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Consumers' Value Perceptions of Seafood

An analysis of consumer attitudes, preferences, and willingness to pay for seafood in Bangladesh

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A dissertation for the degree of Philosophiae Doctor, March 2022

DEDICATION

I dedicate this thesis to my beloved parents and family.

Acknowledgements

First, I want to thank my supervisors, Jinghua Xie and Øystein Myrland, for their valued guidance and fruitful comments, which have helped considerably to develop and complete my thesis. They always inspired me to examine the research topics relevant to the exploration of potential markets, analyse consumer perceptions and preferences and estimate seafood demand. My special thanks go to Øystein Myrland for his extraordinary support in providing the study materials and giving effective advice on learning and using software, especially econometric modelling and analysis using R software. I would also like to express my heartfelt gratitude to Yajie Liu and Bich Xuan Bui at the NFH College of Fisheries for their direction in learning the design of choice experiments related to unlabelled seafood products.

I would also like to acknowledge my co-authors and colleagues from my research field in Bangladesh, who helped greatly to collect data and run the survey experiments. More specifically, the discussions with Professor Dr Akter Hossain, Assistant Professor Mr Jewel Das, Assistant Professor Mr Tamim Foisal, Lecturer Mrs Nazmoon Akhter, Lecturer Miss Zannatul Mawa, and Mr Md Nurul Alam, PhD candidate of Marketing at Louisiana State University, USA, on practical issues concerning the field work and data collection were invaluable.

Many thanks to all my excellent colleagues at the School of Business and Economics (HHT), UiT The Arctic University of Norway, especially the non-academic staff, for their administrative and practical help in making daily life easier in Tromsø and Norway during the PhD project. More specifically, I am indebted to Inger Janne Johansen, Head of Administration, School of Business and Economics, UiT, for her friendly and cordial cooperation. Without the support, discussions and encouraging words from these scholars, the thesis would not have been completed.

Last and of course not least, I would like to extend my gratitude to my wife, Kulsuma A. Nahid, for her endless support, and express my love and affection to my daughters, Nashiha Zohair Zia and Nabiha Zohair Zia, and my son, Zimranul Hoque Zia, for their endless joy and love.

Tromsø, Norway

November 2021

Mohammed Ziaul Hoque

List of Abbreviations

CA	Choice analysis
CVM	Contingent valuation method
DCA	Discrete choice analysis
DCE	Discrete choice experiment
DCM	Discrete choice model
EFA	Exploratory factor analysis
GEV	Generalised extreme value
GRQ	General research question
HACCP	Hazard analysis and critical control points
IIA	Independence of irrelevant alternatives
MSC	Marine Stewardship Council
MNL	Multinomial logit
ROL	Ranked ordered logit
RUM	Random utility model
SEM	Structural equation modelling
SRQ	Specific research question
WTO	World trade organisation
WTP	Willingness to pay

List of Papers

Paper 1: Hoque, M.Z. (2020). Sustainability indicators for sustainably farmed fish in Bangladesh, *Sustainable Production and Consumption*, 27, 115-127, https://doi.org/10.1016/j.spc.2020.10.020

Paper 2: Hoque, M., Akhter, N., & Mawa, Z. (2021). Consumers' Willingness to Pay (WTP) for Organically Farmed Fish in Bangladesh. *Journal of Agricultural and Applied Economics*, 1-28. doi: https://doi.org/10.1017/aae.2012.12

Paper 3: Hoque, M.Z. and Alam, M.N. (2020), Consumers' knowledge discrepancy and confusion in intent to purchase farmed fish, *British Food Journal*, 22, 3567-3583. https://doi.org/10.1108/BFJ-01-2019-0021

Paper 4: Hoque, M.Z. and Myrland, Øystein. (2021). Consumers' Willingness to Pay for Fish Safety Inspection in Bangladesh, forthcoming (The manuscript is in the first revision of the review process to the journal *Aquaculture*, Elsevier).

Authors credit taxonomy

The contributors' roles for each paper are given in Table 1

Table 1 – Taxonomy of contributor's roles

Particulars	**Paper 1**	**Paper 2**	**Paper 3**	**Paper 4**
Concept and idea	MZH	MZH	MZH	MZH, ØM
Study design and methods	MZH	MZH	MZH	MZH
Data collection	MZH	MZH, ZM	MZH, MNA	MZH
Analysis and interpretation	MZH	MZH, NA	MZH, MNA	MZH
Manuscript preparation	MZH	MZH, NA	MZH, MNA	MZH
Read and critical revision of the paper	MZH	MZH	MZH	MZH, ØM

MZH = Mohammed Ziaul Hoque

MNA = Md Nurul Alam

NA = Nazmoon Akter

ØM = Øystein Myrland

ZM = Zinatul Mawa

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Summary

Consumers' perception of seafood products plays a critical role in determining their consumption behaviour. As a great quantity of seafood is produced by aquaculture, specifically farmed fish, consumers' perception of farmed fish is crucial. In recent years, consumers in developing and emerging countries have increased their concern about seafood safety. This thesis investigates consumers' perception of seafood in an emerging market such as Bangladesh and their willingness to pay (WTP) for fish attributes such as safety and green labels. The thesis contributes to the literature by adding value to the empirical knowledge of consumers' perceptions and attitudes and the discrepancy of knowledge in emerging markets, especially about sustainable and organic farmed fish. The thesis comprises an independent introductory section and four individual papers.

The first paper investigates consumers' perception of sustainability indicators and how they affect consumers' preference for farmed fish. In general, there is a positive association between the sustainable production process and the indicators of sustainability. According to tradition and theory, economic, environmental, carbon, and ecological footprints, and social dimensions apply when considering the sustainability of aquaculture. As for fish attributes, indicators of sustainability occur in four areas: economic, environmental, biological, and social. Those areas, along with consumers' knowledge of sustainability; attitudes towards farmed fish; and sociodemographics were considered in a generic multinomial logit model. Consumers' values of ecological judgement were quantified with probability theory and descriptive statistics at various levels of sustainability. A basic latent class logit model also segmented the Bangladeshi market for sustainable aquaculture. Among the environmental, biological, social, and economic indicators, consumers are more likely to consider the ecological and biological ones when choosing farmed fish. They value the safety label more than the conventional one (status quo), indicating a moderate preference for sustainability over the eco-label and supporting the sustainability of farmed fish. Overall, consumers prefer averagely sustainably farmed fish. When they eat a large quantity of farmed fish, they look for a high level of sustainability, indicating a positive association between the frequency of fish consumption and the level of sustainability.

Paper two examines a potential market for farmed shrimp in Bangladesh that has a safety certification. To quantify consumers' perceptions of different types of farmed shrimp – conventional, safe and organically farmed shrimp produced in inland, coastal and marine

aquaculture – a rank-ordered logit model was employed using data from a choice experimental design. Exploratory factor analysis (EFA) was used to form two latent variables: consumers' perceived knowledge of farmed fish and their attitudes towards it. The main findings in that study are as follows. First, consumers are more likely to prefer organically farmed fish produced in marine aquaculture. Second, regarding fishing sites, consumers prefer inland-farmed fish to fish farmed on the coast. Third, between the two types of conventionally farmed shrimp, consumers' WTP for inland farmed shrimp is higher than for coastal-farmed shrimp. Finally, as consumers' knowledge about fish farming is important in influencing their fish choices, the study showed that consumers who have a low level of knowledge about farmed fish are less willing to pay for conventionally farmed fish. Interestingly, we find they have a stronger WTP for safely farmed shrimp than for organic shrimp. This suggests that safely farmed fish would be rewarded over organic fish in the Bangladeshi local market.

The third paper assesses the discrepancy in consumers' knowledge (subjective vs objective) regarding farmed fish. It also determines the impact of consumer perceptions of knowledge, knowledge discrepancy, and confusion on their intent to purchase farmed fish. By employing EFA, Levene's test for equality of variances, and structural equation modelling (SEM), this paper quantifies urban households' attitudes and confusion over farmed fish, their perceived knowledge of farmed fish, and their over- and under-estimation of knowledge regarding this type of fish. The effect of their estimated knowledge on their attitudes was then examined. The outcomes of the study show that there is a discrepancy between consumers' subjective and objective knowledge. Hence, the difference between subjective and objective knowledge is knowledge discrepancy, where a positive discrepancy states that consumers have higher subjective knowledge than objective knowledge. Subjective knowledge increases the intention to purchase farmed fish, but objective knowledge does not. However, objective knowledge leads to less confusion regarding such fish. Besides consumers' knowledge of farmed fish, their level of confusion about farmed fish does not significantly influence their attitudes towards it. Although consumers' attitudes positively influence their purchase intent, their knowledge and knowledge discrepancy do not affect the formation of attitudes. Interestingly, over half of the total respondents overestimated their actual level of knowledge, and that negatively affected their attitudes towards farmed fish.

Food safety inspection is the key to an enforcement system. Therefore, to formulate an effective food policy, the effectiveness of such control activities should be examined through

the eyes of the consumers. Therefore, the objective of the fourth paper is to investigate consumer response to regulations over secured seafood. This paper explores consumers' WTP for fish inspected by national and local authorities. A range of utility ratios of fish attributes, a conditional logit model and a generic multinomial logit model are used to analyse the data collected from a survey of households in the two major cities, Dhaka and Chittagong, Bangladesh. Consumers' attitudes towards fish attributes (production method, product form, fish safety control, and price) were analysed and compared to attitude ratings, attitude ranking, and preference ranking. Their perceptions of fish safety inspections are high only in their affective reaction; there is a lack of a cognitive response. Likewise, compared to wild fish, consumers prefer farmed whole fish, but not if it is frozen. Local food safety inspections increase the utility of whole fish to consumers, and they are willing to pay a higher price for locally authorised safety inspected fish. Finally, they are most likely to reject farmed fish that have not been inspected for safety. Such results show that farmed fish certified safe by a local authority be rewarded in an emerging market like Bangladesh.

Keywords: Seafood, Aquaculture, Fish products, Consumer perception, Consumer preference, Willingness to pay, Discrete choice analysis, Emerging markets, South Asia, Bangladesh.

JEL Classification : C35, D10, Q13, Q22

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Part I: Introduction

1.1 Background

How consumers value the quality of food, their perception of its safety and the components of their willingness to pay (WTP) for it are associated with consumer demand and food choice (Grunert, 2005). Grunert adds that consumer choices include their demand for and interaction with the supply of foods. This area of research has been gaining momentum as an associated and mediating tool between supply and demand, since consumers' perceptions of the food supply help to create demand for these foods (Grunert, 2005) (see Figure 1). Furthermore, how consumers value food production and how it is supplied, handled, processed and stored, along with potential health risks, influences their perceptions of food safety (Bukachi et al., 2021).

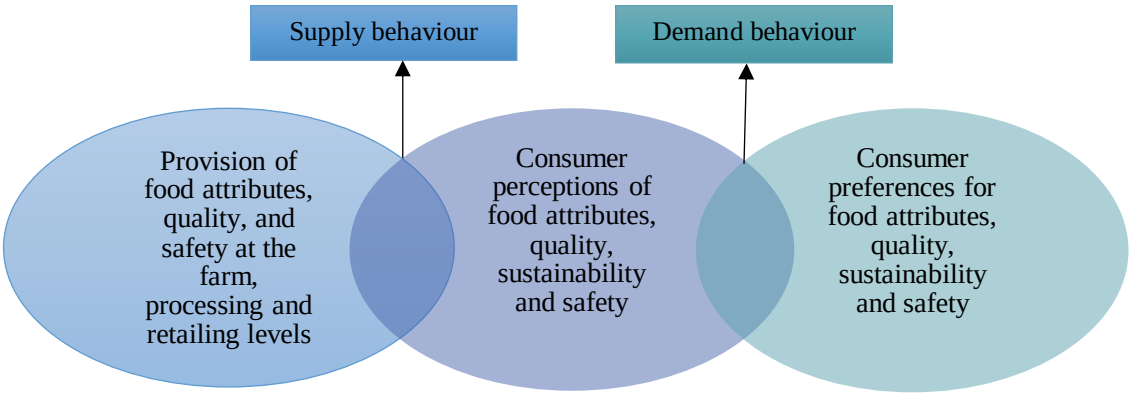

Figure 1 - Research on food attributes, quality, sustainability and safety (based on Grunert, 2005).

To ensure food safety, security and nutritional quality for a growing world population, seafood consumption is an essential source of proteins, vitamins and micronutrients, and it is part of a balanced and healthy diet (Sampels, 2014). It is therefore important to understand the extent of consumers' knowledge of seafood and its attributes. In practice, the great variety of seafood in markets and restaurants and consumers' heterogeneity in choice make the seafood market complicated. How then do consumers perceive seafood attributes? Many policies about seafood are based on straightforward controls dealing with provisions from the World Trade Organisation (WTO), Hazard Analysis and Critical Control Point (HACCP) principles, and safe and sanitary control of the farming, processing, and shipping of seafood products. However, those policies are not complete because the use of control techniques has not been thoroughly examined from the consumers' perspective (Liu et al., 2014).

Fish are an outstanding source of high-quality animal protein and essential fatty acids, specifically long-chain polyunsaturated fatty acids (Beveridge et al., 2013). A complex mix of product attributes such as production methods, food quality, freshness, health benefits and nutrition and concerns about safety, environmental suitability and animal welfare determine consumers' food choices (Lennernas et al., 1997). For instance, the consumption of wild-caught fish is influenced by ethical and sustainability considerations, and the consumption of farm-raised fish is influenced by perceptions of quality (Verbeke et al., 2007).

Fishery and aquaculture products have been an integral part of the human diet since fishing began in natural waters and producing fish food through aquaculture (Albert, 2013). Total fish consumption is forecast to grow by 30 % between 2010 and 2030 (World Bank, 2013). The increasing demand for fishery and aquaculture products, and the associated technical and commercial opportunities, make aquaculture development[1] a critical area of fishery sector policy. However, the growth in production is constrained by space and water availability and the risks of adverse environmental impacts (Duarte et al., 2009; FAO, 2010). Besides the environmental issues, there is also a wide debate on the quality and safety of farmed fish (Moretti et al., 2003). Farmed salmon has been found to be more contaminated than wild salmon (Krkosek et al., 2007), and European salmon was found to be more contaminated than North and South American salmon (Hites et al., 2004). Furthermore, one of the long-running debates in aquaculture is the use of fishmeal and fish oil in feeds. This debate has been particularly intense in light of the substantial number of tonnes of wild fish it takes to produce a tonne of farmed salmon (FIFO[2] ratio). The figures documented in the literature range from 3:1 to 10:1 (reference), whereas Tacon and Metian (2008) gave the figure for salmon in 2006 as 4.9:1[3] (Andrew, 2009).

Therefore, there is a growing public perception about water pollution resulting from the use of chemicals in aquaculture and threats to natural fish populations. For instance, salmon lice produced on farms may cause problems for wild salmonids (Johansen et al., 2011). These growing concerns about the problems raised by seafood aquaculture have significantly

[1] Globally, 62 % of fish for consumption will be produced by aquaculture by 2030.

[2] Fish in/Fish out ratio

[3] Meaning it takes 4.9 ton of wild fish to produce 1 ton of salmon.

affected consumers' perception of farmed seafood. In general, consumers show a positive trend towards farmed fish, but this is weakened when environmental issues are raised (Froehlich et al., 2017) and such fish are less favourably considered than their wild-caught equivalents (Laura et al., 2021). Such a value-action gap occurs because of the discrete association between consumers' attitude and their choices.

Studies have shown that consumers perceive wild fish to be best in terms of safety and health, and farmed fish best with regard to environmental sustainability and fish welfare (Rickertsen et al., 2017). They rank farmed fish from developing countries lower than fish farmed in advanced countries. Consumers also rank salmon the highest amongst many attributes and prefer wild fish to the farmed version from developed countries (Rickertsen et al., 2017). The criticism of farmed fish (Hites et al., 2004), followed by a contentious public dialogue (Luoma & Lofstedt, 2007; Schlag, 2011), have complicated the public's estimates of the risks and benefits of farmed versus wild fish. As wild fish are considered prohibitively expensive by many, the affordability of farmed fish is a significant benefit for most consumers. Therefore, they are torn between the appeal of cheap and convenient food, their concerns about intensive farming, and the denaturalisation of foodstuffs (Gaskell, 2010). They receive mixed messages about the differences between farmed and wild fish, highlighting the importance of better risk communication (Luoma & Lofstedt, 2007). These differing interpretations and discrete perceptions of aquaculture are likely to have contributed to the erosion of public trust (Luoma & Lofstedt, 2007).

