0.3236	0.4285	0.3438	–0.1595	0.1116
Fisheries income	0.9336***	0.3555	–0.2954	0.2830	0.1446*	0.0875
Fee	0.2667	0.3142	0.1822	0.3489	0.0432	0.0995
ASC_{SQ}	–27.7375	840056	3.1639***	0.6600	–2.0386***	0.4027
Summary of statistics						
Average class probabilities	0.406		0.279		0.315	
Log-likelihood			–241.689			
Pseudo R^2			0.4160			
No. of parameter			20			
AIC			1.7446			
BIC			1.9915			
No. of observations			300			
No. of individuals			50			

Segments 2 and 3, representing around 2% and 32% of the sample respectively, are harder to characterise. These segments differ most distinctly in their preference towards retaining the status quo, with Segment 3 strongly averse whilst Segment 2 are strongly in favour. Segments 2 and 3 both prefer the current (40%) harvest rate over the lower (30%) harvest rate. Segment 3, puzzlingly, appears averse to the higher (50%) harvest rate, whilst Segment 2 prefers this higher harvest rate to the current level. This preference remains unexplained. In addition, Segment 3 shows a preference for higher fisheries income whereas Segment 2 does not. All segments disregard the fee attribute in their decision making, probably reflecting the implausibility of the proposed fee payment mechanism and its enforcement.

CONCLUSION

The application of the LC model to evaluate human behaviour which can accommodate preference heterogeneity among the respondents has been mostly applied in developed countries. In comparison, the application of this model for the same purpose in developing countries is limited. In Malaysia, Othman et al. (2004) attempt to assess the non-market values derived under the status quo and alternatives management options in Larut Matang Mangroves. They employed an MNL model instead of LC model to introduce potential sources of heterogeneity by interacting socio-demographic and attitudinal variables in the model.

The application of the LC model accounts for preference heterogeneity founded on the concept of endogenous (or latent) preference segmentation in which there are separate (latent) segments of respondents. It is characterised by homogenous preferences, but preference structures can differ substantially between segments (Birol et al. 2006). Segmentation is likely to be influenced endogenously by an individual's socio-demographic, economic and attitudinal characteristics and LC models acknowledge that this segmentation could be affected by socio-demographic and attitudinal characteristics which have not been recorded by the analyst. LC models thus assume that socio-demographic and attitudinal characteristics of respondents, both observed and unobserved, affect choice indirectly through their impact on segment membership. LC models, therefore, allow the segmentation to emerge 'latently' through likelihood maximisation in model estimation (Birol et al. 2006).

The results of the LC model of this study revealed considerable variation in preferences for delivery of key ecosystem services and preferences towards status quo or alternative scenarios within the three distinct subgroups. Quantifying the variation in these relative preferences can assist decision making by enabling a broader range of stakeholders' views to be taken into account in developing management policies particularly with regard to the aquaculture activities in Setiu Lagoon. The results reveal that most aquaculturists portrayed significant preferences on different levels of harvest rate. They are also highly averse to retaining the status quo scenario and prefer to choose alternative scenarios.

This finding shows that they want something to be done to change the environment of the lagoon particularly a new policy to improve the lagoon's water quality. Hence, improvements to the natural environment of the lagoon area are suggested which could increase the harvest rate of aquaculture production, collection of shellfish and the capture of wild fisheries within the lagoon. Improvements in Setiu Lagoon's water quality could be achieved by the implementation of best practice of aquaculture management, periodical monitoring of water quality level and deepening the bottom of the lagoon in order to increase the flushing rate. Improved water quality without monitoring the growth of new cages will affect the effectiveness of the authorities' actions and plan. Here, the implementation of licence fees could help authorities monitor the environment of the lagoon and provide prolonged health. Therefore, efficient collection of licence mechanisms and good enforcement should be done by related parties such as the Department of Fisheries or local authorities.

As a conclusion, the results of this study propose that the LC model could be applied successfully in Malaysia provided that a number of critical challenges are addressed wisely. Existing studies, particularly in a developing country setting, suggest that one of the most critical challenges is the questionnaire design stage to counter the potential difficulties which could arise from unfamiliarity with the payment vehicle attribute, other selected attributes and choice sets design, as well as the cognitive levels issue. Moreover, critical research design and planning involving the researchers, local experts, stakeholders and extensive focus groups consultation to ensure effective field data collection are also crucial.

