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Sustainability indicators for sustainably-farmed fish in Bangladesh

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ABSTRACT

To be sustainable, farmed fish should be environmentally suitable, biologically ideal, socially acceptable and economically viable. As these sustainability indicators (SIs) strongly influence consumers' fish purchase intent, farms should report them as a balanced source of sustainability information. However, in the literature, little attention has been paid to biological indicators in assessing aquaculture sustainability, nor to the extent of the SIs. Furthermore, the assessed SIs have not been examined by consumers. Therefore, this study measures consumers' perceived value of these. Consumers' sustainability knowledge and attitude towards farm-raised fish are also taken into account. Multinomial logit and basic latent class logit models are employed, together with a direct survey of households in Bangladesh. The results demonstrate that a low level of water use and appropriate feeding in the production process (e.g., environmental and biological indicators) of farmed fish increase consumers' utility and that they are willing to pay a price premium for these attributes. Consumers look for the 'safety label', which indicates intermediately, averagely, and fairly sustainable farmed fish. Initially, consumers prefer averagely sustainable fish, but when they eat a high amount of farmed fish in their total fish consumption, they are more likely to prefer fairly sustainable ones, which are high sustainable. Therefore, the study results indicate that produced fish should be marketed with environmental and biological sustainability indicators, including food safety labels. Additionally, a close monitoring system will increase social acceptability, leading to sustainable fish farming and consumption.

1. Introduction

Because of its nutritional value and dietary features, fish consumption has been increasing globally. However, with population growth, overfishing, pollution, and ocean acidification, wild fish stocks have significantly decreased (Gordon et al., 2018). This rising fish demand and the decline in wild fish have influenced the growth of aquaculture over the last four decades (World Bank, 2013; Naylor et al., 2000). As a result, more than 220 species of shellfish and finfish are cultured (Naylor et al., 2000), and many important fish species are therefore categorised as wild-caught or farm-raised in the market. Therefore, consumers need to consider whether the fish is wild or farmed when they are shopping. If it is farmed, they need to know if the production process was sustainable. Additionally, consumers remain unsure whether the fish have been preserved with harmful additives or preservatives. Therefore, their dependency on fish product information has gained momentum and has become a vital part of their buying decisions in both developed and developing economies.

Currently, developing economies are becoming sources of global economic growth, but also of the emissions associated with the more intensive use of natural resources to fuel their conventional economic growth patterns (OECD, 2012). The OECD added that by 2030 developing economies will have increased the economic benefits from the sustainable use and management of fisheries and aquaculture, in which sustainability indicators (SIs) will be the backbone of monitoring progress towards sustainable development goals (SDGs) at the local, national, and global levels. Therefore, the issues of sustainability and SIs, and interest in the aquaculture of developing economies, are becoming more critical (European Commission, 2017). Four environmental, economic, biological, and social pillars have been recommended to justify the sustainability of aquaculture (Pullin et al., 2007). The biological indicator is a microbiological test system that can increase domestication, genetic enhancement, and feed and energy conversion efficacy. In the current literature on aquaculture sustainability, little attention has been paid to this biological aspect (Pullin et al., 2007). Accordingly, public choices have been influenced by the imbalanced informa-

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[1] Web link: https://en.uit.no/om/enhet/ansatte/person?p_document_id=517394&p_dimension_id=226746, https://scholar.google.nl/citations?user=gz6E4E0AAAAJ&hl=en

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tion communicated to them (O'Rourke & Ringer, 2016), thus leaving room for further research.

Total fish consumption is estimated to substantially grow by 30 percent between 2010 and 2030 (World Bank, 2013). To meet this increasing demand for fish products, aquaculture has been proliferating in the last decade (Little et al., 2016); its contribution to total fish production was 46.8 percent in 2016, up from 25.7 percent in 2000 (FAO, 2018). This increasing demand for farmed fish depends on sustainable fish farming; communication of the SIs of farms; farmed fish exports; and equitability of the distribution of fish to people. Furthermore, Pieniak et al. (2013) found that quality and food safety knowledge was the most interesting information for consumers when buying fish. However, aquatic food security and credibility are only achieved when the food supply, in this context farmed fish, is sufficient, safe, and sustainable (Jennings et al., 2016). In reality, the growth of fish farming is controlled by issues of excess water consumption; availability of space; the high price of feed (Naylor et al., 2000); water unavailability; the environmental risks (Duarte et al., 2009); and social and organisational risks (Schlag & Ystgaard, 2013). Moreover, modern fish farming has raised a variety of potentially controversial issues (e.g., wildly different figures for the feed conversion ratio (FCR) to produce farmed salmon), which may influence public awareness (Schlag & Ystgaard, 2013). The intensification of aquaculture production processes and consumer education can lead to changed public perceptions of fish product safety and environmental impacts in emerging economies (European Commission, 2017). The quality and safety of farmed fish can be enhanced substantially by domestication (Pullin et al., 2007). Using feeds with an appropriate FCR in the aquaculture, genetic enhancement can be significantly improved, which leads to the building of balanced domestication and the right farming conditions to produce healthy fish (Pullin et al., 2007).

In addition, to produce and disseminate the required information, development of labels in the health sector and in relation to sustainable products has taken place (Monier-Dilhan, 2018). Accordingly, eco-labels are used to indicate the degree of sustainability of fisheries and aquaculture (EU, 2013). However, safe and sustainable products are still limited to emerging economies (Monier-Dilhan, 2018), with limited use of food labels in Asian markets (Jonell et al., 2013). In Bangladesh, an emerging Asian economy, which is ranked fourth in world aquaculture production, some farmers use an excess amount of snail meat as feed for the rapid growth of fish, making farming practice unsustainable (Barman & Karim, 2007). For instance, improved feed resulted in a decline of 34% in the use of snail meat, from 164,192 t in 1998 to 22,774 t in 2000 (Barman and Karim, 2007). Furthermore, in Bangladesh, producers and fish vendors unethically use formaldehyde to protect fish from microbial spoilage, which is the case in different wet markets (Rahman et al., 2012). Although there is extensive product differentiation in the aquaculture of Bangladesh's economy, the market has no use for prescribed sustainability labels. Therefore, Bangladesh's inability or unwillingness to adopt fish sustainability labelling (e.g., ASC labelling or eco-labelling) leads to a weakening in its competitive strength in the market and erosion of its global market share.

Additionally, with regard to the growing concerns amongst local consumers about sustainability issues, Bangladesh's fish supply is currently becoming unreliable, and consumers have been losing confidence in sustainable management systems (SMSs). To overcome these sustainability problems and to improve the management of extensive inland water farm resources, and also to bring an increased level of aquaculture to the market, the government of Bangladesh has adopted the Development of Sustainable Aquaculture Project (DSAP) with the help of the United States Government (USAID) and the WorldFish Center. Additionally, the authorities have been operating various mobile courts in retail markets to implement the fish product sustainability and safety scheme. Though publicised as a robust approach to solving food sustainability concerns, it is uncertain whether these latest efforts will make Bangladeshi fish products sustainable and improve the country's goodwill with its seafood business partners. While little attention has been paid to the problems affecting SMS and food value, to the best of the author's knowledge, no research has been conducted which analyses consumers' awareness of sustainability and their preferences for aquaculture SIs in Bangladesh. Since little is known on this subject, this study aims to fill the knowledge gap and help design a sustainable aquaculture policy by investigating the effect of consumers' perceived values of the SIs of fish attributes, their sustainability knowledge, their attitude towards aquaculture products when choosing farmed fish, and their willingness to pay (WTP).