Aquaculture, as currently practised, is still an ambiguous and confusing industry for many people (Hoque et al., 2021). As such, social scientific research on the topic is only a recent development (e.g., Aarset et al., 2004; Burgess & Tansey, 2005; Hojier et al., 2006; Amberg & Hall, 2008; Verbeke et al., 2008; Grigorakis, 2010; Schlag, 2011). Detailed empirical research on consumer differentiation between wild and farmed fish is lacking (Schlag & Ystgaard, 2013). The lack of knowledge is a recurrent concern for consumers, who demand balanced information and continuous communication. Hence, comprehensive studies can disseminate information that will help to understand future consumer perceptions. The acceptability of farmed fish and fish farming depends on the socially responsible development of the aquaculture industry (Lofstedt & Schlag, 2010).

Therefore, the studies in this thesis aim to answer the following research questions. To what extent do consumers know about seafood products produced by aquaculture, and are

they aware of food sustainability, food safety and quality? How do they perceive the attributes of seafood produced by fish, more specifically the safety and quality of farmed fish, and how do these perceived values influence their choice of fish for food? Although developing and emerging economies, especially Asian ones, enjoy a seafood trade surplus, supplying more than the average of total world demand (Sampson et al., 2015), consumer perceptions of seafood in such economies are not well documented. Therefore, the empirical focus of this thesis is on the emerging market for seafood produced by fish, particularly farmed fish.

The literature on seafood demand includes analysis of consumers' profiles and segments, lifestyle and consumption frequency, their perceptions of and attitudes towards product attributes and their WTP (Ortega et al., 2012; Reinders et al., 2016). The study of attributes that affect food product retail prices could help both producers and retailers develop better production and marketing strategies (Cicia, 2021). Furthermore, socioeconomic characteristics influence consumers' preferences for aquatic products and their seafood purchasing decisions (Puduri et al., 2011). In terms of seafood production and consumption, emerging Asian countries, particularly China, Indonesia, Vietnam, Thailand and Bangladesh, are top-ranked in Asia and the world (Dey, 2000). It is expected that Bangladesh's overall positive seafood trends will provide opportunities for world seafood demand and supplies to explore potential Asian markets. Therefore, the papers in this thesis highlight consumer perceptions of the attributes of fish products, such as production methods, product origins, food safety inspection and sustainability, and how these values affect their selection of fish products from an emerging Asian market. We expect that the outcomes of the thesis could help governments develop seafood policies and aid marketers in engaging in creative solutions. The results and insights could also help consumers access market information and safe and green seafood. In this thesis, the influences of consumers' perceptions of food attributes on their food choices are examined to help design seafood policies. It employs numerous model-based micro-level analyses of the economic behaviour of households, individuals, and enterprises under the topic of microeconometrics (Trivedi, 2009).

1.2 Microeconometrics and the analysis of choices

The consumer is the fundamental economic unit for choice analysis (CA). They determine which foods are purchased and in what quantities. Individual consumers select food approximately 200 times a day (Novak & Brownell, 2011) and millions of such "food choices" are made each day by consumers around the world (Kearney, 2010). Such choices

are analysed by price and pricing strategies (Steenhuis et al., 2011), conflict, uncertainty and cognitive activity. The related psychological processes can be observed (Lerner et al., 2014) in the fields of both standard and behavioural economics. The economic behaviour of individuals, households and firms is related to the model-based analysis of individual-level or grouped data in microeconometrics (Trivedi, 2009). Therefore, these microeconometric methods apply broadly to social and mathematical sciences that analyse cross-sectional and panel surveys, censuses and experiments about choices to provide information and outcomes of food policy to involved actors. Such methods for CA are also valuable for providing summaries of model-based data and prediction of theoretical outcomes.

Therefore, the range of microdata in microeconometrics can be more significant in confirming the features of both the continuity and smoothness of the variables themselves and the associations between them (Trivedi, 2009). For instance, households' mean weekly frequency of fish consumption is likely to vary smoothly. Even in a particular week, the frequency of seafood consumption may be zero, and a positive frequency of consumption may change (e.g., 10 kg to 15 kg or 20 kg to 12 kg) from time to time. Therefore, microdata reveal 'holes, kinks and corners' (Pudney, 1989). Holes show the increasing intent to buy seafood; kinks represent the switching of seafood consumption behaviour, and corners correspond to the occurrences of non-consumption of seafood at a given time. To know the holes of seafood consumption and overcome the problems of negative kinks and corresponding corners, a multiple-discrete choice model can be applied to analyse the demand for differentiated products using micro-level data (Hendel, 1999). Consequently, discrete choice analysis (DCA) and the nonlinearity of consumers' choices are vital to microeconometrics because discrete choice models (DCMs) are derived from the principle of random utility maximisation (Trivedi, 2009).

1.3 From random utility to modelling choice

In the theory of consumer behaviour, the concept of utility is key to microeconomics. Considering utility, consumers can choose from the bundles of continuously variable numbers of products. In practice, they choose a single option from a finite number of exhaustive sets that maximise their utility. This is known as a discrete choice (Train, 2000). To model such a discrete choice, analysts can hypothesise that marketers do not know all the facts about the respondents, such as their perceptions, attitudes, preferences, income, educations and exact location (Hess et al., 2018). Although consumers' behaviour may vary over time, either

systematically or idiosyncratically, ideally a good, practical model should contain a random component so that choices can be represented probabilistically (Hess et al., 2018). Accordingly, the idea of combining a random component with the concept of utility maximisation, and then incorporating it into the model, is appealing. It is to choose referred to as the random utility model (RUM) (Hess et al., 2018). In formal analysis, when we consider a consumer making a selection from a finite set of choices, random utility indicates that a random vector, namely $U_{1,\ldots,}U_J$ could increase the monotone transformation of utility. As a result, the likelihood of choosing any options $i \in M$ (M is the choice set) is provided by:

$P_i = P_r\left(U_i > U_j\right)$ for all $i \neq j \in M$ (1)

Hence the RUM is a 'distribution-free model' in which utility is conceptualised as a random ordinal variable with no explicit distributional properties (Regenwetter et al., 2010). Most of the model with a discrete response variable is derived from a random utility illustration (Dagsvik, 2004). Generally, logit, nested logit and probit models are used to model a relationship between a response variable 'Y' and one or several independent variables 'X' (Train, 2002). Hence, the response variable 'Y' is a discrete variable that represents a category, or choice, from a set of mutually exclusive categories or choices. The analysis of consumer choice applying DCMs from several alternatives based on maximised utilities is known as DCA.

1.4 Discrete choice analysis

The Nobel laureates in economics, James Heckman and Daniel McFadden, have contributed fundamentally to microeconometrics, defined as the 'rocket science' of consumer economics (Cohen, 2000, p. 45). Heckman has contributed to solving the difficulties created when a random selection method generates the data, which is a common phenomenon in microeconometric research (KVA, 2000). Although microeconometric modelling is useful for discrete choice analysis with cross-sectional and panel data, one example of random sampling data difficulties in CA is unobserved heterogeneity. This is simply the differences among study participants, which are not measured and may provide incorrect statistical findings. Heckman worried about the ability of such unobserved heterogeneity to create specific selection biases or problems in econometric duration analysis. His contributions have also helped in treating selection problems without imposing restrictive assumptions concerning the distribution of unobserved variables. In a joint work, Heckman proposed a non-parametric

estimator with wide application in economics research and demography (Heckman & Singer, 1984). He also contributed to the models of discrete choice by solving simultaneous integral equations.

McFadden has contributed significantly to theory and methods for DCA (e.g., the choice from a finite set of options such as food choice, mode of transportation or occupation) (KVA, 2000). Choosing one option from alternatives often excludes other options from a choice set. Such preferences imply a discrete choice or the choice of lumpy products, which arise bundled with many product attributes and engaging choices. These problems of discrete choices frequently appear in economics; one example is the modelling of an individual's food choices from various alternatives. Hence, the observations to be described are qualitative or discrete and should not be characterised by continuous variables. The demand theory of standard economics and conventional econometric methods is inappropriate to explain variations in continuous variables or to investigate discrete choices (McFadden, 1980). Problems also arise in applying DCM because it is a mechanism of deterministic choice and does not fit with real choice, so it has been criticised by economists and psychologists (Muro-Rodríguez, 2017).

According to psychological analysis, individual choices are related to the intrinsically probabilistic approach in which discrete probabilistic choice can be a good option to analyse choices (Thurstone, 1927; Luce, 1959). Probabilistic models consider essentials of randomness that may give mixed results for random variation, even with similar initial situations. Therefore, in practice, such probabilistic models have limited use in analysing people's choices. So, McFadden developed the microeconometrics approach[4] to overcome problems that deal with individual choice as a deterministic defined DCM (Aloulou, 2018). Such a model may function well even with imperfect information about the characteristics of product alternatives in an experimental survey. Moreover, a microeconometric model focuses on probabilistic representations of choice, in which all the probability is concentrated on a single utility function that helps to derive a choice with less error (Marley, 2017). In economics, environmental management, urban planning, engineering and transportation, the DCA could help understand individual choices.

[4] The microeconometric approach is an interface between economics and statistics that encompasses economic theory and statistical methods used to analyze microdata that appear as cross-section and panel data.

1.5 Trends in the development of discrete choice analysis

McFadden (1974) published a paper entitled 'Conditional Logit Analysis of Qualitative Choice Behaviour', which changed researchers' fundamental thinking about the econometric analysis of individual choices. In the paper, he proposes the idea of integrating the econometric method and the economic theory of discrete analysis. According to the economic theory of behaviour, consumers choose from a finite set of options an alternative that maximises their utility. To analyse the modelling of such choices, it is assumed that respondents are selected by repeated random sampling, with a vector *a* of each individual's attributes (e.g., age, income, gender), and a set *M* of alternatives presented to the individual (e.g., methods of fish production, namely wild, inland-farmed, and coastal-farmed) from which they make choice *i* from the set *M*. In the model, it is hypothesised that the agents' utility from choosing *i* can be explained in the additive form $u\ (i, a) = v\ (i, a) + e\ (i, a, w)$, where $v\ (i, a)$ is identical to all respondents with experiential attributes *a*, and $e\ (i, a, w)$ is specific to the individual. Though both utility terms are deterministic, the first part is 'representative', and the second is 'idiosyncratic' of the population. Treating the unobserved utility, hereafter $e\ (i, a, w)$, as the realisations of random variables $\varepsilon\ (i, a)$, the conditional choice probability of a randomly selected individual choosing alternative $i \in M$ in given observed attributes *a* and set of options *M* can be obtained using the following equation:

$$P(i|a, M) = P_r[v(i, a) + \varepsilon(i, a) \geq v(j, a) + \varepsilon(j, a)\ \forall j \in M] \quad (2)$$

Equation (2) is referred to as the additive random utility model of discrete choice. The logit model is a direct choice model that benefits from being mathematically clean and straightforward to explain (Savage, 2019). To make the resulting logit model specification, it is expected that the 'representative' utility part $v\ (i, a)$ depends on known attributes of the alternatives. The associated vectors of a parameter can then be estimated by applying maximum likelihood distribution. The choice probabilities in equation (2) can be reduced to the following convenient logit form:

$$P(i|a, M) = \frac{\exp\ \sigma v\ (i, a)}{\sum_{j \in M} \exp \sigma v(j, a)} \quad (3)$$

The logit model is often used to examine the relationship between a categorical outcome and one or more numerical or categorical predictor variables. Although the concept of multinomial logit has been widely used, McFadden's derivation of the conditional logit model

is a unique innovation. When respondents have multiple options, including an alternative 'do not buy either', a conditional logit model is used to estimate the preference (Hensher et al., 2005; Roheim et al., 2012) where the probability of respondent *n* choosing product *j* of choice set *k* can be written as:

$$P_{nkj} = \frac{e^{\beta_j x_j + \gamma_{nj} x_j z_n}}{\sum_k e^{\beta_j x_j + \gamma_{nj} x_j z_n}} \quad (4)$$

In econometric analysis, the multinomial and conditional DCM provides an analytical advantage. McFadden' econometric model combines hedonic analysis of alternatives and RUM, known as the multinomial logit (MNL) model (Holmes et al., 2017). The MNL model is a popular and widely used logit model that generalises the logistic regression to more than two problems, providing log odds of the nominal outcome as a linear combination of the predictor variables that estimate a consumer's choice based on relative utility (Mehendiratta & Hansen, 1997). This choice for goods can be modelled using the disaggregate utility or demand approach with the MNL model, in which the probability that respondent *n* chooses alternative *j* from choice set *k* is:

$$P_{nkj} = \frac{\exp\left(x'_{kj}\beta\right)}{\sum_{i=1}^{J} \exp(x'_{ki}\beta)} \quad (5)$$

The rank-ordered logit (ROL) model deals with heterogenous heteroscedasticity, and it is widely used in discrete choice analysis (Castelein et al., 2020). In the model, respondents are asked to rank the alternatives by order of preference, with the most preferred alternative indicating high utility. If U_{ij} is the rank given to alternative *j* by respondent *I*, and if there are *J* alternatives, U_{ij} can be considered as an integer value from 1 through *J*, with 1 being the 'best' and *J* the 'worst' in preference (Allison & Christakis, 1994). A random utility model can generate a model for such choice behaviour (Allison & Christakis, 1994). With *J* alternatives, the utility is given by alternative *j* for individual *I*, defined in a linear function as:

$$U_{ij} = V_{ij} + E_{ij,} \quad (6)$$

where each U_{ij} is the sum of a systematic component V_{ij} and a random component E_{ij}. Each E_{ij} is independent and equally distributed with an extreme value or double exponential distribution. Each V_{ij} can be assumed to be a numerical value indicating the degree to which respondent *i* prefers alternative *j* over other alternatives that reflect utility. For example, rank-

ordered logit uses the log-likelihood function to estimate the utility weights and comparable prices (Hausman & Ruud, 1987). The utility index of the *m*th alternative is designated by:

$$V_m = x'_m \beta + u_{m,} \; m = 1, \ldots, M \; (7)$$

where x_m is a *K*-vector of alternative attributes; ß is a *K*-vector of utility weights; and u_m is a randomly distributed error term (with an extreme value distribution). The logit probability that alternative *j* is preferred to alternatives 1,. . . , *j*-1 is:

$$F_j \left[x_{1,\ldots,} x_j; \beta \right] = \exp\left(x'_j \beta\right) \Big/ \left[\sum_{i=1}^{j} exp\left(x'_i \beta \right)\right], j > 1 \; (8)$$

Denoting the index of the alternative ranked *m*th by r_m, the probability of observing the rank ordering $r \equiv \left(r_{1,\ldots,} r_M \right)$ is

$$Pr\left(r, x; \beta\right) = \prod_{m=2}^{M} F_m \left[x_{rM,\ldots,} x_{rM-m+1}; \beta\right], (9)$$

The attractiveness of the ROL and MNL models lies in their integration of microeconomic theory and computational simplicity. This creates the statistical independence of the random utility, which implies the independence of irrelevant alternatives (IIA). This assumption of IIA in discrete-choice modelling suggests that the probabilities from among other options are independent. For instance, a choice set does not affect the odds ratio of two distinct choices. Therefore, the IIA rule helps to reduce sample bias and estimate the utility by applying the MNL model using choice-based samples (McFadden, 1981).

To overcome the restrictive application of the IIA assumption, Hausman and McFadden (1984) introduced a rule for testing the validity of IIA, followed by a specification test by McFadden (1987). McFadden also explained how to relax the IIA property by contributing to the nested MNL and generalised extreme value (GEV) models. In these models, individuals' choices are interpreted as having a hierarchical relationship that permits a particular statistical dependence among the alternatives.