ACKNOWLEDGEMENT

We would like to thank the financial support for this research by the Ministry of Higher Education under the Niche Research Grant Scheme (NRGS) Sub Project 6 (2014/53131/12).

NOTES

1 The segment with which each respondent is most closely associated is determined by the individual-specific probabilities of segment membership which are estimated during likelihood maximisation. Individuals are said to be 'strongly associated' with a particular segment if their individual-specific probability of membership for that segment is ≥ 90%.

REFERENCES

Adamowicz, W.L, Louviere, J.J. & Williams M. 1994. Combining revealed and stated preference methods for valuing environmental amenities. *Journal of Environmental Economics and Management* 26(3): 271–292.

Adamowicz, W.L, Swait, J.D., Boxall, P.C., Louviere, J.J., & Williams, M. 1997. Perceptions versus objective measures of environmental quality in combined revealed and stated preference models of environmental valuation. *Journal of Environmental Economics and Management* 32(1): 65–84.

Adamowicz, W.L, Boxall, P.C., Williams, M. & Louviere, J.J. 1998. Stated preference approaches for measuring passive use values: Choice experiments and contingent valuation. *American Journal of Agricultural Economics* 80(1): 64–75.

Kanninen, B.J. 2007. *Valuing Environmental Amenities Using Stated Choice Studies: A Common Sense Approach to Theory and Practice*. Springer.

Allenby, G.M. 1990. Hypothesis testing with scanner data: The advantage of Bayesian methods. *Journal of Marketing Research* 27(4): 379–389.

Alipiah, R.M., Raffaelli, D., Smart, J. & Nik Fuad, N.M. K. 2018. Modelling the impact of aquaculture on Setiu Wetland Ecosystems using Bayesian Belief Network (BBN) approach. *Journal of Sustainability Science and Management* 12(2): 183–193.

Alipiah, R.M. 2010. *Valuation of Ecosystem Services for Wetland Management: Case Study of Setiu Wetlands, Terengganu, Malaysia*. Unpublish PhD. Thesis. University of York. England.

Barbier, E.B. 1993. Sustainable use of wetlands valuing tropical wetland benefits: Economic methodologies and applications. *The Geographical Journal* 159(1): 22–32.

Barbier, E.B., Acreman, M.C. & Knowler, D. 1997. *Economic Valuation of Wetlands: A Guide for Policy Makers and Planners*. Ramsar Convention Bureau, Switzerland.

Ben-Akiva, M. 1987. *Discrete Choice Analysis: Theory and Application to Travel Demand*. MIT Press series in transportation studies. Cambridge, Mass, MIT Press.

Barton, D.N. & Bergland, O. 2010. Valuing irrigation water using a choice experiment: An individual status quo modelling of farm specific water scarcity. *Environment and Development Economics* 15(03): 321–340.

Bennet, J. & Blamey, R. 2001. *The Choice Modelling Approach to Environmental Valuation. New Horizons in Environmental Economics*. Edward Elgar, Cheltenham, UK.

Bateman, I.J., Day, B.H., Jones, A.P. & Jude, S. 2009. Reducing gain-loss asymmetry: A virtual reality choice experiment valuing land use change. *Journal of Environmental Economics and Management* 58(1): 106–118.

Beharry-Borg, N. & Scarpa, R. 2010. Valuing Quality Changes in Caribbean coastal waters for heterogeneous beach visitors. *Ecol. Econ.* 69: 1124–1139.

Bingham, G., Bishop, R., Brody, M., Bromley, D., Clark, E., Cooper, W., Costanza, R., Hale, T., Hayden, G., Kellert, S., Norgaard, R., Norton, B., Payne, J., Russell, C. & Suter, G. 1995. Issues in ecosystem valuation: Improving information for decision making. *Ecological Economics* 14(2): 73–90.

Birol, E., Karousakis, K. & Koundouri. P. 2006. Using a choice experiment to account for preference heterogeneity in wetland attributes: The case of Cheimaditida wetland in Greece. *Ecological Economics* 60(1): 145–156.

Boxall, P.C., Adamowicz, W.L, Swait, J. D.,Williams, M. & Louviere, J.J. 1996. A comparison of stated preference methods for environmental valuation. *Ecological Economics* 18(3): 243–253.

Boxall, P.C. & Macnab, B. 2000. Exploring the preferences of wildlife recreationists for features of Boreal Forest management: A choice experiment approach. *Can. J. For. Res*. 30(12): 1931–1941.