Depending on the scheme boundaries, different fisheries and aquaculture sustainability indicators (SIs), such as environmental suitability, biological idealness, food safety, technological feasibility, societal acceptability, and economic viability can provide significant and balanced sustainable information for consumers and food policymakers (Hasan, 2001; Le Gouvello and Simard, 2017). Although the industrial ecology community has focused on life cycle assessments and the eco-footprints of farms, together with aquatic fish product eco-labels to define the SIs, little is known about what levels or forms of these indicators are more effective in fish choice architecture (O'Rourke & Ringer, 2016). To fill this information gap, the social science community has been investigating how consumers perceive the value of the SIs they receive in the markets when making decisions. The purpose of using indicators is to measure and monitor performance (Azapagic, 2004), and to enhance the effectiveness, transparency, and accountability in managing a natural system (Garcia et al., 2000), with their functions based on simplification, quantification, and communication (Blengini & Shields, 2010). As sustainability is a natural system and a complex issue, a system of indicators is needed to provide stakeholders with aquaculture SIs (Garcia et al., 2000; Azapagic, 2004). These systematised indicators should be examined in partnership with consumers (Liu et al., 2014).

The literature reports that consumers have preferences for different SIs as credence attributes (Feucht & Zander, 2017) and that these can be used to compare different experimental research treatments (Valenti et al., 2018). Additionally, indicators should be selected based on specific criteria and used in the context of set objectives in order to be an essential part of performance evaluation (Garcia et al., 2000). Therefore, this study considers four indicators in its experimental design to assess aquaculture sustainability, which are based on policy relevance, analytical soundness, accessibility to users at an appropriate scale, and measurability, criteria which are recommended for useful SIs by the OECD (Toggweiler & Key, 2001) (see Table 1 and Appendix A). They are then proposed as indicators to achieve the SDGs (Garcia, 1996; Garcia et al., 2000). For instance, the long-term trend in water consumption and FCR is presented as a resource scarcity indicator that motivates consumers to conserve and support sustainable use of the sea and marine resources for SDG. Similarly, the price of fishmeal is considered an incomplete indicator of resource scarcity for natural resource management in sustainable development (Bertrand, 2002). Although decoupling economic growth from environmental degradation is challenging in aquaculture, SIs can contribute to the SDG by reducing the ecological footprint. Therefore, it is subsequently hypothesised that consumers' values regarding farm-raised fish attributes with regard to SIs (e.g., determinants of sustainability) help support asymmetric information among economic agents about fish farming and farmed fish consumption. To test the hypothesis, the data on choice are linked with consumers' per-

Table 1
Fish type, attributes, and the levels of attributes.

Fish type and attributes	Descriptions/state of indicators	Levels and scaling of sustainability indicators
Water efficiency	This is an environmental indicator: the quantity of water consumed to raise animals that live in water, such as fish, used as feed, for conservation, restoration, or sport. A lower amount indicates optimum water consumption.	In terms of consumption of water, high = 3.5 m^3/kg; neutral = 2.5 m^3/kg; and low = 1.5 m^3/kg.
Appropriate feeding	The commercially produced fish feed using wild fish employed in fish farming, with the level measured by the Feed Conversion Ratio (FCR); that is, the ratio of feed given to animal weight gain. A lower ratio indicates appropriate feed.	In terms of the Feed Conversion Ratio (FCR), low = 1.00; neutral =1.50; high = 2.00.
Food label	This is a food safety indicator to estimate fish sustainability. An eco-label will accurately reflect a high level of fish sustainability, meaning that the fish is a significantly healthier option. A safety label reflects a moderate level of sustainability, indicating that pesticide residues, heavy metals, and microorganisms are contained within such fish, but that the content is under control and safe for consumers (Yu, Gao, & Zeng, 2014). Poorly-sustainable fish are produced locally, and are slightly higher in quality than very poorly-sustainable ones. Nevertheless, this type of fish is unregulated at the national level, thus intuitively it is less safe and not eligible to receive a sustainability label.	Food labels: eco-label for superbly- sustainable and simply-sustainable fish; food-safety label for fairly-sustainable, averagely-sustainable and intermediately-sustainable fish; no label for poorly-sustainable and very poorly-sustainable fish.
Price	This is an economic indicator expressing the cost of purchase; what consumers would pay for one kg of the fish selected. Here it is denoted in Bangladeshi currency, taka, globally coded as BDT.	BDT 200/kg for sustainable fish; BDT 160/kg for moderately- sustainable fish; BDT 120/kg for poorly-sustainable or conventional fish.
Fish type	First, consumers' ecosystem values and wellbeing were assessed according to their involvement in and expectations of the attributes mentioned above when choosing farmed tilapia, through probability distribution (Laurent & Kapferer, 1985). Second, the seven sustainability indicator scales (levels) were used to judge these scores. Hence, the scaling indicators were used as a tool for qualitative measurement of consumers' value judgements (Prescott, 1996). A high score indicates a high value and a high level of sustainability (see Appendix A).	Sustainability indicator scaling: 80% and above = superbly-sustainable; 71% to 80%= simply-sustainable; 61% to 70% = fairly-sustainable: 51% to 60% = averagely-sustainable; 41% - 50% = intermediately-sustainable; 21% - 40% = poorly-sustainable; 0% - 20% = very poorly-sustainable.

ceived sustainability knowledge and their attitude towards farmed fish. An experimental design then characterises their choice patterns and WTP for farmed tilapia in relation to the SIs. The targeted respondents were 500 households in Chittagong, Bangladesh, with the use of a within-subject design. They were interviewed using an experimental design. The collected data were analysed with multinomial logit (MNL) and basic latent class models (LCM) using STATA and R software, respectively.

The structure of the remainder of the study is as follows. An attempt is first made to produce a theoretical framework together with the econometrics model. The model and collected data are then analysed. Subsequently, the research results are presented, followed by related discussion. Finally, the paper ends with the concluding remarks and suggestions for further research.

2. Theoretical Framework and Econometrics Modelling

Aquaculture is an emerging global aquatic food-producing industry. The industry's current growth is taking place in the context of public awareness of production systems, food quality and safety, health impacts, sustainability, and animal welfare (Aarset et al., 2004; WagnerValenti et al., 2018). According to tradition, economic, environmental, and social dimensions apply when considering aquaculture sustainability (UN, 1992; Maynard et al., 2020). Sustainability is applied in the ecological sense (Edwards, 2010), which is concerned with preserving biological systems and natural resources (Harte, 1995). Therefore, sustainability has become a buzzword (Bock, 2012), and there is a gradient between unsustainable and sustainable systems which leads to the identification of different levels of sustainability (Wagner et al., 2018). Achieving such sustainability levels is a difficult job, which should be done gradually, with sustainable interventions in the existing SMS (Wagner et al., 2018). Therefore, to evaluate aquaculture sustainability, various mixed methods such as carbon and ecological footprints (Gyllenhammar & Håkanson, 2005; Madin & Macreadie, 2015), emergy analysis (Garcia et al., 2014; Wang et al., 2015; Williamson et al., 2015) and life cycle assessment (Santos et al., 2015; Medeiros et al., 2017) are used. Furthermore, aquaculture sustainability can be evaluated by applying various sets of indicators, which are variables that define a process in a simplified way and are employed to measure specific attributes (Valenti et al., 2018).

Several sustainability labels, such as Fair Trade, Rainforest Alliance, Carbon Footprint, and Animal Welfare, have emerged to support food attributes. The eco-label has also appeared as an indicator of sustainability (Grunert et al., 2014), specifically for farmed fish (Julia & Frank, 2017). Additionally, to certify environmentally and socially responsible aquaculture, Aquaculture Stewardship Council (ASC) and Global Aquaculture Alliance labels have appeared. Moreover, it is believed that green and organic food labels may increase the environmental sustainability of agriculture and can help reduce food-borne diseases (Sanders, 2006; Yin et al., 2010). Health and disease prevention could significantly contribute to sustainable development (Buse and Hawkes, 2015). More specifically, the impacts of aquaculture on rural communities' food security are crucial for such development (Costa-Pierce, 2010; Béné et al., 2016). However, without food safety, we cannot have food security (Thea et al., 2017), which is reflected by social sustainability indicators (Wagner et al., 2018). Food safety and security are two complementary elements of a sustainable future (Dayanne et al., 2020), and must be aligned to achieve sustainability (Vågsholm et al., 2020). As public confidence in food safety is critical for sustainable and resilient food production systems (Vågsholm et al., 2020), food safety labels can be linked positively with food sustainability labels. Accordingly, farmed fish with the 'eco-label' and 'food-safety label' will fulfil the criteria to be sustainable. As a result, the demand for sustainability-labelled, eco-labelled, and food-safety labelled farmed fish should be higher than for unlabelled ones.