Another significant generalisation of the MNL model is the mixed logit model, in which the choices of the same attributes of diverse groups are aggregated. McFadden and Train (1998) show that any well-behaved RUM of discrete choice analysis could be estimated to any interval of confidence using this model. However, in applying the model, multiple probability simulation is required to show the computational difficulties. Therefore, the mixed

logit model is not suitable for dealing with problems with a relatively large number of alternatives. Lerman and Manski (1981) added the new idea of calculating the choice probabilities using Monte Carlo simulation, whereby recurring random draws are allowed from a multivariate normal distribution. Subsequently, McFadden (1989) developed this simulation approach by contributing a new estimation method, namely simulated moments.

On the other hand, the heterogeneity of the choices of a group of homogeneous consumers can be shown discretely by using an LCM. In this model, *i* individuals are placed into *r* latent classes (Boxall & Adamowicz, 2002). For instance, an observation *J* that manifests categorical variables where each variable covers K_j possible results for individuals $i = 1, \ldots, N$. The manifest variables can take a different 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 *k*th response to the *j*th variable; otherwise, $Y_{ijk} = 0$, where $j = 1, \ldots, J$ and $k = 1, \ldots, K_j$. In the LCM, *f* (Y) is discrete and may take *r* distinct values (Train, 2003). Hence, the posterior probability of each individual fitting to each class, uncertain on the perceived values of the manifest variables, can be explained employing equation 10 (Linzer & Lewis, 2010):

$$\hat{P}(r|Y_i) = \frac{\hat{p}_r f(Y_i;\, \hat{\pi}_r)}{\sum_{q=1}^{R} \hat{p}_q f(Y_i\,;\, \hat{\pi}_q)} \quad (10)$$

Alternatively, individuals' prior choice is accounted by the LCM, which differs depending upon their observed covariates. To assess individuals' latent class membership, equation 10 simplifies the basic LCM by permitting the inclusion of covariates (Dayton & Marcready, 2019). Hereafter, it is assumed that the log-odds of latent class membership priors are connected linearly with the covariates. If β_r is the vector of coefficients corresponding to the *r*th latent class, with *S* covariates, β_r has size $S + 1$, which is one coefficient on each of the covariates, plus a constant. Generally, the first latent class is considered as the reference or base, where $\beta_1 = 0$ is predetermined. The probabilities of posterior class membership in the LCM are then obtained by equation 11(Linzer & Lewis, 2010):

$$\hat{P}(r|x_i; Y_i) = \frac{P_r(X_i;\, \hat{\beta}) f(Y_i;\, \hat{\pi}_r)}{\sum_{q=1}^{R} P_q(X_i;\hat{\beta}) f(Y_i;\hat{\pi}_q)} \quad (11)$$

Furthermore, the contingent valuation[5] method (CVM) can be used to elicit information about peoples' environmental perceptions and/or recreational choices (Portney, 1994). Currently, the CVM is interlinked with other preferred methods, such as stated CA and choice experiments (CE) (Louviere et al., 2000). CVM is referred to as a 'stated preference' method because the format asks people to describe their values directly rather than supposing ones from actual choices (revealed preference). Applying CVM can be a lengthy, complicated and expensive process. Therefore, to collect valuable data and obtain effective results, the experimental survey should be appropriately designed and pre-tested. The survey questions in CVM focus on specific environmental services and a context that is precisely defined and understood by the respondents. Sociodemographic and socioeconomic characteristics, such as gender, age, income, education and consumption, also are collected in this CVM. If it can be shown that respondents' preferences are not random, but vary systematically and are conditioned to certain observable demographic information, then population characteristics can be used to estimate the total WTP for the service evaluated. Therefore, CVM is popular and widely used in estimating environment-related health effects (Markandya & Ortiz, 2011).

In dichotomous choice CVM (DC-CVM), respondents are asked if they would buy something with a single, randomly assigned bid amount (Hanemann, 1984), which is also widely applied in the literature about food marketing and consumer choice (Drichoutis et al., 2017). The crucial merit of this method is that it helps reduce respondents' cognitive tasks as they decide whether to buy (Boncinelli, 2018). However, the significant role of consumers' perceptions, ranging from the psychophysical perception of attributes through to the psychological formation of perceptions to reduce cognitive dissonance and mental budgeting for cost and time, have not been widely explored in empirical studies using DCA of economic choice (McFadden, 2000). Belonging to the family of DCMs, the RUM is used to calculate consumers' WTP (Hess et al., 2008).

1.6 Assessing willingness to pay in discrete choice models

To set sensible prices for seafood, marketers require detailed knowledge about their consumers' WTP. Therefore, it is not surprising that a good number of studies have focused on the determinants and estimations of WTP (Jedidi & Zhang, 2002; Miller et al., 2011). Marginal values based on estimated parameters reflect the WTP based on product or service

[5] Contingent valuation is a method of predicting the value that a consumer/person places on a product or service.

attributes. According to Train (2009), the estimate can be calculated as the negative ratio of the coefficient of a non-price attribute variable (β_{np}) to the price coefficient (β_p). The formula is:

$$WTP_{np} = -\frac{\beta_{np}}{\beta_p} \quad (12)$$

Again, interaction effects of attributes *x* with respondent-specific information (e.g., sociodemographic variables *S*) can be added to both models described above to further disentangle preference heterogeneity with respect to the observable part of utility (Kallas et al., 2007). Similar to other regression models, the marginal effect of an attribute (which is defined as the first derivative of the specification with respect to the attribute) then depends not only on the coefficient of the respective non-price attribute β_{np} and/or the respective cost attribute β_p but also on the coefficient of their interaction between a sociodemographic variable and the respective attributes, which can be denoted as α_{np*S} for a non-price attribute and α_{p*S} for a price attribute. These additional coefficients must be further multiplied with a meaningful value of the respective sociodemographic variable, for example, the median (denoted as $\tilde{S}$). This is because the sociodemographic variable does not cancel out when taking the first derivative. Therefore, the WTP for a non-price attribute would be calculated as:

$$WTP_{np} = -\left(\frac{\beta_{np} + \alpha_{np*S}.\tilde{S}}{\beta_p + \alpha_{p*S}.\widetilde{S}}\right) \quad (13)$$

In the 1990s, McFadden contributed to environmental economics by investigating individuals' WTP for natural resources. Using WTP as the dependent variable and a bundle of independent variables, a bid curve that predicts the probability of a 'yes' response to a particular offer price can be estimated for open-ended CVM formats such as, WTP = *f* (age, income, education, gender, environmental quality). He also examined the characteristics of CVM to estimate the value of environmental resources and to generate new econometric techniques. CVM involves asking people directly in an experimental survey how much they would pay for a particular environmental service. In some experiments, people are asked what compensation they would accept to sacrifice a specific ecological service. This is called 'contingent' valuation because the respondents are asked to state their WTP, based on an exact hypothetical scenario and the image of the environmental benefit. CVM is referred to as

a ‘stated preference’ method because the format asks people to describe their values directly rather than supposing them from actual choices (revealed preference).

1.7 Applications of discrete choice analysis

Discrete choice analysis is an approach that uses microeconomic theory to maximise benefits by making appropriate decisions both individually and organisationally. McFadden developed discrete choice theory by quantifying benefits in terms of money from a product, such as public investment (Ben-Akiva & Lerman, 1985; Pearce et al., 2002). In DCA, data are collected by applying a discrete choice experiment (DCE) (de Bekker-Grob et al., 2012), in which the DCE and DCMs represent the development and renovation of choice theory and effectively select attributes from mutually exclusive alternatives (Simecek, 2019). Through DCEs, consumers’ benefit from each consumed and tested product attribute may thus be exposed, as well as the effect of each product attribute on the probability of choosing the product (Gao & Schroeder, 2009; Profeta, 2020). DCE is regarded as an innovation to elicit implicit motives for food choices (Kamphuis et al., 2015).

In DCEs, respondents (e.g., customers) must choose from a set of different products offered at determined prices. In this case, fish products differ in the tested product attributes (e.g., production method, local feed share, price). According to microeconomic theory, participants choose the product with the highest benefit. The DCE approach comprises several theories. The first is consumer theory, in which any food is viewed as a bundle of attributes, and a combination of foods produces a vector of quantities of these attributes (Lancaster, 1966). The second is random utility theory, in which participants opt for the food alternative with the highest utility (or value) (McFadden, 1974). DCEs also offer an opportunity to identify the most critical influences on food-based eating decisions, which should be embattled to improve dietary involvement and policies in various consumption behaviours. The attributes examined in the studies have been similar, although no DCEs to date have examined the role of familiarity when choosing food (Livingstone, 2020).

Using a DCM of consumer behaviour (McFadden, 1973; Berry, 1994; McFadden & Train, 2000), researchers may specify that consumers have several alternatives from which they can gain food, and these alternatives are described as a package of perceived attributes (Villas-Boas & Taylor, 2016). Several groups of DCMs, such as probit, logit, multinomial logit, dichotomic logit, conditional logit, mixed logit and nested logit, have been developed and applied in microeconomics. Each of these models is specified by the independent variables

that characterise the alternatives by the statistical distribution law, which follows the error terms and their capacity to overcome the constraint of IIA. DCMs are based on the premise that the choices of economic agents are mutually exclusive alternatives, implying that if an individual chooses one, they give up the choice of others. This procedure makes it possible to disaggregate better, personalise subjects' behaviour, and perceive their preferences according to their attitudes and motives. Therefore, DCM considers that the environment that shapes the behaviour of the choice of an individual is random and specific to each situation (Aloulou, 2008), and it can be a good fit for the analysis of applications across a wide range of geographic, social and decision-making contexts (Shiftan & Goulias, 2010). Therefore, DCM can be applied in the food economy by estimating the demand for a food product and evaluating the importance of food safety and quality. Thus, recently, DCM has become an effective tool for assessing consumers' choices of seafood products (Cantillo et al., 2020), in which psychology is playing an increasingly important role in policy implications for sustainable choice (Clayton et al., 2015).

1.8 Psychology and consumer choices

Standard utility-based economic theories assume that consumers always seek to maximise their (long-term) utility and make their choices based on the information available. Many food policies are designed around such availability of information (Downs et al., 2009), and they assume that people will decide rationally (Cawley, 2004). In practice, however, this approach has only a small impact on people's food choices (Liu et al., 2013). Such assumptions may not always describe actual behaviour, as individuals are not entirely rational in their decision-making because of behavioural heuristics and cognitive biases. A key criticism of utility-based models in the literature on behavioural economics and mathematical psychology is that individuals do not behave rationally to maximise utility (Kahneman, 2003). There is ample evidence that agents' judgements, preferences and behaviour are at face value systematically irrational (Kahneman & Tversky, 1990). Although we often choose poorly as human beings, we are vulnerable to biases that make us poorer and less healthy than we would be with optimal decision-making. However, insights from consumer psychology may help people behave rationally and decide more effectively (Liu et al., 2014).

Consumer psychology from a behavioural perspective is characterised by the direct measurement of consumer activity. Longitudinal studies often use it, and it is a basis for the theory of behaviour analysis. This research area focuses on what consumers do in space

through time regarding the search for, and acquisition, use, and disposition of, goods and services. Second, behavioural analysis focuses on indirect measures of consumer behaviour, such as attitude, intention or liking. At present, the practical and theoretical relevance of the behavioural perspective of consumption is growing in influence in the fields of both economics and psychology. Analysts set out the rules on which a decision-maker's behaviour might be considered rational from that person's perspective. Then, a lack of consistency with behavioural paradigms is regarded as irrational behaviour. There are therefore solid underlying assumptions for some modelling frameworks that can lead to problems in ascertaining consumers' real insights. Key findings include the following: individuals' preferences and judgements are unstable and context-dependent (Tversky & Simonson, 1993) and most of the time individuals are cognitively constrained (Jamasb & Pollitt, 2005). They tend to use different cognitive procedures and rules to deal with complex decisions (Tversky & Kahneman, 1974; Manzini & Mariotti, 2007). Researchers in behavioural decision theory and cognitive psychology have identified several heuristic and cognitive processes of interpretation and approaches that may consistently affect decision-making (Schwenk, 1984) and how people ultimately make choices.

1.9 Psychological theories of choice and the random utility model

A theory has (a) a set of variables, (b) rules describing how the variables interact and (c) specifications for how to measure the variables (Hansen, 1976). In psychological choice theory, several psychological variables interact in almost all types of behaviour regarding choice. Such choice theories vary, both in the application of variables and the specification of their interaction. Different environmental and predispositional variables and their internal and external responses have a significant role in psychological theories (Hansen, 1976). Psychological variables affect the perception of products, and they influence individuals' choices. Thus, in the psychology of economics, many researchers study the conditions in which agents make choices, and in current choice research, operationalising psychological variables has become increasingly important.

To better understand and quantify this, psychological variables have been categorised into four types (Hansen, 1976). S_1 variables are mostly related to the physical environment of the marketplace; for example, the noise level, store size, and ambient temperature. S_2 variables include perceived alternatives, the perceived environment, perceived messages and other values that are used in the papers included in this thesis (Appendices A and B). S_3

variables may include the number of stimuli, the pattern and complexity of stimuli and categorical effects. Finally, S_4 variables include familiarity, perceived conflict, emotional arousal, and pleasure (Appendix C). Many analysts describe environments in terms of S_1 and S_3 variables. Other researchers may define them as a situation perceived by a decision-maker derived from S_2 and S_4 variables (Hansen, 1976).

Ratchford and Andreasen (1974) suggest an arrangement of consumer decision situations to describe how people gather information to deal with these situational variables. They focus on the four major components of i) the perceived necessity of a decision; ii) the difficulties faced in making a decision; iii) the objectivity of the information, which leads to a less favourable information search; and iv) ensuring the availability of information. The situational variables of choice and the decision-making process through information analysis are linked to human predispositions (Hansen, 1976). Hansen adds that almost all predispositional variables are directly linked to product alternatives and the situation in which people must make a choice. For instance, the situation might involve preferring one option from many alternatives, expectations about the aspects of the situation, and the intention regarding choice behaviour. The variables that explain a particular situation and influence the cognitive structure in an extensive range of situations are known as personality traits and fundamental needs, and they are classified into four categories (Hansen, 1976). P_1 variables involve personality. P_2 variables include general attitudes, values and interests. P_3 variables apply to assess more-specific attitudes, beliefs, images and trusts, and P_4 variables are choice-specific predispositions such as preferences, intentions, WTP and purchasing probabilities.

Hess et al. (2018) grouped the phenomena according to whether the psychological variables and theories were consistent with the RUM. They showed that theories and psychology concepts such as anchoring effects, zero price effects, status quo bias, mental accounting and elimination by aspects are fully consistent with the RUM. The phenomena and theory of psychology, namely lexicography and extreme sensitivities, reference-dependent preferences and loss aversion, decoy context and framing effects, regret, complexity, simplification of choice tasks and heuristics are not always consistent, and some might not be consistent at all (Hess et al., 2018). Therefore, a new measurement technique in

mathematical psychology (Luce and Tukey, 1964) and a deliberative choice experiment[6] (Lienhoop & Volker, 2016) were articulated for choice refinement. Researchers may find a complete choice motive after deliberation, as well as indications of choice adjustment or an increase in choice certainty (Lienhoop & Volker, 2016).

1.10 Refinements of choice analysis

Besides the principles of RUM, for an appropriate study of the perceptions, attitudes and mechanisms of decision-making, analysts should consider the psychological aspects of agents. How people make choices from desirable alternatives cannot be isolated from the disciplines of psychology, economics and mathematics (Edwards, 1954). However, this multidisciplinary approach to decision-making may hinder economic development models. Considering the economic and psychological variables and how individuals make decisions can clarify economic choices (Gradinaru, 2014). By studying a working group, Ben-Avika et al. (1999) considered both the elements of economics and psychology to provide a contemporary understanding of choice theory. An adaptation of it is shown in Figure 2. The figure describes a decision-making process that starts with earlier information and choices operating through experiences and memory to create the framework of a decision problem. The outcome of this choice then influences other decision problems. The black arrows in the figure coincide with the choice theory of standard economics, indicating a theory of rational choice. In this theory, the information collected on options is converted into perceived attributes employing probability rules. These attributes then form an individual utility through the cognitive process, which is then maximised (McFadden, 2000).

[6] Deliberative choice experiments require the integration of the tools of conventional choice experiments with group discussions (deliberations) to facilitate the knowledge of preferences for unfamiliar or complex situations (Bartkowski, 2017).