Boxall, P.C. & Adamowicz, W.L. 2002. Understanding heterogeneous preferences in random utility models: A latent class approach. *Environmental and Resource Economics* 23(4): 421–446.

Brander, L.M., Florax, R.G.M., & Vermaat, J.E. 2006. The empirics of wetland valuation: A comprehensive summary and a meta-analysis of the literature. *Environmental and Resource Economics 33*(2): 223–250.

Carlsson, F., Frykblom, P. & Liljenstolpe, C. 2003. Valuing wetland attributes: An application of choice experiments. *Ecological Economics* 47(1): 95–103.

Chopra, K. & Adhikari, S.K. 2004. Environment development linkages: Modelling a wetland system for ecological and economic value. *Environment and Development Economics* 9(1): 19–45.

de Groot, R.S., Alkemade, R., Braat, L., Hein, L. & Willemen, L. 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological Complexity* 7(3): 260–272.

Do, T.N. & Bennett, J. 2008. Estimating wetland biodiversity values: A choice modelling application in vietnam's Mekong River delta. *Environment and Development Economics* 14 163–186.

Dugan, P.J. 1990. *Wetland Conservation: A Review of Current Issues and Required Action*. IUCN, Gland, Switzerland

Faccioli, M., Riera, A., & Torres, C. 2015. Valuing the recreational benefits of wetland adaptation to climate change: A trade-off between species' abundance and diversity. *Environment Management* 55(3): 550–563

Farber, S.C., Costanza, R. & Wilson, M.A. 2002. Economic and ecological concepts for valuing ecosystem services. *Ecological Economics* 41(3): 375–392.

Fisher, B., Turner, K., Zylstra, M., Brouwer, R., De Groot, R. S., Farber, P., Ferraro, R., Green, D., Hadley, Harlow, J., Jefferiss, P., Kirkby, C., Morling, P., Mowatt, S., Naidoo, R., Paavola, J., Strassburg, B., Yu, D. & Balmford, A. 2008. Ecosystem services and economic theory: Integration for policy-relevant research. *Ecological Applications* 18(8): 2050–2067.

Garrod, G. & Willis. K.G.1999. *Economic Valuation of the Environment: Methods and Case Studies*: Edward Elgar, Cheltenham, UK.

Gupta, S. & Chintagunta, P.K. 1994. On using demographic variables to determine segment membership in logit mixture models. *Journal of Marketing Research* 31(1): 128–136.

Heckman, J. & Singer, B. 1984. The identifiability of the proportional hazard model. *The Review of Economic Studies* 51(2): 231–241.

Hanley, N., Wright, R.E. & Adamowicz, W.L. 1998. Using choice experiments to value the environment. *Environmental and Resource Economics* 11(3): 413–428.

Hanley, N., Mourato. S. & Wright. R.E. 2001. Choice Modelling Approaches: A superior alternative for environmental valuation? *Journal of Economic Surveys* 15(3): 435–462.

Hanley, N., Colombo, S., Tinch, D., Black, A. & Aftab, A. 2006. Estimating the benefits of water quality improvements under the water framework directive: Are benefits transferable? *European Review of Agricultural Economics* 33(3): 391–413.

Hensher, D.A., Milthorpe, F.W., Smith, N.C. & Barnard, P.O. 1990. Urban tolled roads and the value of travel time savings. *Economic Record* 66(2): 146-156.

Hensher, D.A., Rose, J.M., & Greene, W.H. 2005. *Applied Choice Analysis: A Primer*. Cambridge: Cambridge University Press.

Hensher, D.A. 2006. How do respondents process stated choice experiments? Attribute consideration under varying information load. *Journal of Applied Econometrics*. John Wiley & Sons, Ltd. 21(6): 861–878.

Horne, P., Boxall, P.C. & Adamowicz, W.L. 2005. Multiple-use management of forest recreation sites: A spatially explicit choice experiment. *Forest Ecology and Management* 207: 189–199.

Hoyos, D. 2010. The state of the art of environmental valuation with discrete choice experiments. *Ecological Economics* 69(8): 1595–1603.

Hu, S., Niu Z. & Chen Y. 2017. Global wetland datasets: A review. *Wetlands* 37:807–817.

Kaffashi, S., Shamsudin, M.N., Radam, A., Yacob, M.R., Rahim, K.A. & Yazid, M. 2012. Economic valuation And conservation: Do people vote for better preservation of Shadegan International Wetland? *Biological Conservation.* 150: 150–158.