Furthermore, the economic impact of the eco-labelling of fish products is affected by other factors, such as consumers' altruism (Andreoni, 1990); their interest in the product; its overall sustainability (Brécard et al., 2012); consumers' income; and their WTP. Moreover, for consumers who have a higher level of income, the marginal utility should be lower (Tirole, 1988), as they will be less price-sensitive, and their WTP should be higher (Brécard et al., 2012). The literature demonstrates that consumers' WTP for wild fish and sustainable foods is higher than for conventional foods

(Davidson et al., 2012; Mazzocchi et al., 2016). Like other conventional agriculture farms, fish farms may have certain adverse effects on the environment (Hall and Amberg, 2013). However, aquatic fish product choice depends mainly on risks and a balanced evaluation of costs and benefits (Bacher, 2015). Therefore, farmed fish availability and international trade are strongly influenced by food sustainability and food safety, together with consumers' perceived risk.

Presently, consumers are more likely to choose eco-labelled foods if they are highly concerned about environmental issues (Grunert et al., 2014). In addition to environmental effects, one of the long-standing issues is the use of fish oil and fishmeal in feeds and the number of wild fish used to produce farm-raised ones. This issue has been particularly evident when studies have provided asymmetric numbers for the weight in pounds of wild fish it takes to produce a pound of farmed fish (the FIFO ratio[1]). In additional, modern aquaculture has raised a range of potentially controversial issues, which have impacted on public perceptions (Schlag & Ystgaard, 2013). These have led to a decrease in consumer confidence in the quality, safety, and production methods of farmed fish (Moretti et al., 2003). In turn, this decreased confidence level leads consumers to consider non-scientific general concerns, such as nature and trust, which influence their preference for wild over farmed fish (Schlag & Ystgaard, 2013). However, these issues and impacts are yet to be fully assessed, but have sparked consumer and media interest in food contamination (Watterson et al., 2008).

Consumers show a positive trend towards farmed fish in general, but this is weakened when environmental issues arise (Froehlich et al., 2017). Different reasons have been given to explain this mixed and contradictory impression amongst consumers of farmed fish. First, the industry is still a relatively new one for most people; scientific research on the subject is only a recent development (Verbeke et al., 2008). Second, consumers are not passive recipients of information (Petts et al., 2001), and their perception of farmed fish is low (Schlag, 2010). Their beliefs concerning farmed fish are based on image transfer and emotions based on traditional livestock production, rather than on their perceived knowledge and the facts (Verbeke et al., 2007). Therefore, consumers may be influenced by adverse reports in the media on farmed fish and local environmental disasters (e.g., oil spills), which are not directly linked to fish farming, or the differences between the forms of marine farming may not be entirely understood (Froehlich et al., 2017). Usually, only a small consumer segment is concerned about food sustainability, and they have a low level of knowledge regarding fish farming and its products (Zander et al., 2018). As a result, understanding aquaculture sustainability is challenging, and rigorous initiatives are required along the whole value chain to develop this market, in which the retail sector is the key actor (Zander et al., 2018). Although subjective evaluation is recommended to measure consumers' understanding (Selnes, 1986), there is little understanding of the impact of the level of consumers' sustainability knowledge on their farmed fish choices, specifically in emerging economies. Detailed empirical research on consumer differentiation of aquaculture is also lacking (Schlag & Ystgaard, 2013). Therefore, these issues are considered in the study's experimental design to support the effort to understand consumer choices for sustainably-farmed fish in relation to SIs and to explore opportunities to trade the sustainably-farmed fish.

When studying buying behaviour in relation to the choice between several alternative products, in the economics literature it is common to use the discrete choice model (Train, 2003). This model explains the mathematical function that estimates a consumer's choice based on relative attractiveness or utility (Shomik Raj Mehndiratta, 1997). One of the most commonly used discrete choice models is the MNL model, which provides log odds of the nominal outcome as a linear combination of the predictor variables. For instance, a consumer can discretely choose one type of fish from the different alternatives considered to be intermediately-sustainable, averagely-sustainable, fairly-sustainable etc. In this study, the household choice for sustainably farmed fish was modelled using the disaggregate fish demand approach, with the MNL model expressed below:

$$P_n = \frac{\exp(V_{in})}{\sum_{j=1}^{K} \exp(V_{jn})} \tag{1}$$

where $P_n(i)$= the probability of individual $n$choosing alternative i; V_{jn}= utility obtained by individual n from alternative j; and K = number of accessible fish alternatives. The utility of individual $n$from alternative $j,V_{jn,}$ is derived from the following linear function of the independent variable:

$$V_{jn} = \beta_{0j} + \beta_{1j}X_{1n} + \beta_{2j}X_{2n} + \ldots + \beta_{nj}X_{qn} \tag{2}$$

where β_{0j} = an alternative specific constant for alternative j; $\beta_{1j,}\ \beta_{2j,}\ \ldots\ldots,\ \beta_{nj,}$ = coefficients associated with the independent variables; $X_{1n,}\ X_{2n,}\ \ldots\ldots,\ X_{qn,}$= independent variables for individual n; and q = number of independent variables in the model.

On the other hand, a group of homogeneous consumers' heterogeneity of preferences can be shown discretely by employing an LCM. In this model, i individuals are substituted into several r latent classes (Boxall & Adamowicz, 2002). For example, we observe that J manifests categorical variables, with each variable covering K_j possible results for individuals $i = 1, \ldots, N$. The manifest variables can produce a diverse number of outcomes, which are denoted by j. The observed values are Y_{ijk} of the J manifest variables, such that $Y_{ijk} = 1$ if respondent i provides the kth response to the jth variable; otherwise, $Y_{ijk} = 0$, where $j = 1, \ldots, J$ and $k = 1, \ldots, K_j$. In the LCM, $f\ (Y)$ is discrete and takes $r$distinct values (Train, 2003). Finally, the posterior probability of each individual belonging to each class is uncertain and depends on the perceived values of the manifest variables, can be accounted for by employing equation 3 (Linzer & Lewis, 2010):

$$\hat{P}(rY_i) = \frac{\hat{p}_r f\left(Y_i;\ \hat{\pi}_r\right)}{\sum_{q=1}^{R} \hat{p}_q f\left(Y_i\ ;\ \hat{\pi}_q\right)} \tag{3}$$

In contrast, individuals' prior is explained by the LCM, which varies depending upon their observed covariates. To estimate individuals' latent class membership, the model simplifies the basic LCM by allowing the insertion of covariates (Dayton & Macready, 2019; Hagenaars & Mccutcheon, 2002). poLCA, an R programming package, randomly chooses the first latent class as a 'reference' case. In addition, it is assumed that the log-odds of latent class membership priors are linked linearly with the covariates. If β_r is the vector of coefficients conforming to the rth latent class, with S covariates, β_r has length $S + 1$, which is one coefficient on each of the covariates, plus a constant. As the first class is considered as the base, $\beta_1 = 0$ is predetermined by definition. The probabilities of posterior class membership in the LCM are then obtained by equation 4 (Linzer & Lewis, 2010):

$$\hat{P}(rx_i; Y_i) = \frac{P_r\left(X_i;\ \hat{\beta}\right) f\left(Y_i;\ \hat{\pi}_r\right)}{\sum_{q=1}^{R} P_q\left(X_i; \hat{\beta}\right) f\left(Y_i; \hat{\pi}_q\right)} \tag{4}$$

The MNL and the LCM specifications were estimated using STATA version 16 software, and R version 3.5.2 respectively. Estimates of the MNL model and LCM are shown in Table 4. The coefficients of the models are marginal utilities, which are not interpretable because of their ordinal utilities. However, the ratios of

[1] FIFO (the Fish In:Fish Out ratio) has been examined over time as a way of considering the performance of aquaculture concerning the wild fish that are utilised for feed.