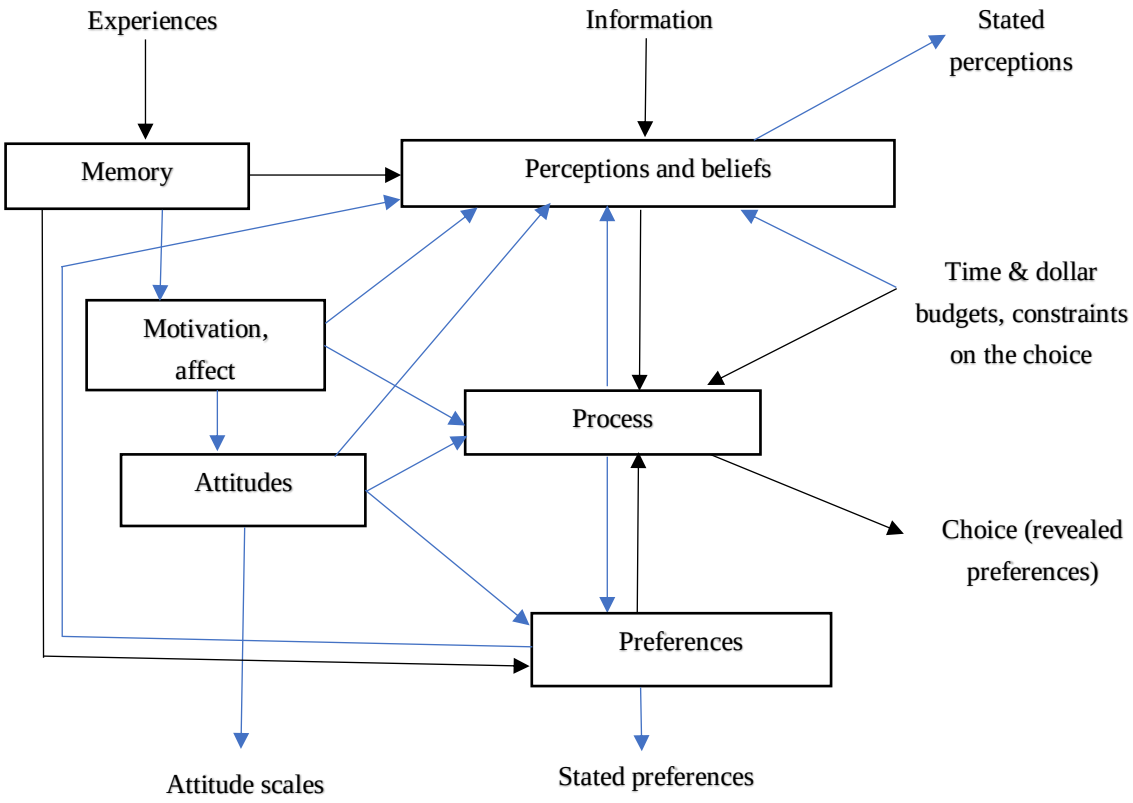

Figure 2 - The choice process, adapted from McFadden's Nobel prize lecture.

In Figure 2, the blue arrows represent the psychological variables that play a significant role in decision-making. Academics in the interdisciplinary field of decision-making, which includes behavioural economics, cognitive science, academic marketing and organisational behaviour, have obtained numerous findings and insights regarding how people make choices. With rich experimental data on purchase intentions and behaviour, a related line of work has transformed mathematical and statistical models of decision-making, and it aims to signify the underlying choice process (Bruch & Feinberg, 2017). Accordingly, psychological procedures (e.g., group persuasion) and psychological factors (e.g., attitude, motivation, trust, beliefs, social norms, knowledge and habit) affect the quality of peoples' decision-making (Kaarbo, 2008). For instance, time for reflection and information processing affect respondents' preference refinement. Such refinement in choice experiments varies depending on how complex, familiar and controversial are the products or services presented to respondents to make a choice (Lienhoop & Volker, 2016). Although the views are different, the concepts of preference, perceptions and process appear in both psychological and economic theories of choice. The critical performance of seafood choices in the markets and consumption are the consequence of an interaction between socioeconomic and psychological choice theories (Richter & Klockner, 2017).

1.11 Consumers' preferences for safe and green seafood

Fish attributes are the key determinants of fish preferences, with women and well-educated people more inclined towards green consumption (Liere et al., 1981). Several sustainable or eco-labels have emerged to indicate these food attributes to increase consumers' awareness of the areas in which the economic impact of the eco-labelling of fish products is influenced by their income and WTP (Vitale et al., 2020). For example, consumers are willing to pay a premium for sustainably labelled salmon fish and steaks and quality-labelled frozen prawns (Alfnes et al., 2018; Menozzi et al., 2020). Consumers correlate labelling information with product safety and quality, so, such labelling is considered a guarantee of safe fish (Pieniak & Verbeke, 2008). In the seafood sector, two variables, the recognition and understanding of eco-labels on seafood products (e.g., from the Marine Stewardship Council (MSC), Fish for Life, Aquaculture Stewardship Council and KRAV[7]) and concern for the adverse environmental impacts associated with seafood production have become the best predictors of the intent to purchase eco-labelled seafood (Jonell, 2016). Therefore, eco-certification is a popular market-based tool to reduce negative environmental impacts on fisheries and aquaculture products.

International reactions to seafood eco-labels are heterogeneous (Robert et al., 2001). Consumers display a strong interest in fish quality labels, and they will pay a premium for fish that is claimed to be healthy and nutritious (Conte et al., 2014). Freshness and cleanliness are considered more important than the price and volume of fishery products (Omemu & Aderoju, 2008). Considering all countries and fish species, consumers will pay a premium for sustainability-labelled seafood (Menozzi et al., 2020). When they are provided with additional information such as sustainability ratings, they prefer both sustainability-labelled and eco-labelled fish more than conventional live fish. In general, consumers prefer live tilapia to the fresh type, but in the USA, prepared tilapia is preferred over the live type because of the inconvenience associated with handling live fish (Meas & Hu, 2014). Although Asians have a higher per capita consumption of live aquatic products than their American counterparts (Venkata et al., 2011), their awareness of sustainability issues concerning live food fish is low, so they prefer wild-caught fish to live aquaculture ones (Fliess, 2009). Moreover, green certification leads to more certainty for consumers in buying fish, but this can be a problem

[7] KRAV is the Swedish brand for organic production, which is found on several items in Scandinavian stores.

for live, chilled and fresh seafood that is not packaged (Wessells et al., 2001). Consumers' perceptions and preferences for green seafood can also be assessed together with their WTP for it (Vitale et al., 2020).

On average globally, additional WTP was highest for organic production and green food, followed by sustainability, higher animal welfare, local, coastal fisheries and fish produced in Europe (Zander & Feucht, 2018). Therefore, organic and sustainable production and higher animal welfare standards appear to be the most promising attributes for product differentiation in advanced economies. The highest level of extra WTP was observed in Germany, followed by Italy, Finland, Germany, Denmark, Spain and the UK (Zander & Feucht, 2018). WTP was highest for superior animal welfare standards and organically produced seafood in France. In addition, about three-quarters of survey respondents in the USA showed a preference for MSC-labelled products (Johnston et al., 2001). In emerging markets like Vietnam, consumers are more likely to prefer eco-labelled shrimp than conventional ones (Xuan, 2021). However, consumer perceptions in other emerging and potential seafood markets in South Asia, such as Bangladesh, have not been well documented. Therefore, this thesis aims to explore consumer perceptions of fish products and their WTP for safety-inspected and sustainably and organically produced seafood.

1.12 An overview of the seafood market and consumer choice in Bangladesh

Seafood[8] is a great source of nutrients like protein, amino acids, fibre, vitamins and minerals (Hosomi et al., 2012), and it has less fat, saturated fat, sodium, and calories compared to other foods. Seafood consumption is an essential part of a healthy and balanced diet (Trondsen et al., 2003), and it is significantly associated with public health (Baki et al., 2018) and less cardiovascular disease (Verbeke & Vackier, 2005). Therefore, the World Health Organization (2017) recommends consuming it once or twice a week, and the American Heart Association (2017) at least twice a week. Because of these food qualities and institutional recommendations, the demand for seafood has been increasing over the last decades (Myrland et al., 2000; Trondsen, 2004), and it could increase by 21–44 million tons by 2050, a 36–74% increase compared to yields in 2018 (Costello et al., 2020).

[8] The term 'seafood' is used in this study to encompass wild and farmed, finfish, crustaceans and shellfish, both of marine and freshwater origin, and in fresh, frozen and processed forms (Jaffry et al., 2004).

High demand, inadequate supply, the advent of aquaculture, sustainability risk, consumers' less positive perceptions of farmed fish, their heterogeneity in perceptions and the huge number of marketers and customers make the seafood market increasingly volatile. Therefore, significant variations have been found in seafood market trends. For instance, Asian consumers have shown the most substantial growth in per capita consumption, while consumption has decreased in Africa, America (Trondsen, 2004) and Europe (Welch et al., 2002; FAO, 2009). Consumers are increasingly heterogeneous in knowledge, confidence and perceptions of seafood (Onozaka, 2014). An analysis of potential consumers' perceptions and future seafood market trends would be beneficial to show how to explore the potential market for seafood and attract the right consumers (Reinders, 2016).

Seafood produced by fish is an essential source of quality protein, and it is cheaper than other animal protein sources. So, it provides an opportunity to form an efficient market structure. It has been the primary animal protein source in Asian diets (Ortega, 2011), where per capita fish consumption is 24 kg/year –higher than the world average of 20 kg/year (FAO, 2016). During the last two decades, Asia has contributed about 89% of world aquaculture production, and it is projected that Asia will continue to lead world aquaculture with even higher rates until 2030 (FAO, 2018). In 2014, Asia accounted for 70.8% of global fish production (88.9% of aquaculture and 56.5% of capture production) excluding aquatic plants. Further, aquaculture in Asia is also more diverse than in other regions in terms of production systems and cultivated species (Bush et al., 2019). South Asia accounts for 9.3% of global fish supply, and India and Bangladesh are the region's top producers (FishStatJ., 2016) with the largest share of inland capture production (30% of total capture fishery production) among sub-regions in the Asia-Pacific area (Lungren, 2006).

Bangladesh is a south Asian emerging market with the potential to have a very high seafood demand. Fish is the largest source of animal protein in Bangladesh (60% of the total), and its percentage will continue to rise because of increasing consumer purchasing power. Accordingly, the Bangladesh aquaculture sector has been developing steadily during the last two decades because of growing demand and depleted natural fish stocks in ponds, rivers and marine areas. In Bangladesh, wild fish capture is decreasing and fish farming is growing (see Figure 3). Specifically, farmed fish production grew 25-fold in the three decades up to 2017 (Hernandez et al., 2018). Evidence shows that 73% of rural households in Bangladesh are engaged in some form of aquaculture (Mazid, 1999), with 1.2 million people directly

employed and 12 million indirectly engaged in fishery-related activities (Dey et al., 2008). Overall, consumers' positive attitudes towards seafood in Bangladesh (Dey et al., 2005) provide opportunities for world seafood supplies to explore potential Asian markets.

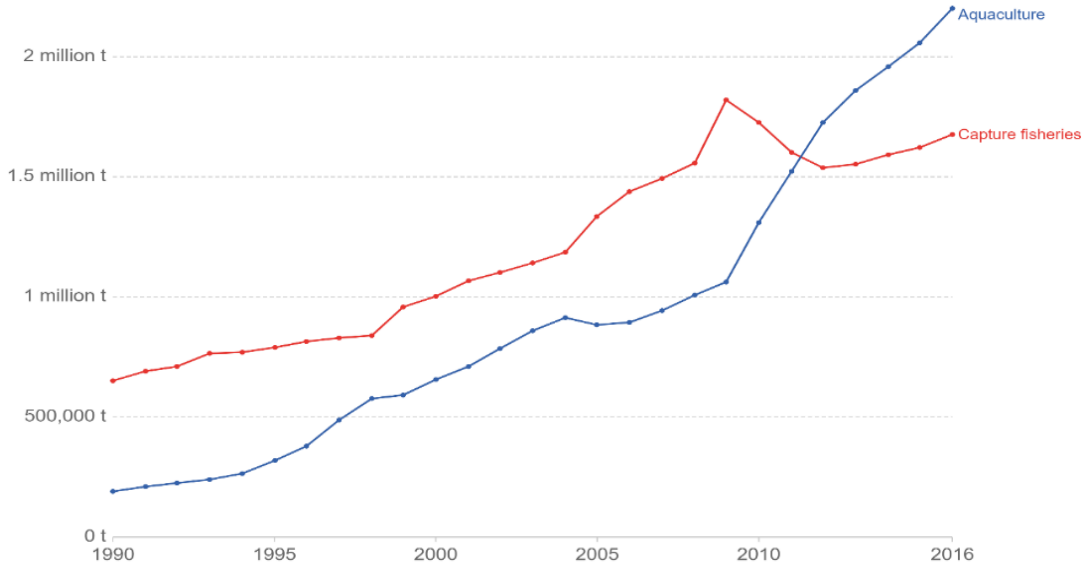

Figure 3 - Wild fish vs aquaculture seafood production in Bangladesh, 1990 to 2016. The vertical axis indicates the quantity in tonnes; the horizontal axis years. Source: UN Food and Agriculture Organisation (FAO), OurWorldInData.org.

The frequency of fish and seafood consumption in Bangladesh is highest amongst South Asian countries. It is even higher than in India (see Figure 4). Fish remains by far the most significant and frequently consumed animal-source food in Bangladesh, but it varies substantially by location, income group and season. In local markets, consumers prefer bigger fish (Uddin et al., 2019), but they think wild fish are tasty, whether they are small or large. Therefore, they purchase wild fish irrespective of high market prices. Poor households consider fish a luxury because of their limited income. Thus, consumers in local markets are most likely to buy low-cost pangas and tilapia when the price of alternatives increases (Uddin et al., 2019). Nevertheless, fish is considered a staple in more affluent homes. Consequently, with an increase in per capita household income and population, fish production and consumption are both expected to increase (Dey et al., 2010).

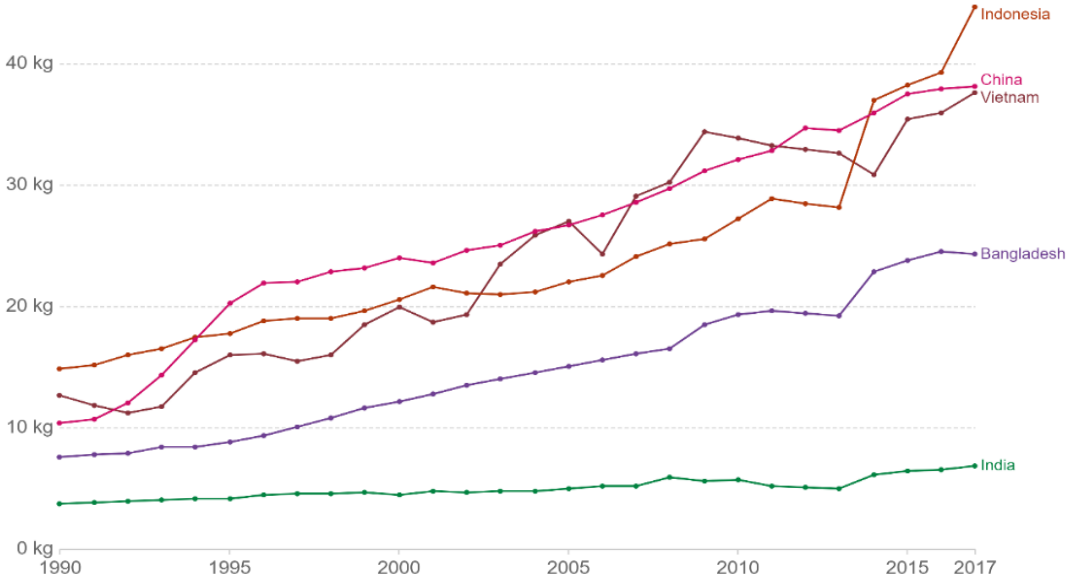

Figure 4 - Fish and seafood consumption per capita in Bangladesh and the five other leading regions in Asia, 1990 to 2017. The vertical axis measures quantity in kg; the horizontal axis years. Source: UN Food and Agriculture Organisation (FAO), OurWorldInData.org.