Kamakura, W.A. & Russell, G. J. 1989. A probabilistic choice model for market segmentation and elasticity structure. *Journal of Marketing Research* 26(4): 379–390.

Kemperman, A.D.A.M. & Timmermans, H.J.P. 2006. Heterogeneity in urban park use of aging visitors: A latent class analysis. *Leisure Sciences: An Interdisciplinary Journal* 28(1): 57–71.

Kosenius, A.K. 2010. Heterogeneous preferences for water quality attributes: The case of Eutrophication in the Gulf of Finland, the Baltic Sea. *Ecological Economics* 69(3): 528–538.

Lancaster, K.J. 1966. A new approach to consumer theory. *Journal of Political Economy* 74(2): 132.

Layton, D.F. 2000. Random coefficient models for stated preference surveys. *Journal of Environmental Economics and Management* 40(1): 21–36.

Long, J.S. 1997. *Regression Models for Categorical and Limited Dependent Variables. Advanced Quantitative Techniques in the Social Sciences Number 7*. Sage Publications: Thousand Oaks, CA.

Louviere, J.J., Henley, D.H., Woodworth, G., Meyer, R. J., Levin, I.P., Stoner, J.W., Curry, D. & Anderson, D.A. 1981. Laboratory-simulation versus revealed-preference methods for estimating travel demand models. *Transportation Research Board*: 42–51.

Louviere, J.J. & Hensher, D.A. 1982. Design and analysis of simulated choice or allocation experiments in travel choice modelling 500 Fifth Street, NW Washington, DC 20001 USA, Transportation Research Board: 11–17.

Louviere, J.J. & Hensher, D.A. 1983. Using discrete choice models with experimental design data to forecast consumer demand for a unique cultural event. *The Journal of Consumer Research* 10(3): 348–361.

Louviere, J.J. & Woodworth, G. 1983. Design and analysis of simulated consumer choice or allocation experiments: An approach based on aggregate data. *Journal of Marketing Research* 20(4): 350–367.

Louviere, J.J. 1988. *Analyzing Decision Making: Metric Conjoint Analysis*. Newbury Park, California, Sage Publications, Inc.

Louviere, J.J., Hensher, D.A. & Swait, J.D. 2000. *Stated Choice Methods: Analysis and Applications*. Cambridge University Press. UK.

Luce, R.D. & Suppes, P. 1965. Preference, utility, and subjective probability. In *Handbook of Mathematical Psychology*, edited by Luce, R. D., Bush, R. R. & Galanter, E. Vol. III.: 159. Wiley New York.

Marchak, J. 1960. Binary-choice constraints and random utility indicators. *Stanford Symposium on Mathematical Methods in the Social Sciences*. In Arrow, K. J., Karlin, S., and Suppes, P. edition. Proceedings of the First Stanford Symposium on Mathematical Methods in the Social Sciences, 1959. Stanford University Press, Stanford CA.

McCutcheon, A.L. 1987. *Latent Class Analysis*. Beverly Hills and London, Sage Publications.

McFadden, D. 1974. Conditional logit analysis of qualitative choice behaviour. *Frontiers in econometrics*. P. Zaremba. New York, Academic Press: 105–142.

McFadden, D. 1986. The choice theory approach to market research. *Marketing Science* 5(4): 275–297.

MEA. 2005a. *Ecosystem and Human Well-Being: Wetlands and Water Synthesis.* Washington, D.C., World Resources Institute.

MEA. 2005b. *Ecosystems and Human Well-Being: Synthesis.* Island Press, Washington, D.C.

Milon, J.W. & Scrogin, D. 2006. Latent preferences and valuation of wetland ecosystem restoration. *Ecological Economics* 56(2): 162–175.

Morey, E. & Greer Rossmann, K.G. 2003. Using stated-preference questions to investigate variations in willingness to pay for preserving marble monuments: Classic heterogeneity, random parameters, and mixture models. *Journal of Cultural Economics* 27(3): 215–229.

Morey, E., Thacher, J. & Breffle, W. 2006. Using angler characteristics and attitudinal data to identify environmental preference classes: A latent-class model. *Environmental and Resource Economics* 34(1): 91–115.

Morrison, M., Bennett, J. Blamey, R. & Louviere, J. J. 2002. Choice modelling and tests of benefit transfer. *American Journal of Agricultural Economics* 84(1): 161.