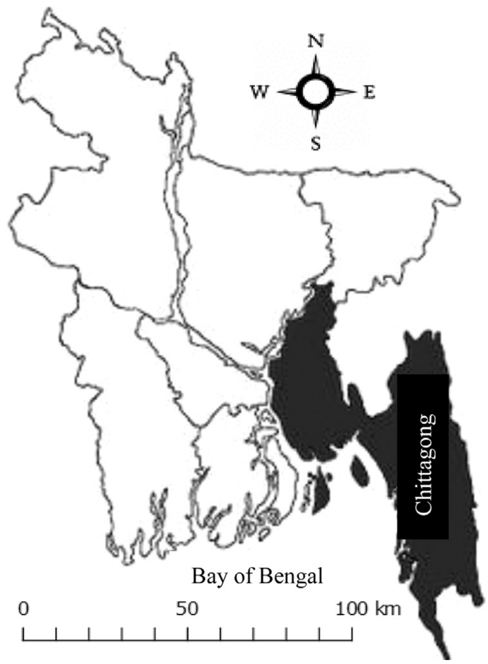


Fig. 1. Black shading indicates the Chittagong area.

the coefficients are marginal rates of substitution (MRS), which can be interpreted. For example, if the observable part of utility is $V = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3$, joint variations of *x1*and *x2* give an equal MRS, which leads to remain indifference for the same level of utility, such that: $dV = \beta_1 dx_1 + \beta_2 dx_2 = 0$; and $-\frac{dx_2}{dx_1}| \; dv = 0 = \frac{\beta_1}{\beta_2}$. Accordingly, these outcomes are utilised to attain a WTP measure, which is given by:

$$\mathrm{WTP}_k = -\frac{\beta_k}{\beta_p} \tag{5}$$

where $\mathrm{WTP_k}$ is the willingness-to-pay for the *k*th attribute; β_k is the estimated parameter of the *k*th attribute; and β_p is the estimated price coefficient. The WTP for the attributes in the MNL model are demonstrated in Table 4.

3. Material and Methods

In Asia, including Bangladesh, tilapia farming is a profitable business (Dey et al., 2000; Rahman et al., 2012). In Bangladesh, fish provide 60% of total animal protein, of which the contribution of tilapia in 2012-2013 exceeded 11%, which is a remarkable figure for an exotic species (FRSS, 2013). Additionally, the contribution of tilapia to agricultural GDP was 1.56% (FRSS, 2013). Therefore, Bangladesh started to export the fish, and in 2012-2013 the export volume was 333 mt, valued at BDT 36.4 million (FRSS, 2013). Chittagong (see Fig. 1) is called the 'Gateway of Bangladesh' for its key contribution to foreign trade; the city's per capita fish consumption is the highest in the country (Needham & Funge-Smith, 2015). Furthermore, people living in the city are relatively wealthier than the rest of the country (BBS, 2019) and thus are suitable subjects for our attempt to explore the growing consciousness in an emerging market such as Bangladesh. The city is most influenced by the awareness of food sustainability in advanced western countries. In Bangladesh, all tilapia is produced on farms, so knowing the perceived value of the fish by consumers in this city would be interesting for Bangladeshi fish market segmentation. Besides, the policy formulated based on the results of the study should be more effective. Therefore, Chittagong's urban zone was the sample area for the study, and the respondents were interviewed presenting a structured questionnaire (see Appendix B) in the local language Bengali.

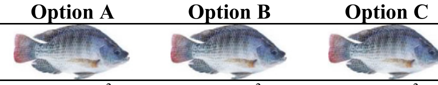
To gather the representative sample, stratified cluster sampling processes were employed. There are 12 administrative areas (police stations (PSs)) in the city. Each PS includes several small administrative areas called 'wards,' resulting in 41 areas in total. To choose the subjects, ten police stations (Katowali, Bakoliya, Bayazid, Chandgaon, Hathazari, Khulshi, Patenga, Panchlaish, Double Mooring, and Halishahar) were randomly selected. One ward from each PS was also chosen randomly to recruit 50 respondents by employing the convenience sampling method.

The fieldwork was undertaken from 2 August to 3 October 2018. Before the ultimate version of the survey was completed, a pre-test survey on 21 subjects from two PSs (Katowali and Chandgaon) was conducted to confirm that the respondents understood the questions and that no semantic nor measurement problems existed. As no significant obstacles were found, it was decided to keep the same language and measures for the final version. Primary respondents who were older than 21 and responsible for buying fish and taking care of what the other household members ate were chosen to be questioned. Before proceeding, the Dean Committee, University of Chittagong, Bangladesh, approved the ethical standard of the survey content. On average, each interview took 20 minutes. The purpose of the research was specified in a motivational letter, along with the relevant information (textual and visual) about sustainability indicators.

3.1. Questionnaire and measures

The first section of the questionnaire centred on fish choice through the choice-focusing attributes of fish production methods. The six choice selections were presented in a table, and respondents were requested to choose one from every selection (Fig. 2). Three fish options with four attributes (SIs) were considered in order to assess consumers' value perception of fish sustainability in each choice set. In line with cutting-edge theory, the focus group stakeholder participants helped to identify, interpret, and apply the four crucial sustainability dimensions, namely the environment, biology, food security, and economics (Feenstra et al., 2005). The leading and most widely used indicators of the four dimensions of aquaculture sustainability were considered when selecting these four attributes. Further, an additional option, 'opt-out,' was included in each selection to allow the option to select none of the choices if none were found to be suitable. Their values were then assessed on seven SI scales (very poorly-sustainable, poorly-sustainable, intermediately-sustainable, averagely-sustainable, fairly-sustainable, simply-sustainable, and superbly-sustainable), based on the indices of human and ecosystem well-being used in the 'sustainability barometer' of Prescott Allen (1996) and Garcia et al., (2000). The choice experiments organised in a within-subjects study design was affected by the quantity of water used in production (excess, fair, low); the feed used in production (appropriate, neutral, inappropriate); the sustainability level as shown by the food label ('eco-label' = sustainable, 'safety-label' = moderately-sustainable, 'no-label' = unsustainable or poorly-sustainable); and the price per kg of the fresh tilapia (sustainable = BDT 200, moderately-sustainable = BDT 160, poorly-sustainable or conventional = BDT 120). To estimate the amount of water and FCR used in the production process, existing and relevant studies were consulted, and the estimated amounts were justified in a focus group discussion. The price was also estimated in the focus group discussion so that the estimated values were relevant for the local economy. Although the targeted respondents were the 500 households in the Chittagong urban area, ten questionnaires were rejected as they were unusable, being only partly completed. Therefore, 490 consumers were

Imagine you are in the market and you would like to buy 1 kg of the fish you usually buy. Do you choose Option A, Option B, Option C or Option D?



	Option A	Option B	Option C	Option D
Attributes				
Water used (quantity measured in cubic metres/kg)	2.50 m^3 (Cubic metres)	2.50 m^3 (Cubic metres)	1.50 m^3 (Cubic metres)	None of these
Feed used (quality measured by the feed conversion ratio)	2.00 FCR	1.50 FCR	1.00 FCR	
Food label	Eco-label	Safety-label	No-label	
Price/kg	BDT 160	BDT 160	BDT 160	
I would choose:	☐	☐	☐	☐

Fig. 2. Example of a choice set

considered in a between-subject design, providing a data set of n = 490*6*4 = 11760.