Although the results of behavioural analysis, demand elasticities, consumer perceptions, preferences and WTP may vary significantly between geographical regions, most previous studies concerning seafood have focused on individual markets such as the EU, France, the US or Japan (Herrmann et al., 1993; Bjørndal et al., 1994; Wessells & Wilen, 1994). We found an absence in the literature of world estimates (Xie et al., 2009) and those of Asian emerging countries (Hoque, 2020). Furthermore, fish product attributes and their effects on household choice in developing and emerging countries have received limited attention in previous studies. Therefore, this thesis includes four papers concerning consumers' attitudes and perceptions of fish (mostly farmed fish) and their willingness to pay for it, specifically for safe and green seafood (i.e., sustainable and organic).

2. Objective and research questions

This thesis aims to add knowledge about the economic characteristics of seafood (especially farmed fish) in the emerging market of Bangladesh by exploring consumer perceptions of farmed fish, the value of sustainability indicators on sustainably farmed fish and consumers' WTP for organically farmed and safety-inspected fish. Consumers' perceived knowledge of farmed fish, their awareness of food safety and their preferences for safety inspections also are considered. Therefore, the study's general research question (GRQ) is this: In what way do consumers prefer sustainably, organically, and safety-inspected fish and

how does their perceived knowledge of the value of food safety and their attitude towards farmed fish affect their fish choices?

Four specific research questions (SRQs) also are aimed to find answers to the GRQ. SRQ1: How can we examine consumers' value of sustainability indicators in preferring sustainably farmed fish? SRQ2: How can we determine consumers' willingness to pay (WTP: for organically farmed fish? SRQ3: How can we analyse consumers' perceived knowledge, attitude and confusion concerning farmed fish and their purchase intention? and SRQ4: How can we investigate consumers' food safety awareness and their WTP for safety-inspected fish? These four SRQs are answered in four individual research papers adapted for the thesis.

To get suitable answers to specific research questions requires original data, an amalgamation of multiple sources, and relevant understanding and/or arguments (Bryman, 2007). Therefore, this thesis considers four sets of original survey data from the urban households of the emerging market of Bangladesh in four studies. Then, the answers to the GRQ might help to achieve the primary aim of the thesis.

3. Study areas, data and methods

The thesis includes four papers that discuss urban household responses to questions regarding fisheries and aquaculture products in Bangladesh. The households in each survey were considered in a between-subject design. The study areas were selected strategically within Bangladesh, based on economic status, sociodemographics, geographical conditions, tradition and cultural connotations of seafood consumption. The data for the first and second papers were collected from Chittagong (the principal seaport and business hub of Bangladesh), as the households in this city eat more seafood than any other city in the country (Needham & Funge-Smith, 2014). The second paper covers major regions in the south, centre and north of the country. Finally, data were collected from two economically and politically important cities: Dhaka and Chittagong. Dhaka is the capital city, and Chittagong is the commercial capital of the country. Both are densely populated. The sample sizes and the periods of the surveys are summarised in Table 2, while the study areas are shown in Figure 5.

Table 2 - Methodology, analysis and reporting characteristics of the studies

Paper	**Sampling method and survey period**	**Study area***	**Sample size (households)**	**Methods applied to analyse the data**
Paper 1	Stratified cluster sampling, 2018	Chittagong	N = 490	Exploratory factor analysis, generic multinomial logit, and latent class logit model.
Paper 2	Stratified random sampling, 2019	Rangpur, Dhaka, and Chittagong	N = 660	Exploratory factor analysis and rank-ordered logit model.
Paper 3	Stratified cluster sampling, 2018	Dhaka and Chittagong	N = 500	Exploratory factor analysis, Levene's test for equality of variances, structural equation modelling.
Paper 4	Stratified random sampling, 2019	Chittagong	N = 422	Exploratory factor analysis, conditional and generic multinomial logit models, and a range of utility ratios.

*The study areas are shown on the map of Bangladesh in Figure 5.

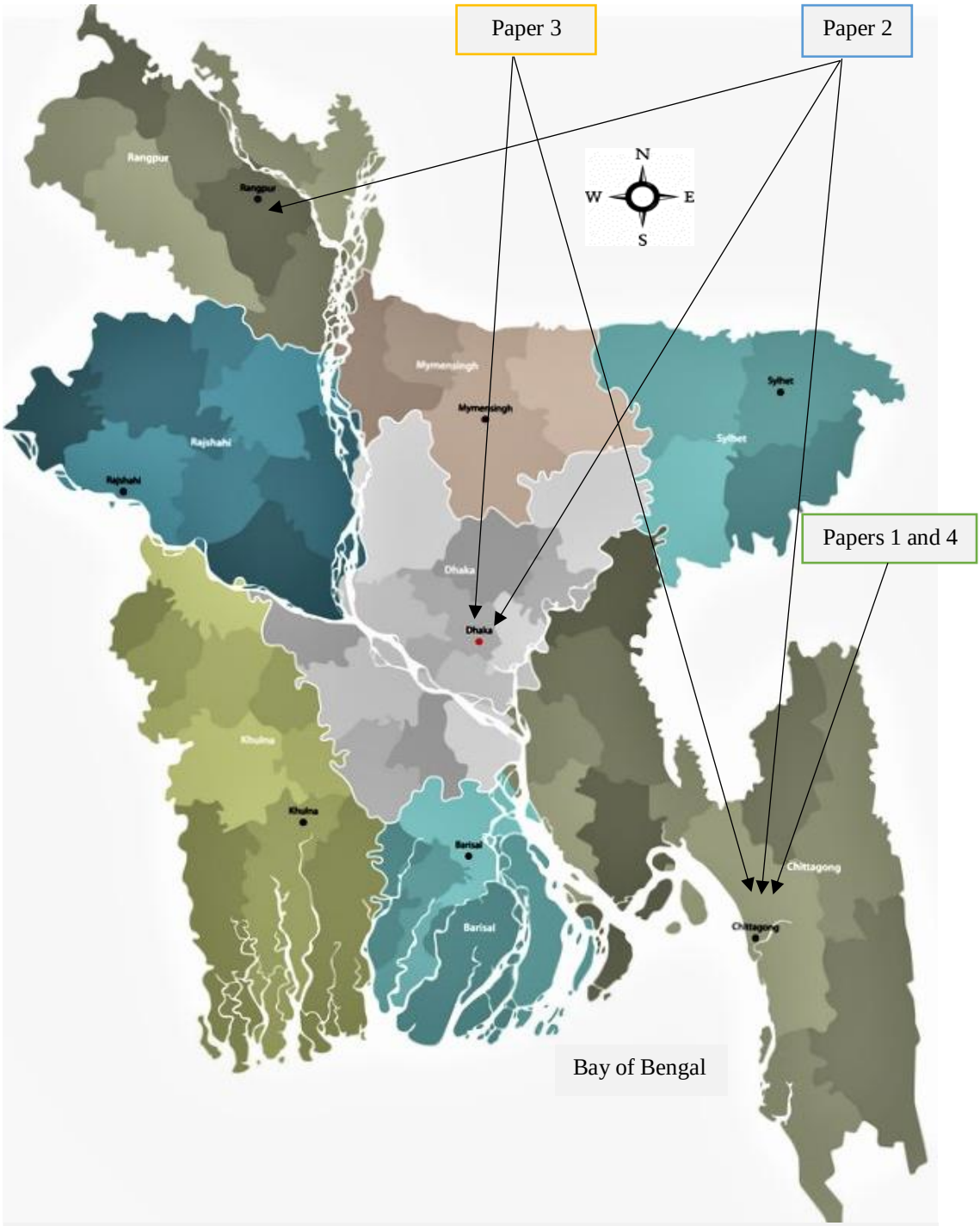

Figure 5 - Map of Bangladesh indicating the study areas of the thesis. Image taken from www.freepik.com, Image number Adobe Stock| #393796099.

4. Discussion and Conclusions

To formulate an effective seafood policy for developing and emerging economies, consumers' perceptions of seafood should be investigated through their preferences, lifestyles, past behaviour, attitudes towards aquaculture fish, the environment, retail or wholesale trading practice and knowledge of fisheries and aquaculture products. In most cases, seafood produced by fisheries and aquaculture has been investigated in the case of advanced economies. To the best of the author's knowledge, there is little literature on consumer perceptions of seafood in emerging economies, especially economies like Bangladesh. We hope that exploring such economies will contribute to the literature and that the study will be of value for implementing global and regional seafood policy.

The studies in this thesis employ four comprehensive household surveys using the direct interview method. Therefore, the analyses are based on the microdata of seafood sales in the retail markets of the country. The studies attempt to address the knowledge gap in consumer perceptions of food safety in general and of fish products in particular, together with consumers' preferences and WTP for such products. The need to gain insight into consumers' perceptions of farmed fish has been identified as a key factor in determining whether Bangladeshi aquaculture will achieve its growth potential. The vital research objective is to elucidate the effects of consumers' perceptions on their choice of seafood in general and from aquaculture in particular. The studies seek to estimate seafood choices and determine how consumers' choice of different fish products may be affected by product attributes, socioeconomic variables and consumers' values, perceptions and attitudes towards seafood.

Consumers' objective and subjective evaluations of aquaculture (e.g., the quality of farmed fish) depend on their perceptions and understanding of the production process and the technology used in the production system (Alam, 2019). This link between agents and fisheries assumes a causal relationship between knowledge, perception, attitudes, evaluation and behaviour (e.g., purchase intention, preferences, choice, WTP) (Hashanuzzaman et al., 2020). Therefore, the papers in this thesis consider the relationships between households' knowledge of fisheries and aquaculture, their awareness of food safety and their evaluation of product attributes and food safety inspection, areas which are rarely covered in previous research. In measuring the effects of the perceptions of seafood attributes (e.g., production method, product form, processing methods, food labels) on fish choices, complementary fish

species, the shape and size of species and their sources, retail market prices (supermarkets and open markets/wet markets) also are considered in the list of attributes (Papers 1 and 2).

Furthermore, consumers' perceived knowledge and consciousness of fisheries and aquaculture product safety are considered in estimating their preferences in microeconometric and structural equation models (see Papers 3 and 4). For effective strategies, approached in an innovative way, a combination of discrete choice and psychological choice variables, such as attitude, trust, beliefs, affects, values, confusion and perceived knowledge are considered to refine the choice by testing if these associations have any effect on seafood choice. The effect of consumers' psychographics, along with their consumption frequency, on seafood choices was assessed. In the profiling variables, the differences between consumers' rating attitude, ranking attitude, and preference attitude toward seafood are considered in the fourth paper. Finally, SEM is used to assess how the level of knowledge and its discrepancies or confusion about farmed fish and purchase intention affects the formation of attitudes towards seafood (see Paper 3).

In exploring the influence of perceived knowledge on the intention to purchase farmed fish, consumers show a discrepancy between subjective and objective knowledge. Their subjective knowledge is effective in reducing confusion and increasing their purchase intention. Although consumers' attitudes influence their intent to purchase seafood, this discrepancy and their level of knowledge cannot add value when forming their attitudes. Therefore, other personality and psychological variables, such as consumers' perceptions of safety control, safety labels and sustainability indicators, are considered as the antecedents of attitudes to seafood and seafood preferences. The outcomes also show that the environmental and biological indicators of the sustainability of farmed fish increase consumers' utility. Therefore, fish should be marketed with food safety labels and indicators of environmental and biological sustainability. Besides such indicators, safety controls at the local level increase the utility of seafood, and consumers are willing to pay more for it. However, this value of food safety inspection is high only in their affective reaction. Moreover, the method of production and the product form also can influence consumers' seafood preferences. For instance, they prefer farmed fresh fish, but not the frozen version, suggesting that fresh, safety-inspected farmed fish will be rewarded in the emerging seafood market.

In general, wild fish have a more favourable image regarding taste, safety, health and nutritional value than farmed fish. Therefore, households value fish attributes and quality

certification in their buying decisions at least in relation to farmed fish. Knowledge about health, nutrition and risk greatly influences consumers when purchasing seafood. In emerging economies like Bangladesh, the value of fish from freshwater inland aquaculture has increased over that of the coastal and marine types. However, regarding organically farmed shrimp, the marine version was preferred by consumers. Although farmed fish seafood dominates in local Bangladeshi markets, consumers prefer wild fish over the lower-priced farmed fish produced by entrepreneurial aquaculture, such as carp, pangasius, tilapia and climbing perch. Therefore, the industry has a great responsibility if it wants consumers to continue to buy seafood produced by aquaculture for its high nutritional value and eating quality when they shift from wild-caught fish to aquaculture.

When choosing farmed shrimp, Bangladeshi consumers value the safety label, which implies safe-farmed fish and indicates an average level of fish sustainability, more than the eco-label. However, they look for a high level of sustainability while eating farmed fish with high frequency. The interesting finding is that consumers prefer safe seafood over the organic type. Such a preference could be because of a poor understanding of organic seafood or a more favourable impression or readability of safe seafood. Another interesting finding is that consumers are not risk-sensitive in terms of the amounts of fish consumed. This implies that even without a food safety inspection, they prefer to consume an amount of fish that is higher than fish that has had a national food safety inspection. Such discrepancies in the perceptions of food safety can lead to market failures, even though consumers have a health-driven approach to food safety (Lagerkvist et al., 2013). When only the method of production is considered, consumers prefer inland-farmed fish over the coastal version and organically farmed fish produced in marine aquaculture. In addition, within conventional methods of production, they prefer inland-farmed fish to the coastal-farmed type. However, consumers with a low level of knowledge are willing to pay less for conventionally farmed fish.

The literature, including the outcomes of the papers in this thesis on seafood demand and markets, constitutes an analysis of how consumers value seafood attributes, and it provides an estimation of their attitudes towards and perceptions of seafood. These perceptions derive from seafood attributes, sustainability indicators and food safety and quality (Reinders et al., 2016). Research has also revealed that the sociodemographic characteristics of consumers are associated with how they perceive the value of seafood attributes when making choices (Nayga, 1997; Hoque et al., 2021). Consumers' general perceptions, – and their price-

consciousness and risk perceptions – lead to their overall value of seafood (see Figure 6). Such perceived value is the antecedent of consumer demand for seafood in the form of purchase intention, preference, trust, satisfaction, WTP, WOM and consumption, under the heading of value outcomes. Consumers' consumption values have multiple dimensions, such as functional value, social value, emotional value, conditional value and epistemic value under social, economic and psychological perspectives. However, these values are independent, and they can make different contributions to consumers' choices in different situations (Lin & Huang, 2012). To assess consumers' perceptions of the consumption value, the functional, social and emotional values are the primary drivers of consumer choice (Sweeney & Soutar, 2001). The perceived utility derived from belonging to one or more social groups is a social value in which the emotional value is the perceived utility caused by an alternative capability to arouse feelings (Sheth et al., 1991). For instance, fish food products and services are frequently associated with emotional responses. In addition, conditional value is consumers' perceived utility of an option resulting from a particular situation. Finally, the epistemic value is derived from an alternative capacity to arouse the curiosity of consumers (Sheth et al., 1991).