Moser, M., Prentice, C. & Frazier, S. 1996. A Global Overview of Wetland Loss and Degradation. Retrieved 18/02/1998, from http://www.ramsar.org/cda/en/ramsar-news-archives-2002--a-global-overview-of/main/ramsar/1-26-45-87%5E16905_4000_0__.

Nunes, P.A.L., Rossetto, L. & de Blaeij, A. 2004. Measuring the economic value of alternative clam fishing management

Practices in the *Venice Lagoon: Results from a Conjoint* Valuation Application. *Journal of Marine Systems* 51: 309–320.

Nunes, P., Silvestri, S., Pellizzato, M. & Voatto, B. 2008. Regulation of the fishing activities in the lagoon of Venice, Italy: Results from a socio-economic study. *Estuarine, Coastal and Shelf Science*. 80: 173–180.

OECD. 1996. Guidelines for Aid Agencies for Improved Conservation and Sustainable Use of Tropical and Sub-Tropical Wetlands. Paris, France, OECD.

Orme, B. 1998. *Sample Size Issues for Conjoint Analysis Studies*. Sequim, WA, Sawtooth Software, Inc.: 10.

Othman, J., Bennett, J. & Blamey, R. 2004. Environmental values and resource management options: A choice modelling experience in Malaysia. *Environment and Development Economics* 9 (06): 803–824.

Petrolia, D.R., Interis, M.G., Hwang, J. 2014. America's wetland? A national survey of willingness to pay for Restoration of Louisiana's Coastal wetlands. *Marine Resource Economics*. 210 (29): 17–37.

Ramsar. 1971. The Ramsar convention definition of Wetland". *Convention on Wetlands (Ramsar, Iran, 1971)* Retrieved 04/12/1996, 1996, from http:// ramsar.rgis.ch/cda/en/ramsar-activities-cepa-classification-system/main/ramsar/1-63-69%5E21235_4000_0__.

Rajpar, M.N. & Zakaria, M. 2014. Effects of habitat characteristics on waterbird distribution and richness in wetlands ecosystem of Malaysia. *Journal of Wildlife and Parks* 28:107–122.

Snowball, J.D. & Willis, K.G. 2011. Interview versus self-completion questionnaires in discrete choice experiments. *Applied Economics Letters* 18(16): 1521–1525.

Street, D.J. & Burgess, L. 2007. *The Construction of Optimal Stated Choice Experiments: Theory and Methods*. John Wiley & Sons, Hoboken, New Jersey.

Swait, J.D. 1994. A structural equation model of latent segmentation and product choice for cross-sectional revealed preference choice data. *Journal of Retailing and Consumer Services* 1(2): 77–89.

Thurstone, L. 1927. A law of comparative judgment. *Psychological review* 34: 14.

Torres, C. & Hanley, N. 2016. Economic valuation of coastal and marine ecosystem services in the 21st century: an overview from a management perspective (Paper 2016-1). Retrieved from http://www.st-andrews.ac.uk/gsd/research/envecon/eediscus/

Train, K.E. 2003. *Discrete Choice Methods with Simulation*. Cambridge University Press.

Turner, R.K., van den Bergh, J.C.J.M., Söderqvist, T., Barendregt, A., van der Straaten, J., Maltby, E. & van Ierland, E.C. 2000. Ecological-economic analysis of wetlands: Scientific integration for management and policy. *Ecological Economics* 35(1): 7–23.

Turner, B.L., Kasperson, R.E., Matson, P.A., McCarthy, J. J., Corell, R.W., Christensen, L., Eckley, N., Kasperson, J. X., Luers, A., Martello, M.L., Polsky, C., Pulsipher, A., & Schiller, A. . 2003. A framework for vulnerability analysis in sustainability science. *Proc. Nat. Acad. Sci.* 100 (14): 8074–8079.

Wallmo, K., & Edwards, S. 2008. Estimating nonmarket values for marine protected areas: A latent class modeling approach. *Marine Resource Economics* 23: 301–323.

Wang, X., Bennett, J., Xie,C., Zhang, Z. & Liang. D. 2007. Estimating non-market environmental benefits of the conversion of cropland to forest and grassland program: A choice modelling approach. *Ecological Economics* 63(1): 114–125.