A total of 3^4 (81) hypothetical products could be created by connecting the attributes mentioned above with the four factors and three levels (see Table 1). For useful analysis, the study employed an orthogonal fractional factorial design. SPSS provided the minimum number of six choice sets with the 18 product profiles. The order in which the choice sets and label types were presented to the participants was then randomised. Following Balcombe et al. (2010), the participants were instructed to think about the choice scenarios as if they were real. They also rated the statements on sustainability knowledge and attitude towards farmed fish, and ranked the SIs in a ranked-choice voting system. Finally, they completed a demographic survey after the completion of the choice experiment.

The literature reveals that community interest in sustainability is increasing, and that consumer attitudes are mostly high; however, behaviours are not unambiguously consistent with attitudes (Vermeir & Verbeke, 2006). Therefore, this study examines consumers' perceived sustainability knowledge and their attitude when choosing sustainably farmed fish. Two constructs, 'knowledge' and 'attitude' scales, were developed based on previous studies. In doing so, the subjects were asked to rate statements on a seven-point Likert and bi-polar scale of items. The knowledge scale was created by applying the subjective decisions of respondents: "I understand the sustainability certification label on product packaging" (Mostafa, 2008), together with the issues that " I believe that sustainable aquaculture production has a small ecological footprint (Roth & Burbridge, 2001)"; "Ecological sustainability can be assessed as an environmental impact on the area of land used to produce cultured fish (Bosma & Verdegem, 2011)"; and "Helping people escape a low-protein diet is a required condition to become more sustainable (Michalos et al., 2019)".

The general attitude towards farmed fish was assessed by four seven-point bi-polar scale items: 'negative' to 'positive'; 'bad' to 'good'; 'unfavourable' to 'favourable'; and 'enjoyable' to 'not enjoyable' (Lichtenstein & Bearden, 1989). The participants were asked to define their feelings concerning farmed fish by circling one option in each item. The study employed Explorative Factor Analysis (EFA) to decide the best number of dimensions and their mutual connotations based on responses to particular issues in order to build a pattern matrix (Hair et al., 2014).

Based on the EFA pattern matrix, statements two and three (i.e., as listed) were accepted by examining the factor loading principle for the final constructs of 'knowledge' and 'attitude' respectively (see Table 2). The mean values of the two factors for 'knowledge' and the three factors for 'attitude' were then measured to be employed as independent variables. Mean scores of four or below were regarded as showing lower sustainability knowledge or a negative attitude towards farmed fish. A score of five was considered to be neutral, while scores above five were deemed to represent greater knowledge, or a positive attitude. Therefore, the study estimated preference heterogeneity by linking the stated preference choice data, the demographics, and the perceived value of knowledge and attitudes in an MNL model and a basic LCM. The basic LCM was employed using the R package poLCA written by Linzer & Lewis (2010) to analyse consumer profiles and fish market segmentation.

Table 2
Outcome of Explorative Factor Analysis

Observed variables	Latent variables Knowledge	Attitude
"Ecological sustainability can be assessed as an environmental impact on the area of land used to produce cultured fish" [a]	0.833	
"Helping people escape a low-protein diet is a required condition to become more sustainable" [b]	0.780	
Feelings about farmed fish from negative to positive		0.806
Feelings about farmed fish from unfavourable to favourable		0.804
Feelings about farmed fish from enjoyable to not enjoyable		0.709
Eigenvalue	1.353	1.858
KMO score	0.609	
Bartlett's test of sphericity	P<0.000	
Total variance explained (%)	64.211	
Determinant of correlation matrix	0.516 > 0.001	

Note: Extraction method: Principal Component Analysis
[a] (Bosma & Verdegem, 2011)
[b] (Michalos et al., 2019).

4. Results

4.1. Descriptive statistics of respondent demographics and socioeconomic variables

The participant demographics and socioeconomic variables are presented in Table 3. The majority of the participants were male (79 %); 39 % were aged between 21 and 30 years old; and 47 % had 5 to 12 years of education. 36 % of households, the majority, had four family members. As a Bangladeshi culture, men are responsible for buying primary food (almost 80 %) for their family (Schaetzel et al., 2014). The mean monthly income of 52 % of the respondents was equivalent to or less than BDT 30,000 (US$1=BDT84), with the average monthly household income of Bangladesh being BDT 31,883 (PPRC, 2016). The descriptive statistics show that the consumers' perceived level of sustainability

Table 3
Descriptive statistics of the demographic and psychographic variables and the preference patterns for farmed fresh fish.

Sample size (households)	490
Age (%)	
20 to 29	39.2
30 to 39	34.7
40 to 49	18.8
50 to 59	5.9
60 to 69	1.4
Gender (%)	
Male	78
Female	22
Education (%)	
0 to 5 years	6.9
5 to 12 years	46.9
Above 12 years	46.1
Number of family members (mean ± St.dev.)	4.56 ± 1.45
Number of children aged 1-16 (mean ± St.dev.)	1.20 ± 1.05
Monthly household income (BDT) (%)	
Less than 30,000	52.4
30,000 to 50,000	39.6
50,000 to 70,000	6.3
70,000 to 90,000	1.4
More than 90,000	0.2
Personally do the family shopping (%)	
Yes	84.5
No	15.5
Overall fish consumption (%)	
Less than once a month	0.2
Once a month	3.7
Several times a month	6.7
Once a week	15.1
Several times a week	46.5
Almost daily	24.3
Daily	3.5
Fish bought (at least once) in the last 4 weeks (%)	
Yes	93.1
No	6.9
Source of fish bought (%)	
Wet market	42
Supermarket	44.9
Both	13.1
Distinguish between wild and farmed fish (%)	
Yes	40
No	60
Farmed fish bought on each of last ten fish purchases (mean ± St.dev.)	3.96 ± 2.56
Registered member of a volunteer environmental organisation (%)	
Yes	9.4
No	90.6
WTP of the members of environmental organisations (mean ± St.dev.)	188.88 ± 62.51
WTP of the non-members of environmental organisations (mean ± St.dev.)	163.12 ± 33.50

knowledge was average (5.03 on a scale of 1 to 7), and that their attitude towards farmed fish was positive (5.25 on the same scale). The results also reveal that almost all the respondents (93 %) had bought fish during the previous month. Approximately 45% of the urban households bought their fish from the supermarket, 42 % from the wet market, and 13 % from both the wet market and supermarket. Only 9.40 % of the respondents were members of volunteer environmental organisations and their WTP for sustainably farmed fish was higher than that of those who were not in such organisations. If the reason for the choice of opt-out by 3.94 % of the sample was only for their absolute preference for wild-caught fish, then sustainably farmed fish could be a good alternative to wild ones for most of the sampled respondents.

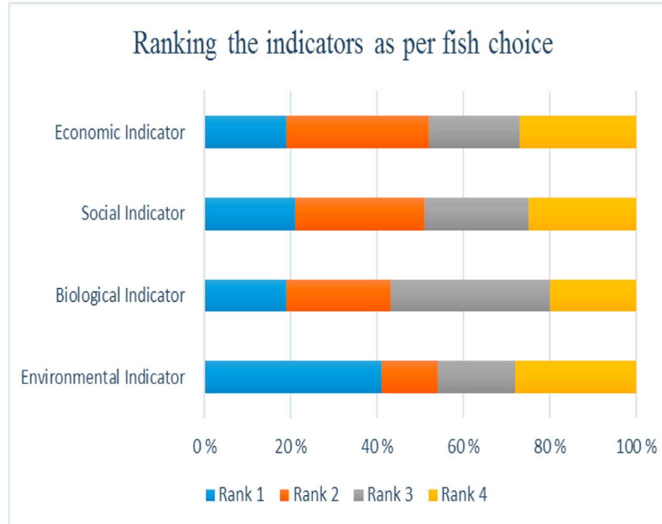


Fig. 3. Percentage of consumers' ranked choices of sustainability indicators.