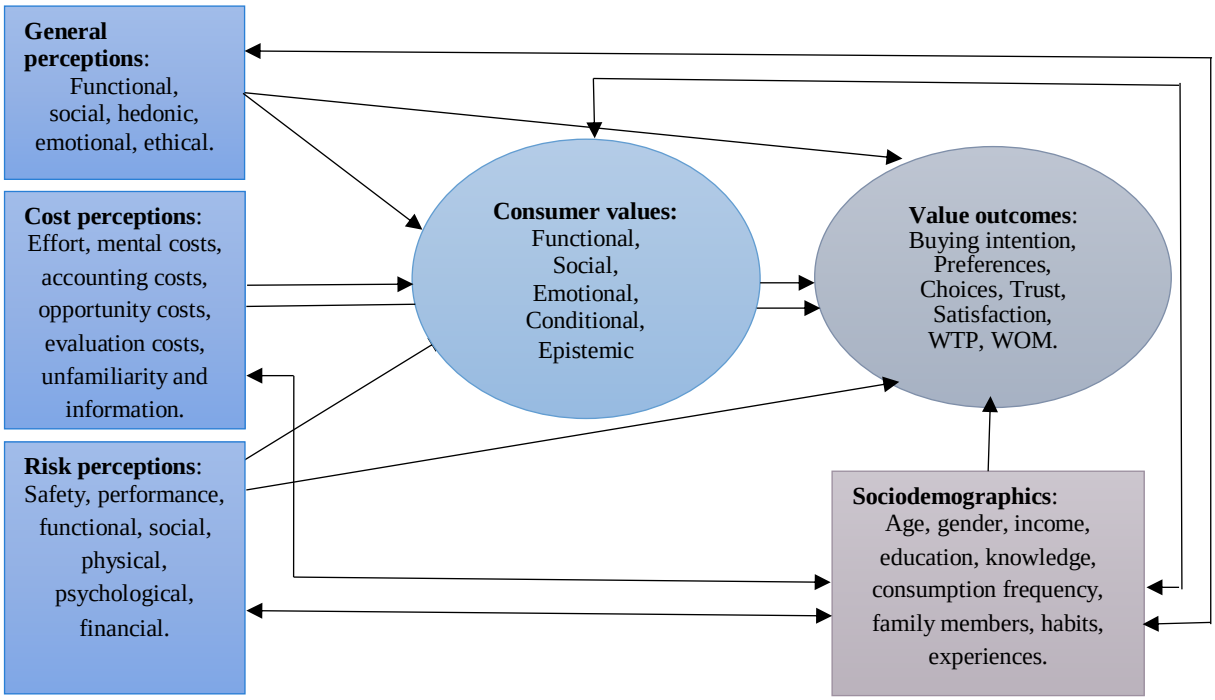

Figure 6 – Consumers' perceived value of fisheries and aquacultural products. WOM = word of mouth.

Although consumers' risk perceptions of seafood are not considered in this thesis, the outcome of the systematic review of the research, the application of marketing and

management research techniques and the use of a DCM could help to formulate an effective seafood policy. Such contributions can help develop the seafood supply chain, ensure the optimal provision of attributes and offer seafood products to consumers that satisfy their values and choices. The outcomes of the studies could also help policymakers reduce consumers' attitude-behaviour gap in demonstrating the balance between interests and preferences for seafood products. This helps to turn consumers from non-users into users of existing products, encourages the development of new fish products and attracts new consumers by reducing barriers and offering seafood at affordable prices.

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Paper 1

Sustainable Production and Consumption 27 (2021) 115–127

Contents lists available at ScienceDirect

Sustainable Production and Consumption

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

Sustainability indicators for sustainably-farmed fish in Bangladesh

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ARTICLE INFO

Article history:
Received 26 May 2020
Revised 11 October 2020
Accepted 17 October 2020
Available online 21 October 2020

Editor: Prof. Adisa Azapagic

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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https://doi.org/10.1016/j.spc.2020.10.020

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:

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

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:

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

where β_{0j} = an alternative specific constant for alternative j; $\beta_{1j,}$ $\beta_{2j,}$ ……, $\beta_{nj,}$ = coefficients associated with the independent variables; $X_{1n,}$ $X_{2n,}$ ……, $X_{qn,}$= 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):

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

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):

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

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.

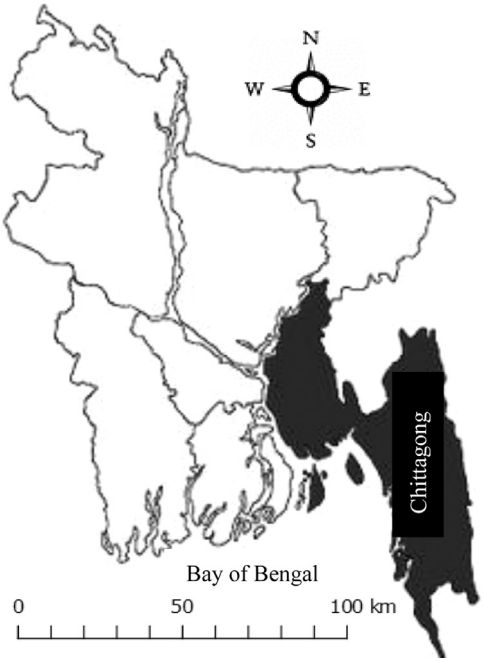

Fig. 1. Black shading indicates the Chittagong area.

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 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?

Attributes	Option A 	Option B 	Option C 	Option D
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.

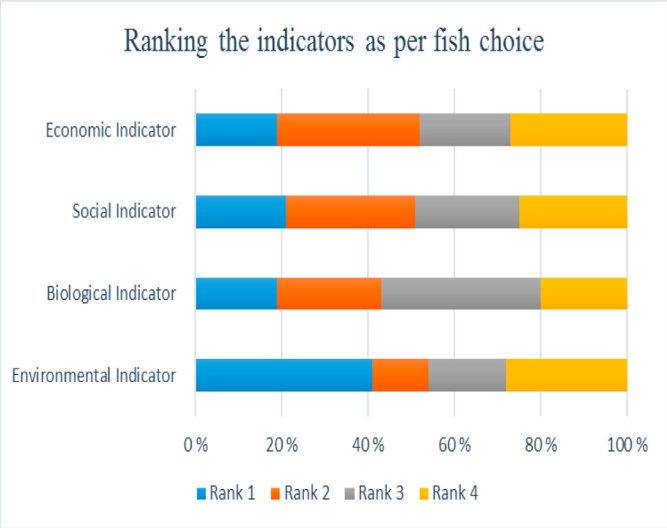

Fig. 3. Percentage of consumers' ranked choices of sustainability indicators.

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

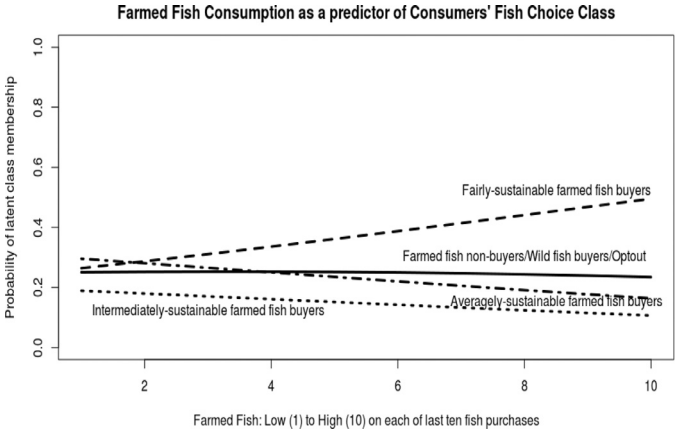

Fig. 4. Predicted prior probabilities of latent class membership at varying levels of farmed fish consumption. The outcomes are from the four-class latent class regression model.

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.

Acknowledgements

The author would like to thank the SPC editors and anonymous reviewers for their thoughtful and detailed comments on the development and quality of the paper.

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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Paper 2

Journal of Agricultural and Applied Economics (2021), 1–28
doi:10.1017/aae.2021.12

CAMBRIDGE UNIVERSITY PRESS

RESEARCH ARTICLE

Consumers' Willingness to Pay (WTP) for Organically Farmed Fish in Bangladesh

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Abstract
This study aims to assess the market potential for organically farmed shrimp. The rank-ordered logit model was employed to investigate consumer perceptions; the findings reveal that consumers prefer organic shrimp from mariculture, and inland-farmed shrimp to the coastal version. The willingness to pay (WTP) for conventional shrimp amongst consumers with low knowledge is less than that for organic shrimp amongst highly knowledgeable ones. In addition, the lower WTP for organic shrimp compared with safe shrimp amongst those with a medium knowledge level shows that the organically farmed shrimp market is lagging behind due to limited knowledge and confusion.

Keywords: Bangladesh; Consumer knowledge; Consumer preferences; Emerging economy; Organic shrimp; Willingness to pay
JEL Classifications: Q22

1. Introduction

Modern organic food production is attracting attention around the world because of the sustainability issues influencing individual and public health, natural and social resources, and the economy (Thøgersen, 2017). Organic food products are crucial from both the production and consumption perspective (Willer and Kilcher, 2009), with consumers considering organic food to be eco-friendly because of the natural growing methods employed (McEachern and McClean, 2002) and the use of fewer pesticides and artificial fertilizers which are harmful to the environment (Cornessen et al., 2008). A positive attitude toward food safety, environment, and healthier options over conventionally grown foods plays a vital role in positively changing attitudes toward organic foods (Azzurra et al., 2019; Hsu and Chen, 2014). Therefore, the link between food safety, health benefits, and environmental development should be strengthened to develop organic food (Shafie and Rennie, 2012).

However, the actual contribution of organic food in the competitive market is relatively low (Verhoef, 2005), with its price premium a clear obstacle to its purchase, which creates a crucial distinction between the willingness to pay (WTP) and the range of factors affecting organic food (Krystallis and Chryssohoidis, 2005). In addition, consumers cannot check the characteristics of organic food (e.g., taste, freshness, benefits to animal welfare, health, and environmental issues) when deciding to buy it. In many markets, the information on such product attributes is either unavailable or unreliable. Therefore, consumers' buying intentions and demand varies according

The data that support the findings of this study are available on request from the corresponding author, [Mohammed Ziaul Hoque]

to their gender (Winterich et al., 2009); age (Scott and Willits, 1994); family income (Stiebeling et al., 1941); household size (Richardson et al., 1996); product availability (Radam et al., 2010); and product quality (Handford et al., 2016). At present, consumers are concerned about food contamination; more specifically, they perceive that seafood contains certain chemical contaminants, so organic labeling could be considered as a positive marketing technique (O'Dierno et al., 2006). Organic food processing increases food quality, sustainability, and consumers' confidence in and acceptance of the product (European Commission, 2020). Consequently, it is imperative to understand the extent of consumers' preference for organic food (Sriwaranun et al., 2015).

Concerns about health and the environment lead to increased consumer desire to purchase "natural," "hormone-free," and "antibiotic-free" fish and shellfish (Boehmer et al., 2005), qualities which indicate sustainable and organic fish. The demand for organic fish has been rising globally due to increased population, increased consumption, rising health awareness, and increases in the price of fish abroad. Therefore, consumers have come to recognize organic farming as a production method, which can satisfy their expectations. To support organic fish farming, ecological succession has been employed in the aquaculture sector (Gandini et al., 2009). In the dominance of freshwater-dependent aquaculture, fish from organic aquaculture can be produced both in marine and brackish water (Datta, 2012). These farming opportunities resulted in an increase in organic aquaculture food production worldwide of more than 415 thousand metric tonnes in 2016 (Lernoud and Willer, 2018). However, the market share of organic aquaculture products remains small (Risius et al., 2019). There is a lack of detailed empirical research on consumer differentiation between organic and conventionally farmed aquaculture products from different sources.

The increasing demand for aquaculture products and technical and commercial opportunities have made the development of fish farming an essential topic globally. Asia leads the world in aquaculture production, with China, India, Vietnam, and Bangladesh the top producers. As Bangladesh is an emerging economy (OECD, 2020) and a riverine country, fisheries and aquaculture businesses have excellent potential (Hoque, 2020). In addition, its geographic position and cultural connotations[1] also favor Bangladesh's support of fisheries and aquaculture. To obtain the required nutrition and protein, Bangladeshis depend on aquaculture products. Currently, they are becoming wealthier and more educated, with urbanization and safety issues becoming major concerns for them (Hoque, 2020). Accordingly, as it is seen as safe and healthy food, the demand for organic products in urban areas has increased despite their high price and absence of reliable information (Iqbal, 2015). Although the trend is growing in both consumption and production sectors, the number of organic food producers, including those of farmed fish, is not keeping pace (Iqbal, 2015). This issue is more critical in Bangladesh due to its large population, the popularity of fish consumption, and the lack of reliable safety information. Despite the fact that the government and NGOs have been attempting to promote the cultivation of organic fish products, to develop consumers' preferences, and to improve the market structure, buyers' lack of knowledge is a recurrent concern for marketers and policymakers, with consumers demanding balanced information and a continuous communication flow.

The literature emphasizes that attitudes to organic food significantly influence consumers' buying intentions and behaviors. In addition, several researchers report that consumers' level of purchase of organic food is very low relative to their positive attitudes (Pearson et al., 2011). Therefore, to obtain consumers' real insights, organic food marketers need to improve and implement effective green marketing practices to support consumers' decision-making process (Suki, 2018). Green marketing practice could involve a supply chain strategy of safe, sustainable, and organic food; marketing communications for eco-friendly products; eco-labeling; and branding (Hughner et al., 2007). Accordingly, the acceptability of fish and fish farming depends on the socially responsible (e.g., organic) development of the aquaculture industry (Schlag, 2010).

[1]The historical and traditional Bangali culture of "fish and rice make a Bangali (Machh-e-bhat-e-Bangali)" also motivates them to eat more fish.

Nevertheless, unlike personal factors, situational and environmental ones have been mostly unexplored in the context of farmed fish, and more specifically, in that of organic farmed fish in emerging markets. While some attention has been focused on the problems affecting the growth and supply of farmed fish, little research has been dedicated to analyzing consumers' concerns about organically farmed fish in particular, and their preferences regarding fish farming processes and their system of origin (e.g., inland aquaculture, coastal aquaculture, or marine aquaculture). Therefore, the objective of this study is to fill this knowledge gap.

To achieve its objective, the study aims to assess the market potential for farmed fish by analyzing consumers' preferences and their WTP for organic and conventionally farmed shrimp. Such knowledge will contribute to the planning of marketing strategies, especially ones related to pricing, for organically farmed fish in domestic markets, which will ultimately benefit producers, retailers, and consumers. The study investigates Bangladeshi market segmentation by estimating the relative value of farmed fish attributes, such as aqua farming processes, prices, and aqua farming systems, all of which could influence consumers' preferences. A sample of 660 consumers from Chattogram, Dhaka, and Rangpur, Bangladesh, were interviewed in an experimental design. The collected data were analyzed with a rank-ordered logit (ROL) model.

The literature review is presented in the following section, followed by a description of consumers' perception of organic food in Bangladesh. The econometric model and data collected are then presented. Subsequently, the research results are analyzed and discussed, followed by the conclusion, which includes the study limitations and proposals for future research directions.

2. Literature Review

Organic food consumption has increased because of various food scares and consumers' awareness of food safety (Azzurra et al., 2019). The food industry is tainted by its use of artificial toxic chemicals that affect human health adversely and cause unexpected deaths (Ashraf et al., 2019; Rahman et al., 2015). A significant reason for consumers' organic food consumption is the issue of health, which influences their purchasing behavior (Carboni et al., 2000). Furthermore, organic food consumption is vital, as it increases sustainable diets and ensures food sustainability (Mørk et al., 2017). The European Union follows a strict policy for the organic sector, taking into consideration organic food and the eco-friendly behavior of consumers (Azzurra et al., 2019). Such practices increase social well-being and foster economic resilience (Schader et al., 2014).

Consumers' purchasing behavior goes through a psychological process which includes recognizing needs; searching for ways to meet these needs by collecting and understanding information; making and implementing plans; making decisions on product purchase; purchasing the product; and giving feedback post-purchase (Basha et al., 2015). In the context of organically farmed food, consumers' purchasing behavior has been investigated by several researchers. For example, Rana and Paul (2017) report that consumers' attitude has a clear impact on their purchase intentions, including the cognitive approach, which indicates thinking, and the affective approach, which helps to form the feeling component (Aertsens et al., 2009). In organic food purchases, the roles of affective and cognition attitudes are compensatory (Dean, Raats, and Shepherd, 2008), while Michaelidou and Hassan (2008) claim that health consciousness, food safety concerns, and ethical self-identity influence consumers' attitude toward organic food. Moreover, the qualities of organically farmed food, such as higher nutrition and better taste, and the avoidance of chemicals and pesticides in the production process, also influence consumers' purchase intentions. For instance, in the United States, consumer demand for natural and organic foods has substantially increased due to renewed and increasing interest in nutrition, public health, animal welfare, and the impact of traditional agriculture on the environment. However, such health and environmental concerns have an insignificant effect on the consumption of organic food because of the limited knowledge about such food in emerging markets (Le-Anh and Tam Nguyen, 2020; Yilmaz and Ilter, 2017).