Westerberg, V.H., Lifran, R. & Olsen, S.B. 2010. To restore or not? A valuation of social and ecological functions of the Marais Des Baux Wetland in Southern France. *Ecological Economics*. 69: 2383–2393.

Willis, K.G., Scarpa, R. & Acutt, M. 2005. Assessing water company customer preferences and willingness to pay for service improvements: A stated choice analysis. *Water Resource. Res.* 41(2): W02019.

Winkler, R. 2006. Valuation of ecosystem goods and services: Part 2: Implications of unpredictable novel change. *Ecological Economics* 59(1): 94–105.

Zhai, G. & Suzuki, T. 2008. Public willingness to pay for environmental management, risk reduction and economic development: Evidence From Tianjin, China. *China Economic Review* 19(4): 551–566.

Zhang, M, Hana, M., Li, J., Butcher, S., Dai, H. & Xiao, W. 2010 Creation of a hyperpermeable yeast strain to genotoxic agents through combined inactivation of PDR and CWP genes. Toxicol Sci 113(2):401–11.

Roseliza Mat Alipiah*
School of Social Economics and Development
Universiti Malaysia Terengganu
21030 Kuala Terengganu, Terengganu
MALAYSIA
E-mail: roseliza@umt.edu.my

Zuraini Anang
School of Social Economics and Development
Universiti Malaysia Terengganu
21030 Kuala Terengganu, Terengganu
MALAYSIA
E-mail: zura@umt.edu.my

Noorhaslinda Kulub Abdul Rashid
School of Social Economics and Development
Universiti Malaysia Terengganu
21030 Kuala Terengganu, Terengganu
MALAYSIA
E-mail: lindarashid@umt.edu.my

James C. R. Smart
Griffith School of Environment
University of Griffith
Brisbane
AUSTRALIA
E-mail: j.smart@griffith.edu.au

Wan Noorwatie Wan Ibrahim
Faculty of Economic and Management
University College Bestari
22100 Permaisuri, Setiu, Terengganu
MALAYSIA
E-mail: noorwatie@ucbestari.edu.my

*Corresponding author

APPENDIX: Research scenario and choice card in the questionnaire

SECTION 2: THE CHOICE CARDS

The Setiu Lagoon ecosystem, covering approximately 880 hectares of total water surface area was identified as a preeminent area for aquaculture activities due to its physical, biological, chemical and hydrological characteristics. At present, the water based aquaculture development in Setiu Lagoon uses only 5 % of the total water surface, offering considerable potential area for a further development. The current concern is that aquaculture activities particularly in Gong Batu area may have caused significant ecological problems due to the physical characteristics of the ecosystems and high intensity of aquaculture activities.

1. In order to resolve these difficulties, a number of management plans has been suggested for the future. The environmental regulations in these management plans may effect outcomes such as:
2. The survival rate of caged fish (percentage of fish surviving to maturity)
3. Shellfish (cockles, clams) production (kg per day)
4. The expected level of income from an aquaculture operation with 20 cages (RM per month)
5. Different levels of annual licence fee for operating a metre square (m^2) fish cage have also been proposed (RM per m^2 per year)

In the next part of this survey we will present you with six choice cards each of which shows three different combinations of these different outcomes as well as a status quo option (do-nothing). We are interested to know your views about which option you would choose on each choice card if the outcomes shown by the options on that card were the only ones available for managing the lagoon ecosystem. (You are asked to tick ONLY ONE option [your preferred option] on EACH CHOICE CARD. This option should be the one which provides the most acceptable combination of outcomes from the set of options shown on that card). There are no 'right' or 'wrong' answers. You should tick the box to show which of the options on that card you personally would prefer if the four options on that card were the only ones available. Different cards will present different combinations of options. Your view on the possible management options will be used as a guideline and/or could assist the government or other groups who are interested in managing aquaculture activities in the Setiu Lagoon ecosystem.

CARD 1	Survival Rate (%) 	Fisheries income (RM/month) 	Shellfish production (kg/day) 	Annual licence fee (RM/cage) 	My choice* (√)
A	40 %	RM1000	20kg	RM1.50/cage	
B	50 %	RM500	30kg	RM2/cage	
C	30 %	RM700	10kg	RM1/cage	
Status quo	40 %	RM500	20kg	RM10/year	

*You are asked to tick ONLY ONE option (your preferred option) on this choice card. This option should be the one which provides <u>the most acceptable combination of outcomes</u> from the set of options shown on this card.