4.2. Consumers' ranking of sustainability indicators (SIs) and their willingness to pay (WTP)

Consumers' preferences for the SIs were assessed by the contingent preference method. In doing so, a ranked-choice voting system was initiated, by which consumers ranked four indicators by preference. The results (see Fig. 3) show that 41 %, the highest number, ranked environmental indicators (water consumption) in the top position, as the most influential factor in choosing farmed fish. For low consumption of quality water, consumers are willing to pay a price premium of BDT 51.75/kg for tilapia, which is the highest among the three SIs. Second, 21 % of respondents thought that the food safety indicator, i.e., the food label, was the most critical indicator of making aquaculture sustainable. However, their WTP was negative for the eco-label and no-label. Third, 19 % of the participants believed that the biological indicator (the FCR) was the most crucial attribute in choosing sustainable fish; their WTP concerning the use of appropriate feed was BDT 46.00/kg. Finally, the economic indicator (price) was ranked in first place by 19% of the participants.

4.3. Consumer preferences for farmed fish and their willingness to pay (WTP)

The econometrics model results demonstrate the significance of addressing the alternatives, together with their attributes, which affect consumers' preferences. Equation (1) illustrates the projected parameters in the MNL model, explained as the marginal effects of the observed independent variables on the logarithm of the odds of success (exponentiate of coefficients). In this study, choice refers to the ratio of the probability of choosing various farmed fish and the value of their perceived attributes, such as water, feed, and food label. WTP can be calculated by choice modelling (hypothetically measured) and the contingent valuation method (real WTP[2]). The evidence shows that the estimated results using these two methods can be different for the utility function (Mogas, Riera, & Bennett, 2009). Therefore, to define how close the hypothetical WTP is to the real WTP, the hypothetical bias was measured

[2] To estimate WTP in the CVM, the subjects were asked to state their WTP for 1 kg of farmed tilapia. For instance, suppose that the price for traditional farmed fish is BDT 120/kg, how much would they be willing to pay for farmed fish from sustainable aquaculture (BDT…)?

Table 4
Multinomial choice model estimate for sustainability indicators used in aquaculture

Variables	Choice of farmed fish in the Multinomial Logit (MNL) model				
	Model with fish attributes only	Model with fish attributes and interactions between attributes and the socioeconomic variables	Consumers' willingness to pay based on the MNL model for fish attributes and the socioeconomic variables		
			WTP	S.E.	C.I.
Excess water	-0.133** (0.063)	-0.109* (0.066)	-27.25	16.99	[-62.24, 7.74]
Optimum water	0.207*** (0.064)	0.157** (0.069)	39.25	19.12	[-0.13, 78.63]
Appropriate feed	0.184*** (0.059)	0.156** (0.062)	39.00	17.13	[3.71, 74.28]
Inappropriate feed	-0.357*** (0.138)	-0.305** (0.144)	-76.25	38.68	[-155.91, 3.41]
Price	-0.004*** (0.001)	-0.004*** (0.001)	–	–	–
Eco-label	-0.850*** (0.054)	-0.687*** (0.093)	-171.70	39.13	[-252.34, -91.15]
No-label	-0.129 (0.092)	-0.093 (0.176)	-23.25	44.26	[-114.41, 67.91]
Opt Out	-3.476*** (0.161)	-3.474*** (0.161)	-868.50	135.3	[-1147.19,-589.8]
HSK*Appropriate feed		0.119 (0.097)	29.75	24.94	[-21.62, 81.12]
HSK *Optimum water		0.228* (0.128)	57.00	33.69	[-12.40, 126.40]
HSK *Eco label		-0.506*** (0.107)	-126.50	35.55	[-199.72, -53.27]
LSK*Inappropriate feed		-0.543 (0.423)	-135.70	108.8	[-359.94, 88.44]
LSK*Excess water		-0.203 (0.145)	54.00	37.44	[-23.11, 131.11]
LSK*No label		0.216 (0.258)	54.00	65.31	[-80.51, 188.51]
Attitude positive*No-label		-0.495** (0.203)	-123.70	55.65	[-238.38, -9.11]
Attitude negative*Eco-label		-0.262 (0.219)	-65.50	56.14	[-181.13, 50.13]
Low consumption*Price		0.000 (0.000)	0.093	0.087	[-0.08, 0.273]
High consumption*Price		-0.000 (0.000)	-0.037	0.09	[-0.223, 0.14]
Low age*Eco-label		-0.093 (0.087)	-23.25	22.09	[-68.75, 22.25]
Low age*No-label		-0.340* (0.179)	-85.00	47.52	[-182.88, 12.88]
High age*Eco-label		-0.009 (0.143)	-1.25	71.56	[-148.63, 146.13]
High age*No-label		-0.005 (0.286)	-2.25	35.69	[-75.76, 71.26]
Female*Eco-label		0.022 (0.081)	5.50	20.37	[-36.47, 47.47]
Income high*Eco-label		0.157 (0.121)	39.25	31.15	[-24.91, 103.41]
Income low*No-label		0.529*** (0.141)	132.20	43.07	[43.53 220.96]
N= 11,760					

Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Parameter estimates from the MNL model. HSK= High sustainability knowledge; LSK= Low sustainability knowledge. Standard Error estimated with the Delta method.

(Schmidt & Bijmolt, 2019) by calculating the effect size[3]; the level of 0.43 shows a moderate level of bias.

Table 4 shows the results of the estimated utility functions. The MNL model coefficients specify that excessive use of quality water and inappropriate feed in the production process are valued negatively by consumers and reduce their utility, so they are less likely to choose produced fish. For these two attributes, consumers' WTP is also negative. On the contrary, a low amount of quality water consumption and appropriate feed used in the production process increases their utility, as people are more likely to choose fish produced with these attributes. Consumers are willing to pay a price premium for a low quantity of quality water use and appropriate feeding in the fish farming method. The results also demonstrate that WTP based on a lower level of quality water consumption is slightly higher than that of appropriate feed used in the production process, meaning that consumers prefer environmental indicators to biological ones. Regarding sustainable fisheries and aquaculture, consumers in Europe also perceive the environmental aspect to be the most significant for sustainability attributes, rather than economic and social sustainability (Zander & Feucht, 2018). Although the supply of wild fish is lower than demand, and prices are beyond many consumers' capacity, their perceived value of such fish is fixed. The results demonstrate that the no-buy option (e.g., opt-out) is valuable and that people are less likely to buy farmed fish when their WTP is also highly negative.

Second, price is an essential issue for consumers; however, an increase in price reduces the utility of fish (by -0.004). The MNL model also demonstrates that the eco-label, hereafter referred to as the sustainability label, decreases consumer utility, and that they prefer to pay less for this attribute. Grunert et al. (2014) also found that sustainability labels do not play a significant role in food choices. The first reason could be that consumers do not understand the meaning of 'eco-label' or assume that a food safety-label indicating a moderate level of sustainability is a powerful option over the 'eco-label' in terms of food sustainability. Alternatively, when consumers see that a low level of quality water is used in the fish production process and that the FCR is appropriate for sustainable fish, no food label is required to recognise such sustainability, because merely providing information on sustainability issues has an insufficient influence on changing typical consumer behaviour (O'Rourke & Ringer, 2016). Consumers are willing to pay less than BDT 23.25/kg for fish with no label. Besides, the interaction between a high level of sustainability knowledge and the 'eco-label' variable is negatively significant, meaning that consumers with a low level of sustainability knowledge frequently choose eco-labelled farmed fish. On the other hand, the 'no-label' decreases their utility for fish, showing that knowledgeable consumers are looking for a new label between the 'eco-label' and 'no-label,' namely a 'food-safety' or 'moderate sustainability' label. In general, as very poorly- and poorly-sustainable fish would

[3] This is the natural logarithm of the response ratio, which is the ratio of the mean of hypothetical and real WTP.

Table 5
Estimated results of the choice probabilities of product alternatives with regard to the sustainability indicators.