Consumer's knowledge about organically farmed food indicates their understanding of the level of the exploration and recognition of product characteristics (Muhummad et al., 2016). Therefore, product knowledge plays a vital role in forming attitudes toward organic food (Gan et al., 2016). Consumers who possess adequate information about such food and its production techniques are more prepared to choose organic products (Gracia and de Magistris, 2007; Saleki et al., 2012). Such findings lead us to assume that low, medium, and high levels of product knowledge will influence consumers' preference for conventional, safe, and organically farmed fish, respectively. Liu et al. (2017) highlight that despite perceiving organic products to be beneficial for both health and the environment, consumers' preferences for such products are subjective, as they have inadequate knowledge about the production standards of eco-labels. For instance, in Vietnam, consumers of organic food face problems due to their lack of related knowledge; many cannot even differentiate between organic and safe foods (Q & Me, 2018; Takayama, 2017). Such lack of knowledge creates a lack of trust (Vega-Zamora et al., 2019) and confusion because of the multiplication of labels, leading consumers to perceive that organic products imply only high prices (Díaz et al., 2012). Furthermore, limited knowledge about organic production techniques negatively affects organic purchases, particularly in developing countries (Gracia and Magistris, 2007; Yin et al., 2010).

In addition to knowledge, consumers' demographic variables also affect their preferences for organic food (Davies et al., 1995; Thompson, 1998). Females are more prepared to pay for organic apples, while males are more likely to pay for organic beef (Illichmann and Abdulai, 2013). Moreover, consumers from highly educated groups (Annunziata et al., 2019), especially women with more extensive education; those from higher-income households; and older consumers are all prepared to pay more for the welfare of farmed fish. They believe that eco-friendly fish are fresher and have a better life (Solgaard and Yang, 2011). However, households with children are not willing to pay a price premium for organic products (Sriwaranun et al., 2015).

A number of previous studies have been conducted on consumers' WTP for organic food. In one, Japanese consumers were shown to be willing to pay 8%–22% more for certified organic vegetables (Sakagami et al., 2006). In addition, Rodríguez et al. (2009) found that consumers from Argentina were willing to pay for organic food, within a broad range of 6%–300%, while another study found that Dominican consumers were prepared to pay 17.5% more for organic products (Boys et al., 2014). Moreover, Canadian consumers were shown to be prepared to pay 10% extra for organic products (Vladicka and Cunningham, 2002). As in the case of organic food in general, organic aquaculture is also presently focusing on consumers' food consciousness. Organic aquaculture production considers animal welfare and public health issues in the production stages. Relevant information is provided by organic labels, increasing consumers' awareness, preferences, and WTP (Mauracher et al., 2013), thus creating market demand and increasing producers' revenues (Ankamah-Yeboah et al., 2019). In Italy, organically farmed marine fish have great potential, as consumers are willing to pay 2.25 €/kg extra over average premium prices (Defrancesco, 2003). Disegna et al. (2009) report that in the case of organic trout, on average potential consumers are willing to pay 2.55 €/kg more, while Norwegian consumers are prepared to pay extra for organic and freedom-food salmon compared with the conventional version (Olesen et al., 2010).

In 2017, total global aquaculture production increased by 49% compared with 2016, with the total production of organic aquaculture almost 0.62 million metric tons, of which 86% was produced in Asia. As the single most valuable globally traded aquaculture product, farmed shrimp plays a vital role, being mainly produced in southeast Asia and Latin America. Recently, the world has focused on organic shrimp production due to consumers' food awareness. Organic shrimp production began in Ecuador in May 2000 and was followed by other countries such as Indonesia, Peru, and Vietnam (Bergleiter, 2002). The world's main shrimp producers are Thailand and China, whose economies rely mainly on the shrimp industry (Research and Marketing, 2019). As shrimp is an essential exportable product in Bangladesh, the country has practiced organic shrimp cultivation on a limited scale in order to meet consumer demand

and increase its economic contribution. Black tiger shrimp (*Penaeus monodon*) production comprises 71.5% of the country's total shrimp farming and represents more than 90% of the total export earnings from farmed shrimp (FAO, 2019). Shrimp farmers in the Bangladeshi economy mostly rely on wild shrimp stock because of the limited capacity of shrimp production (Alauddin and Hamid, 1999). In 2006, the production of wild marine shrimp was 3,200 tons, while the production of farmed Bagda and Golda shrimp was 38,000 and 12,000 tons, respectively (DoF, 2006).

3. Organic Agriculture and Fish in Bangladesh

Organic farming in Bangladesh was introduced in the late 1970s with the support of various NGOs such as PROSHIKA and UBINIG in order to provide seasonal vegetables in a suitable, equitable, and productive way following the principles of biodiversity (Iqbal, 2015; Proshika, 2004). Presently in Bangladesh, consumers' preferences are shifting from traditional to organic food because of its unique characteristics, such as safety, concern for the environment, nutrition, and sensory attributes (Mukul et al., 2013). Consumers like organic food because of its better taste, health benefits, and its attractiveness as a fashionable product. Organic products have great potential as exports as well as in local markets in Bangladesh. Both young and older people consume organic products, with more men preferring organic food; as the fish buyers in the family, they are more willing to pay a price premium for organic foods than women (Ahmed and Rahman, 2015; Iqbal, 2015). Furthermore, consumers' level of education, income, consciousness, and household size, together with the price, and, for example, the breed of fish, in relation to food safety and quality assurance, affect the WTP for organic food (Sarma and Raha, 2016). Prince and Krairit (2017) report that consumers with children, older people, and men who have the regular habit of buying organic meat are encouraged to buy such products in Bangladesh. They add that organic food attributes such as health benefits, verbal recommendations, purchase convenience, and availability significantly affect consumers' intention to buy organic meat. The lack of awareness and knowledge about such products and their price premium significantly and negatively influence people's intention to buy organic foods (Ahmed and Rahman, 2015; Iqbal, 2015). Many consumers claim that organic products are in insufficient supply in Bangladeshi local markets, and that they are limited to particular shops, and continue to be poorly certified. Therefore, consumers have low trust in organic food producers and sales personnel (Ahmed and Rahman, 2015; Sumi and Kabir, 2018).

In Bangladesh, the shrimp sector contributes greatly to income from the foreign exchange market, consequently expanding food production, and improving the livelihoods and income of farming households and associated groups (Ahmed, 2013; Ahmed et al., 2018; Islam, 2008). This sector is the second-largest export industry, generating US$380 million annually, which is 5.6% of the total value of exports (DoF, 2006), with 1.2 million people directly, and 4.8 million households indirectly linked to the sector (USAID, 2006). Although the advent and expansion of the many types of aquaculture of fish and shrimp are not sustainable (Hossain and Hasan, 2017), and outbreaks of disease are the main hindrance for shrimp culture (Alam et al., 2007), shrimp farming in Bangladesh enjoys high demand in the global market, especially in Europe. However, in recent years, international demand for Bangladeshi shrimp has decreased from US$417 million in 2017–2018 to US$365 million in 2018–2019 (Rahman, 2019). Such a decline is the result of failing to meet the international demand for world-class certification of products and the competition generated from the introduction of the farming of "Litopenaeus vannamei" (white leg shrimp) (Rahman, 2019). Moreover, the shrimp industry in Bangladesh has faced substantial economic losses because of infections from viral diseases such as the White Spot Syndrome Virus (Alam et al., 2007; Mazid and Banu, 2002). In addition, the industry has faced low yields, lack of adequate technology, price fluctuations in international markets, bans imposed by the European Union, and lack of government stimulus (Alam et al., 2007; Chowdhury et al., 2006; Paul and Vogl, 2011).

International markets demand high standards and quality shrimp products, a fact that should focus producers' attention on strictly following standardized policy and shrimp production regulations. As a result, alternative organic shrimp production was introduced in Bangladesh. In this regard, the Swiss Import Promotion Program regulated by the Swiss government started the Organic Shrimp Project in 2005 to help small and medium enterprises in developing and emerging economies through consulting, training, marketing support, and the facilitation of access to trade fairs (Paul and Vogl, 2012). In Bangladesh, the agro-climatic conditions, biophysical resources, abundant ponds, and available low-lying rice fields with sufficient wild post larvae in coastal areas are very favorable for farming large freshwater shrimp (Ahmed et al., 2008; Ahmed et al., 2010). Therefore, organic shrimp culture in Bangladesh has great potential due to the increased demand from consumers for organic products in the international market (Ahmed et al., 2018; Aschemann-Witzel and Zielke, 2017; Ruangpan, 2007). However, unstable monthly incomes and different sociopolitical forces hinder the purchase of such food products in Bangladesh (Ashraf et al., 2019).

4. Data and Methods

4.1. Participants

The study intends to develop an integrated picture of consumers' preferences for farmed shrimp. To obtain their opinions, three divisions (counties) were purposively selected, Chattogram, Dhaka, and Rangpur. Geographically, Chattogram and Rangpur are located in the southern and northern parts of the country, respectively, whereas Dhaka is located in the center (Figure 1). In terms of shrimp production, Chattogram is the highest-level area, Dhaka the middle-level, and Rangpur the lowest-level (Appendix A). To recruit respondents, consumers' living standards and fish consumption frequency were also considered. Dhaka and Chattogram are in the second- and third-lowest poverty line positions, while Rangpur is at the lowest level (Appendix A).

In addition, in the cities of Chattogram and Dhaka have the highest per capita fish consumption amongst cities in the country, while Rangpur has the lowest consumption (Needham and Funge-Smith, 2014). These varying criteria helped to choose the representative sample and were suitable for our attempt to explore the growing safety consciousness and diverse fish choices in an emerging market such as Bangladesh. The reason for selecting shrimp was that this species is cultured in inland freshwater, coastal brackish water, and marine saline water (on a limited scale). For the data collection, an experimental design method was followed, in which households were selected randomly by conducting a direct interview method. A questionnaire was sent to the respondents, who were asked to complete it, as well as take part in a face to face interview. Only people older than 21 were asked to participate in the survey, since those under 21 are generally not responsible for fish purchases in the family. Each survey took on average 15 minutes.

Before producing the final survey, the questionnaire was translated from English into the native language Bengali with the help of professional language editors. A pretest survey with 48 respondents was then conducted in two cities (Dhaka, with 25 participants, and Chattogram, with 23) to ensure that they understood the content of all the questions, and that no semantic problems or linguistic complexities existed. As no significant difficulties were found, it was decided to keep the original format for the final version. The Dean Committee, University of Chittagong, Bangladesh, approved the ethical standard of the experiment research content. The survey was conducted from August 21 to October 17, 2019. A total of 704 households took part in the survey; however, 44 responses were excluded due to their unsuitability (incomplete data). Therefore, 660 samples were finally used in the study. In a within-subject design study, the experiment provided a dataset of $n = 660 \times 9 = 5{,}940$.

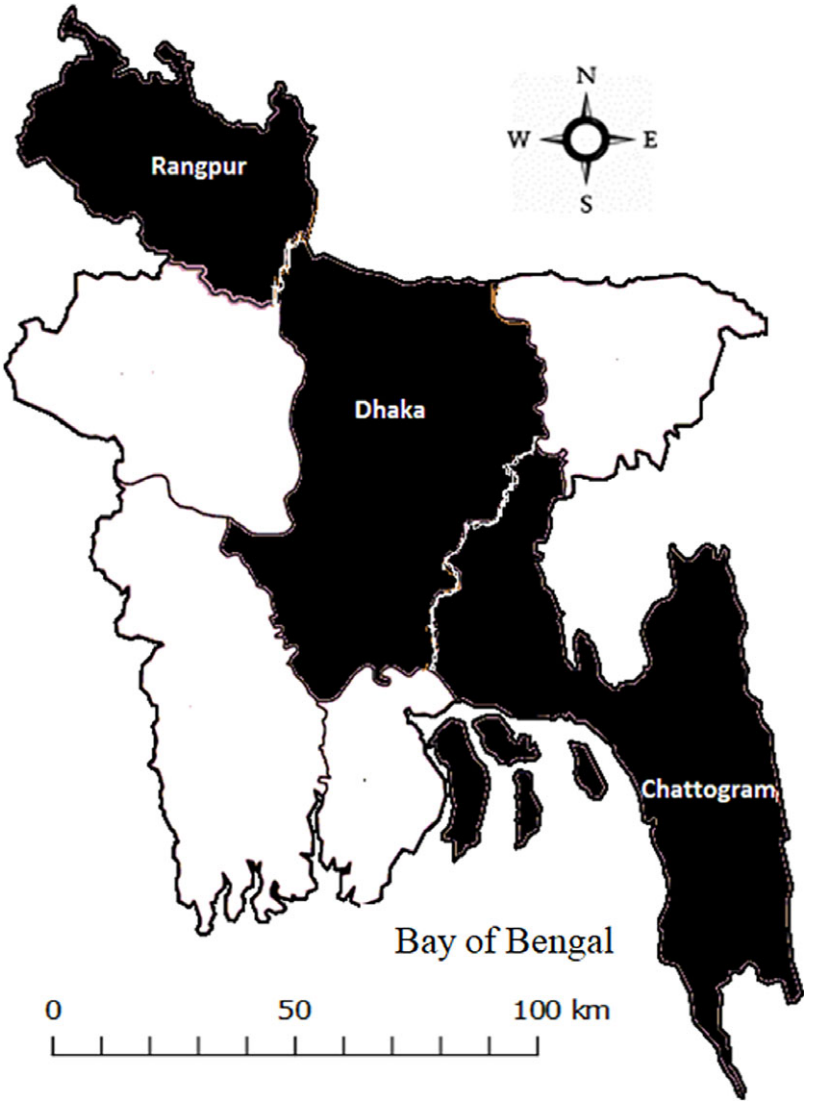

Figure 1. Black shading indicates the study area.

4.2. Questionnaire and Measurements

The first section of the questionnaire consisted of consumers' product knowledge regarding farmed fish, and their attitude toward it. The second section concerned choice of fish based on ranking, focusing on fish attributes. Nine alternatives were presented in a table, and respondents were asked to rank these according to their preferences. The final section was a demographic survey concerning fish-eating behavior. To ascertain the consumers' product knowledge, six questions were posed based on the revolutionary theory of product knowledge taxonomy expounded by Russo and Johnson (1980), using seven-point Likert scale items, ranging from 1 (strongly disagree) to 7 (strongly agree) (Appendix B). To construct general attitudes toward farmed shrimp, five seven-point bipolar scales, from bad to good, negative to positive, unfavorable to favorable, dull to exciting, and terrible to high, were employed to describe respondents' feelings about farmed shrimp in general. The study used exploratory factor analysis (EFA) to find the best number of

Table 1. Outcome of explorative factor analysis

Observed Variables	Latent Variables	
	Knowledge	Attitude
For me the best thing about farmed fish is its availability.	0.714	
I believe pangas is the most economical farmed fish.	0.892	
The most widely consumed farmed fish, I think, would be tilapia.	0.869	
Feelings about farmed fish from unfavorable to favorable.		0.923
Feelings about farmed fish from negative to positive.		0.918
Feelings about farmed fish from bad to good.		0.896
Feelings about farmed fish from terrible to great.		0.880
Feelings about farmed fish from dull to exciting.		0.878
Eigenvalue	2.047	4.042
KMO score	0.631	0.822
Bartlett's test of sphericity	$P < 0.000$	$P < 0.000$
Total variance explained (%)	68.23	80.830
Determinant of correlation matrix	$0.397 > 0.001$	$0.005 > 0.001$

Note: Extraction method: Principal Component Analysis.

dimensions and their common associations based on responses to particular issues (consumers' knowledge and their attitude toward farmed fish), in order to form a pattern matrix (Hair et al., 2010). The EFA considered three statements related to the construct of product knowledge, with the remainder concerning attitude (Table 1). The mean values of the extracted factors from each variable were then measured for use as independent variables. Respondents who gave scores of 5 or below were regarded as agreeing less or having lower perceived values (low knowledge or negative attitude). In contrast, those who gave scores 5 were deemed to be neutral (medium knowledge or neutral attitude). Finally, scores of 6 and above indicated that participants were in strong agreement or had high perceived values (high knowledge or positive attitude).