Variable	Trend of the response to sustainability	Consumer Choice Heterogeneity in the Latent Class Logit Models (LCM). Provisional item response probabilities in the column, by outcome variable			
		Class 1: Opted out or non-buyers of farmed fish or wild fish buyers	Class 2: Averagely-sustainable fish buyers	Class 3: Intermediately-sustainable fish buyers	Class 4: Fairly-sustainable fish buyers
Excess amount of water (Unsustainable)	Yes	0.0000	0.3861	1.0000	0.0000
	No	1.0000	0.6139	0.0000	1.0000
Low amount of water (Sustainable)	Yes	0.0000	0.2738	0.0000	0.4616
	No	1.0000	0.7262	1.0000	0.5384
Appropriate feed (Sustainable)	Yes	0.0000	0.6644	0.7176	0.6370
	No	1.0000	0.3356	0.2824	0.3630
Inappropriate feed (Unsustainable)	Yes	0.0000	0.0554	0.0000	0.0915
	No	1.0000	0.9446	1.0000	0.9085
Eco-label (Sustainable)	Yes	0.0000	0.5563	0.4208	0.6412
	No	1.0000	0.4437	0.5792	0.3588
No-label (Unsustainable)	Yes	0.0000	0.1050	0.2968	0.0000
	No	1.0000	0.8950	0.7032	1.0000
Price (sustainable)	Yes	0.0000	0.3353	0.2805	0.3647
Price (unsustainable)	Yes	0.0000	0.3348	0.2805	0.3653
Opt-out (No-buy)	Yes	1.0000	0.0000	0.0000	0.0000
Opt-out (No-buy)	No	0.0000	1.0000	1.0000	1.0000
Class Probability		0.25	0.32	0.17	0.26
Frequency of farmed fish consumption (Covariates of LCM) N = 11760		Reference case	Coefficient = 0.07709	Coefficient = -0.05632	Coefficient = -0.05841

In this case, water indicates 'good water quality'. AIC (4): 239686.9; BIC (4): 240438.9; χ^2 (4): 1001499 (Chi-square goodness of fit), residual degrees of freedom: 11658. The lowest quantity of natural resources with the highest efficiency indicates sustainable fish; vice versa for unsustainable fish.

have been cultivated, consuming excessive amounts of water and inappropriate feed in conventional fish farming, they are not eligible for a sustainability label. Ultimately, the 'no-label' of unsustainable fish reduces consumers' utility.

Third, while a 'no-label' is not valuable for consumers, it significantly increases their utility when considered together with a low level of income. This classifies 'no-label' and 'low income' as complementary, showing that having a low income forces people to choose low-priced, poorly sustainable fish over sustainable ones. The 'no-label' is negatively significant with a positive attitude, which indicates that a consumer with a negative attitude towards farmed fish is more likely to prefer unlabelled farmed tilapia for their substitution effect. Moreover, a significant negative interaction term between low-age and no-label indicates that older consumers strongly prefer unlabelled or poorly sustainable farmed fish. In local Bangladeshi markets, the supply of sustainable fish is at low levels. Therefore, consumers are less likely to purchase sustainable food because of its short supply (Zanoli & Naspetti, 2002). The results also show that the interaction effect of a high level of sustainability knowledge and the consumption of a low amount of quality water in the production process is valuable and has a positive influence on fish choice, showing that with a high level of sustainability knowledge, consumers are more likely to choose environmentally sustainable farmed fish over unsustainable ones.

4.4. Consumer profile and fish market segmentation: analysis of the basic latent class model (LCM)

The heterogeneity of choice found in the MNL model translates into substantial differences between members of diverse classes in the LCM. This was run with the latent variables, including the 'factor price.' Based on the AIC, BIC, and Chi-square (χ^2) goodness of fit scores, the four latent classes were determined as the best model fit. It is always worth demonstrating that the number of residual degrees of freedom is positive (Linzer & Lewis, 2010), so that the requirement is met. Additionally, the theory also helps reinforce the validity of the classes. A sensible theoretical approach assumes four latent classes of survey participants: fish buyers in the intermediately-, averagely-, and fairly-sustainable categories, and those who have opted out of making fish choices. The intermediately-sustainable category will tend to respond favourably to the characteristics of fish in the poorly-sustainability group, and unfavourably towards sustainable ones, with the reverse being the case for fish buyers in the fairly-sustainable group (see Table 5). The group of averagely-sustainable fish buyers will tend to respond favourably to the average scores of sustainability between the intermediately- and fairly-sustainable characteristics of fish. Finally, those in the opt-out group do not prefer any specific type of farmed fish.

The LCM results for the first latent class (25% of the population), the perceived value of 'opt-out,' is 100%, indicating they do not focus on farmed fish. This refers to the 'no-buy' group, who can also be wild fish-buyers, farmed fish non-buyers or neutral. The second latent class (32% of the population) is distinguished by shoppers who prefer to use the average (sustainable) eco-label, indicating optimum water and appropriate feed in the production process. Further, inappropriate feed and no-label do not create utility for them; we call the members of this latent class 'averagely-sustainable fish buyers'. Consumers with below-average SI scores characterise the third latent class (17% of the population). For this group, the probabilities of choosing use of a lower amount of quality water, the eco-label, and the price of sustainable fish are 0%, 42%, and 28%, respectively, while the probability of choosing appropriate feed is 71%. This is the smallest group in the population; they buy fish that are neither sustainable nor unsustainable. In the fourth latent class, the probabilities of not choosing unsustainable water, feed, and the no-label related to farmed fish are the highest. Consumers in this group gain above average utility from the

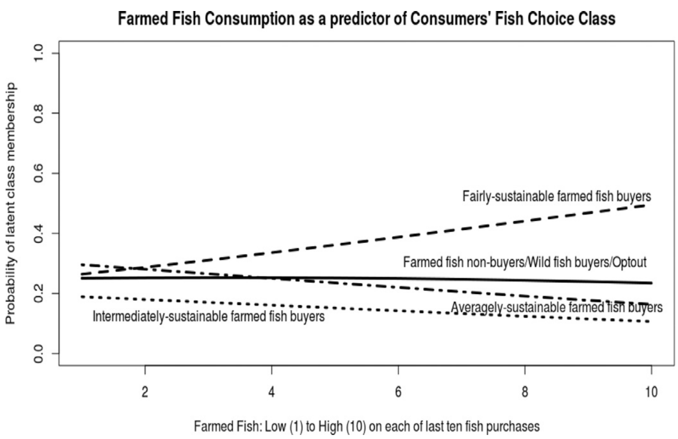


Fig. 4. Predicted prior probabilities of latent class membership at varying levels of farmed fish consumption. The outcomes are from the four-class latent class regression model.

use of a lower amount of quality water, appropriate feed, and an eco-label, or sustainability label. This finding leads to the classification of this third class of consumers (26% of the population) as 'fairly-sustainable fish buyers'.

According to the LCM, the opt-out group is the first latent class, the averagely-sustainable fish buyer group the second, the intermediately-sustainable group the third, and the fairly- sustainable group the fourth latent class. Following equations 3 and 4 (section 2), the log-ratio prior probability that a participant will belong to the averagely-sustainable fish buyer group in response to the opt-out group is ln (p2i/p1i) = - 0.023 + 0.077*frequency of farmed fish consumption. Similarly, the log-ratio prior likelihood that a contributor will belong to the intermediately sustainable fish buyer group in response to the opt-out group is ln (p4i/p1i) = -0.225 - 0.056*frequency of farmed fish consumption. Finally, the probability that a respondent will belong to the fairly-sustainable fish buyer group regarding the opt-out group is ln (p3i/p1i) = 0.224 - 0.058*frequency of farmed fish consumption. Equation 4 is the formula for translating these log-ratios into estimated prior probabilities for each latent class. To explain the predicted generalised logit coefficients, the estimated values of Pri, the prior probability of class membership, were calculated and plotted at varying levels of farmed fish consumption (see Fig. 4).

The results show that consumers with a low level of farmed fish consumption (one out of every 10 instances of fish consumption) have more than a 31% probability of belonging to the averagely-sustainable fish buyer group. In contrast, for consumers who eat 100% farmed fish, this probability is reduced to approximately 20%. The intermediately-sustainable fish buyer group also responds to the declining trends of farmed fish choice. The graph in Fig. 4 shows that consumers prefer fairly-sustainable fish over intermediately- and averagely-sustainable ones, and are members of the no-buy group when they eat farmed fish twice or more out of every 10 purchases. Finally, the probability of belonging to the opt-out group remains unchanged, with a varying level of farmed fish consumption.

5. Discussion

The study results show that consumers are aware of the sustainability indicators, and that these significantly influence their choice of fish. They are willing to pay a price premium for a low use of quality water and appropriate feed in the fish production process. The concern regarding the food sustainability of the farmed tilapia supply may be connected to recent food safety cases involving fisheries and dairy products and the achievements of the sustainable development goals of agricultural products.

In response to the moderately-sustainable labels in the Bangladeshi fish market, consumers do not want either the eco-label (sustainability) or no-label (unsustainability). Those with a low level of sustainability knowledge are more likely to prefer eco-labelled fish, showing that their lack of knowledge or understanding is not liable for the declining consumer utility towards sustainably farmed fish. Furthermore, consumers are not happy with the standard or quality of fish traded in the market. In reality, quality fish with a sustainability label (e.g., eco-label) are in short supply in local markets, so people are more likely to prefer fish with the 'safety-label', which is appropriate for fish which are fairly-(just above average) sustainable. Moreover, in terms of hypothetical choice, consumers trust the food 'safety-label' more than the 'eco-label' because of its greater clarity. This result is promising for Bangladesh agribusiness, which has a large number of consumers. To obtain a moderately-sustainable label, aquaculture must produce fish that maintain a moderate level of SIs at an average cost (BDT 160/kg) in order to attempt to capitalise on consumers' means and limited disposable income. In the fish market, this signals that medium-sized businesses (with fairly-sustainable fish), targeted at medium-level earners with a medium level of environmental suitability and biological idealness fish farming, will be rewarded.

As sustainable fish are in short supply in Bangladeshi local markets, consumers' preferences for relatively less sustainable ones may be a forced choice. The results show that consumers are more likely to prefer sustainable fish if they have a high rate of farmed fish consumption. While fish for export meet a high level of sustainability indicators, they are processed without sustainability management for the domestic market. As small-scale fisheries are excluded from international markets, they can fill the domestic market gap with a low level of business risk because Bangladeshi consumers are not price sensitive towards fairly sustainable fish. After introducing sustainable fish at the second attempt, those that are superbly-sustainable can be familiarised into niche markets with improvement in the sustainability indicators to target consumers. This introduction of tilapia with superb sustainability will represent a policy to change consumer behaviour, as people are reluctant to buy the greenest products (Young et al., 2010; Brécard, 2017). Once these tilapia have been launched onto the market, being in second place on the sustainability list, the chance for simply-sustainable tilapia to create consumer utility will be increased. Additionally, with the Bangladeshi culture of high frequency of fish consumption, the cannibalisation effect of introducing a new label will be minimal, and it is expected that such fish diversification will create competition and possibly eradicate some of the inefficiencies that arise from the monopoly of fish with poor sustainability in fish value chains.

The consumer segmentation analysis found that consumers who eat farmed fish on an average or more than average basis demand a sustainable product. This information should provide both the government and private sector with assurance and an incentive to capitalise in the long term by creating and increasing people's awareness of environmental suitability and biological idealness in quality control services for food sustainability. Unlike industrialised economies, where it is a requirement that food elements be labelled and information provided to consumers, Bangladesh has not yet implemented such a policy, specifically for fish traded on the wet market. Although some processors have willingly started to implement such labels, (e.g. 'best before' dates), unfortunately Bangladeshi consumers do not fully trust this type of information. First, in local markets, consumers experience widespread deceptive promotions. For instance, a counterfeit product was found labelled with a "Beware of fake products" warning. Second, the government has not verified the scheme, so people assume that private firms do not honestly list all the elements, particularly questionable additives, and do not give accurate expiry dates (Ortega et al., 2011). Therefore, food quality, consumers' attitude, and restoration of trust in suppliers are the issues that require attention in order to establish a segmented market place for farmed fish.

Given its importance traditionally and culturally in the Bangladeshi diet, fish serves as a standard to measure household food sustainability preferences. Although we expect consumers to show identical preferences for other essential products, the willingness to pay for food sustainability attributes will vary according to the significant product-specific shifting compositions of characteristics. While this research focuses on the Bangladeshi local market and on a single product, the implications of the findings could apply to other emerging markets for farmed fish. If the Bangladeshi government, agents, and suppliers respond to the concerns and needs of Bangladeshi and foreign consumers by improving farm sustainability indicators and food sustainability, their actions will have a very positive impact on both the local and export markets.

6. Conclusions

The significant theoretical impact of the study is that it conceptualises and develops the modelling of sustainability indicators that influence consumers' preference for farmed fresh tilapia in an emerging economy such as Bangladesh. Currently, food safety and security, nutrition, sustainable food production, and the effects of food production on environmental degradation are essential issues. When food quality and food safety issues arise concerning farmed fish production, sustainability issues gain momentum and become critical in discussion at the policy level. However, consumers' relative values of sustainability indicators and their influence on farmed fish choice have not been examined in-depth. Furthermore, literature regarding the association between consumers' sustainability knowledge and attitude towards farmed fish, and more specifically their preferences for farmed fish, in emerging economies is lacking. Therefore, this study has considered consumers' perceptions of the best indicators of all the sustainability dimensions and their influences on their choice of farmed tilapia. After investigating consumers' valuation of the fish attributes of sustainability performance indicators regarding farmed fish production, the fish markets were segmented, and consumers' willingness to pay for the practice of sustainability performance indicators in farmed fish production was assessed.

Although most fish traded on the wet markets are fresh-farmed without any product segmentation or food labels, the results show that consumers prefer fairly-sustainable farmed fish to intermediately-sustainable ones and the no-buy alternative. As consumers are more likely to eat sustainable fish, there is an opportunity to conduct such fish business in Bangladeshi markets. Although various sustainability options exist in the market, a quarter of the total sample did not buy fish. The majority of respondents assumed that the environmental indicator was the most important in the real and hypothetical choices among the four sustainability indicators. Additionally, a low level of quality water and appropriate feed used in the production process, together with price, significantly influenced consumers' fish choice. Therefore, to justify premium prices and ensure sustainability, a lower quantity of water and appropriate feed should be used in the production process. In addition, the produced fish might be marketed under the direct control of local food authorities to increase social acceptability. In doing so, an increase in fish price could reduce the deficient level of utility, showing acceptance of sustainable fish consumption at a certain level of increased price.

The findings of the paper will be useful in formulating effective marketing strategies for farmed fish in emerging markets. Although the sample size of the study was relatively small and data were only collected from one city, the study method should be more productive and generalise the findings with stratified cluster sampling in the data collection, which is a systematic tool with useable results. Future research should measure other economies with a large sample, specifically emerging ones, to check the validity of the model established in this study. It should be noted that the assessment of aquaculture sustainability and routes to sustainable fish consumption might be conditioned by other attributes not included in the model; for example, ethical indicators. Finally, understanding consumers' preferences regarding sustainability indicators and establishing a sustainable development reference system of what consumers prefer is essential in drafting and implementing food sustainability policies and sustainable development goals. Therefore, an altruistic analysis of the usefulness of various sustainability indicators for sustainable development goals could contribute significantly to the sustainability management system in an emerging economy such as Bangladesh.

Declaration of Competing Interest

The author declares that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.spc.2020.10.020.

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