In the second stage, three fish attributes (farm type, price, and farming system) and three levels (low, average, and high) in terms of the three attributes were considered in order to design product alternatives. A total of 3^3 (27) hypothetical products could be generated by combining the attributes and levels. In the study, three types of production field, marine, coastal, and inland, were considered. To select the fish attributes and to account for their optimal levels, a focus group discussion was held. For practical analysis, an orthogonal fractional factorial design was used, which considered only the main effects of the attributes. This decision was based on the evidence that the main effects explained the variance in the choice model at a level of between 70% and 90% (Dawes and Corrigan, 1974). The program employed (SPSS, version 26) helped reduce the minimum number of choice sets from 27 to 9. Following the study of Balcombe et al. (2010), the participants were instructed to think about the choice scenarios as if they were real. Textual and visual information (see Figure 2) were given to the participants for them to have an idea of the fish type and aqua farming systems used in the choice experiment.

In the third section, the respondents' demographics and socioeconomic characteristics in relation to fish consumption frequency and the markets where they shopped for fresh fish were explored. Finally, the question of whether they could contribute to saving natural fish stocks from depletion through their personal choice of fish was approached in a binary setting. To rank the choice of product alternatives, nine fish products were presented in a table (see Figure 3). To analyze the ranked choice, the study employed an ROL model. As the most preferred choice was independent

Fish type and aqua farming systems	**Description/state of indicators**
	Conventional farmed shrimp: Refers to the raising and breeding of aquatic animals, in this case shrimp, using many pesticides, ratherthan just traditional fishmeal, to increase the growth of the fish rapidly with no safety control.Therefore, there is no label for conventional fish (Hoque, 2020).
	**Safe farmed shrimp:** Shrimp that are under control in the coastal regions. Pesticide residues, heavy metals and the microorganism content within the food comply with government standards and are safe for consumers, but not sustainable (Yu et al., 2014).
	**Organically farmed shrimp:** As organic fish, there is no or limited use of pesticides, chemical fertilizers and other chemical inputs into the production process, which mean the aquaculture can achieve sustainable growth in the fisheries industry.
	**Inland aquaculture:** This type of aquaculturerefers to the raising and breeding of aquatic animals, in this case shrimp, with the use of ponds, reservoirs, lakes, rivers, and other inland freshwater waterways, rather than the more general coastal aquaculture methods.
	**Coastal aquaculture**: This type of aquaculture includes inshore and offshore operations, as well as culture in ponds or lakes near the coast, or specially constructed polders in the coastal regions where brackish water is used in the production process.
	**Marine aquaculture:** This type of aquafarming refers to the breeding, rearing, and harvesting of shrimp that generally takes place in the open ocean. Such culture is also known as mariculture, in which the medium is purely seawater, as no freshwater is added to make it brackish.

Figure 2. Relevant information (textual and visual) about the fish type and the farmed fish production methods.
Sources of images: Apart from the image related to coastal aquaculture (own source), all other images were taken from freepik: https://www.freepik.com/.

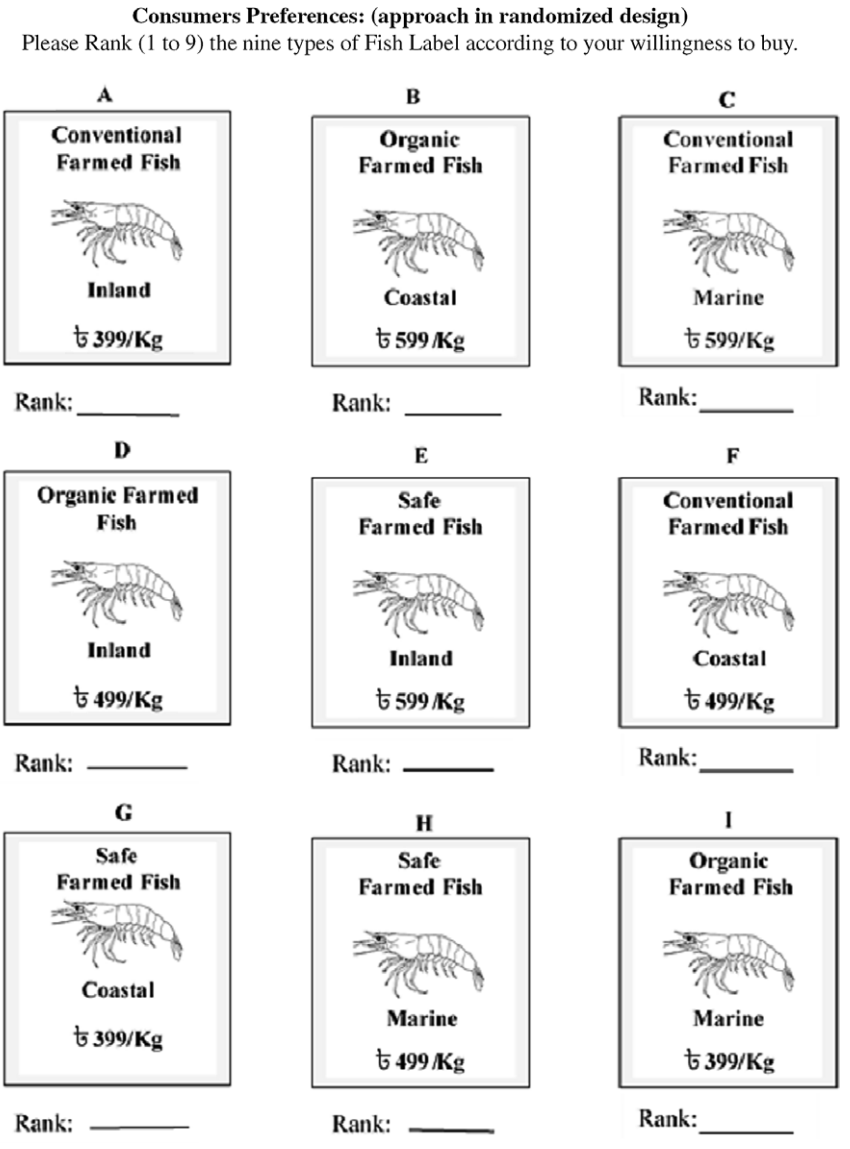

Figure 3. Farmed Shrimp Choices with Focus on Attributes.

of the remaining choices ranked in the model, the independence of irrelevant alternatives property was applicable (Beggs et al., 1981). The ROL model was employed to estimate consumers' fish attributes and the interactions between them, the socioeconomic variables and their WTP in the selected areas of Chattogram, Dhaka, and Rangpur. Interaction terms between the fish attributes and socioeconomic variables were also included in this section because those comprising mobility and self-care were the most salient (Nicolet et al., 2018).

In the experiment, the choice of farmed shrimp was observed only amongst people over 21 years old and responsible for buying fish for the family. However, such a sampling selection could be the cause of sampling bias. Theoretically, the ROL model (equation 5) used in the study could fit, even though the same choices are not made by everyone, and consumers' socioeconomic variables change over time. This unobserved characteristic of the observed sample and nonrandom

sample bias can be adjusted with endogenous covariates in an ordinary sample-selection model (Schwiebert, 2015). In this study, the selection model fits because the preferences of the respondents can differ completely from those who are not responsible for buying fish for the family and who are below 21. Therefore, the differences are for unseen reasons, and it is not clear if these unobservable characteristics may lead to biased results. To control this bias, whether the sample selection mattered was checked by using an extended ordered probit regression (EOPR) in STATA (the Statistical Software, version 16), which outlined whether there was a change in the unobserved characteristics of the respondents' fish choice. In this case, "unobserved" refers to unused factors (gender, the log of income, education, consumption frequency, market type, and awareness of farmed fish) in the estimated model, which may contribute to the analysis of the consumers' choice concerning "choice of farmed fish to save wild fish stock," which is known as an unobserved preference component or responsibility level. These unused factors were observed in the EOPR model as explanatory variables to analyze choice behavior. The endogeneity effect of the probability of the purchase of fish on fish choice was also checked with the EOPR model. The first and second panels in the results show the choice equation and the preference to save wild fish (selection) equation. The results demonstrate an insignificant positive correlation (ρ) between the residuals of overall farmed shrimp choice and the preference to save wild fish stock, at 0.074; S.E. $= 0.242$; z-score $= 0.31$; $p = 0.758$, indicating that selection was not an issue (StataCorp, 2019). Moreover, the almost zero positive correlation between farmed shrimp choice and the preference to buy farmed fish in order to save wild fish stock indicates that farmed shrimp choice is not endogenous with the personal preference for fish to save wild stock, and is not significant ($\rho = 0.005$; S.E. $= 0.074$; z-score $= -0.07$; $p = 0.942$). Such findings indicate that those who are more likely to choose farmed shrimp are more likely to prefer (albeit insignificantly) to save wild fish stock through their personal fish choice (Drukker, 2017).

5. Econometric Model

The study followed the conjoint valuation model, which indicates consumers' decision to maximize their utility. In this case, the respondents were asked to rank the items by order of their preferences, with the most preferred alternative indicating high utility. Assuming that U_{ij} is the rank given to alternative j by respondent i, if there are J alternatives, then U_{ij} may consider integer values from 1 through J, where 1 is the "best" and J is the "worst" in terms of ranking (Allison and Christakis, 1994). A model for such data can be generated from a random utility model, the same model that is employed to explain the standard multinomial logit model (Allison and Christakis, 1994). With J possible alternatives, the utility given by alternative j for individual i is defined in a linear function as

$$U_{ij} = V_{ij} + E_{ij}, \tag{1}$$

where each U_{ij} is the sum of a systematic component V_{ij} and a random component $E_{ij.}$ Each E_{ij} is independent and equally distributed with an extreme value or double exponential distribution. Each V_{ij} can be assumed to be a numerical quantity indicating the degree to which respondent i prefers alternative j over other alternatives that reflect utility. To estimate the utility weights and identical prices, the log-likelihood function was used, which is the ROL (Hausman and Ruud, 1987). The utility index of the mth alternative was designated by

$$V_m = x'_m \beta + u_{m,} \quad m = 1, \ldots, \tag{2}$$

where x_m is a K-vector of alternative attributes; $ß$ is a K-vector of utility weights; and u_m is a randomly distributed error term (with an extreme value distribution). The logit probability that alternative j is preferred to alternatives $1, \ldots, j$-1 is

$$F_j[x_{1,\ldots\ldots,}\, x_i'; \beta] = \exp(x_j^i|\beta) \Big/ [\sum_{i=1}^{j} \exp\,(x_i'\,\beta)], j > 1. \tag{3}$$

Denoting the index of the alternative ranked mth by r_m, the probability of observing the rank ordering $r \equiv (\, r_{1,\ldots,}\ \ r_M\,)$ is

$$\Pr(r, x; \beta) = \prod_{m=2}^{M} F_m[x_{rM,\ldots\ldots,} x_{rM-m+1}; \beta], \tag{4}$$

where $x = [x_m;\, m{=}1,\ \ldots,\, M]$, which has the suitable form of the product of $M - 1$ usual logit likelihood functions. Beggs, Cardell and Hausman (1981) developed and applied this model in a field experiment on choice, which was the result of the independence from irrelevant alternatives (IIA) property of the logit specification. In selecting alternatives, mutual exclusiveness was followed, explaining that all other alternatives were rejected by selecting one alternative (Train, 2009). If a sample considers N observations of x, the attributes of the M alternatives, and the rank ordering of alternatives is r, then the log-likelihood index for the sample of n observations is

$$\begin{aligned} L(\beta) &= \sum_{n=1}^{N} \log\big[\Pr\big(r_{n,} x_n; \beta\big)\big] \\ &= \sum_{n=1}^{N} \sum_{m=1}^{M-1} \log\big[F_{M-m+1}\big[x_{r_M,\ldots\ldots,} x_{r_m}; \beta\big]\big]. \end{aligned} \tag{5}$$

This log-likelihood function is the sum of the ordinary logit log-likelihood functions that can be used to estimate the ROL (Hausman and Rudd, 1987), meaning that the parameters estimated in the model are applicable to the probability of the observed ranking. Positive parameters indicate that the predictor variable is likely to increase the probability of ranking the associated product attribute. Alternatively, negative parameters show that the explanatory value tends to decrease the ranking probability (Zhang and Khachatryan, 2019). The parameter estimation commands of "cmrologit" of the STATA programming fit a choice model for rank-ordered alternatives that assumes IIA is true and allows tied ranks.

In addition, "individual choices are correlated with individual-specific explanatory variables, which take the same value across the choice categories" (Franses and Paap, 2001). Marginal values based on estimated parameters reflect the WTP based on product attributes. According to Train (2009), the estimate can be calculated as the negative ratio of the coefficient of an attribute variable ($\beta_{attribute}$) to the price coefficient (β_{price}); the formula is as follows:

$$WTP_{attribute} = -\frac{\beta_{attribute}}{\beta_{price}} \tag{6}$$

6. Results and Analysis

The survey was conducted on a total of 660 households. The stratified sampling distribution was as follows: 34.85% in Dhaka, 33.33% in Chattogram, and 31.81% in Rangpur. The respondents' average age was 33.03, with 74.80% males and 25.20% females. Culturally, males are responsible for buying almost all food (about 80%) for families in Bangladesh (Schaetzel et al., 2014). In terms of profession, 48.30% of the respondents were employed, 21.30% self-employed, with the remainder, and 30.40%, relying on others for their well-being. Most of the participants (98.50%) ate fish at home, with the remaining 1.50% consuming it in restaurants; 85.20% consumed fish more than once a week, while 14.80% consumed it only once a week. 80.30% of the respondents bought fish from the wet market, 4.10% only from supermarkets, with the remaining 15.60% buying from both. These findings are consistent with the results of the study by Hoque et al. (2021). Although 99.20% of the respondents were aware of farmed

fish, 85.10% believed that it was not safer than wild fish. 90.50% of the respondents were concerned about the environment and thought that by preferring farmed fish they could contribute to saving natural fish stocks (Table 2).

Consumers' attitudes toward farmed fish reflect their preferences for consuming it. In general, 14.70% of the respondents had a positive attitude toward farmed fish, which indicates that they perceived it to be of low intrinsic quality because of the use of food chemicals and pesticides in the production process (Figure 4, Appendix C, and Verbeke et al., 2007b). On the other hand, 60% of consumers did not have a negative attitude toward farmed fish, meaning that the majority preferred it or were neutral toward it (Appendix C). Another explanation may be that the framing effects on consumers' perception of farmed fish are relatively high. Figure 5 (Appendix D) shows that the majority of respondents had above-average knowledge of farmed fish. The results also show that only 1% of consumers had in-depth aquaculture knowledge, whereas 40% had a medium level of related knowledge. The literature indicates that in general consumers have poor knowledge of food production processes and food supply chains (Verbeke, 2005). This lack of knowledge is the main obstacle to purchasing organic food, as consumers do not know its true nature and fail to distinguish between organic, fresh, and safe food (Iqbal, 2015; Q & Me, 2018; Takayama, 2017). Although consumers have a medium or a high level of knowledge about farmed fish, they perceive it negatively, showing a knowledge-attitude gap (Hoque and Alam, 2020) (Appendix D).

This study estimated the conjoint survey data in three different models: Model 1 estimates only product attribute effects; Model 2 estimates the product attributes and their interaction effects; and Model 3 estimates the interaction effects between the product attributes and the perceived knowledge, along with the interaction effects of product attributes. In the models, the estimated parameters signify the corresponding attribute's log odds ratio against the reference/base attribute. The odds ratios are the exponential outcomes of the corresponding parameters. The percentage change in the odds ratio compared to reference attribute of one unit change in the quantity variable was calculated by $[\exp(\beta) - 1] \times 100\%$ (Zheng and Wang, 2016). The ROL regression, as specified in equation (5), was estimated, with the results shown in Table 3.

The results of econometric models 1 and 2 demonstrate the effects of the fish attributes and the interaction terms between them. Model 3, the full model, shows that in the product types, conventional farming reduces consumers' utility significantly and that they are willing to pay less for it than for sustainable and organically farmed fish. This finding is consistent with the study by Sangchoul (2019). On the contrary, consumers are more likely to prefer organically farmed shrimp, an outcome which is in the line with various previous studies, which have indicated that organic practices produce much better results than their conventional counterparts (Bengtsson et al., 2005; Gomiero, 2015; Lorenz and Lal, 2016). Subsequently, consumers are willing to pay a price premium for organic fish (Table 4). In this case, the results indicate that they are willing to pay more for organically farmed shrimp, a fact which is also supported by several other studies (Disegna et al., 2009; Denver and Christensen, 2015; Olesen et al., 2010; Mauracher et al., 2013).

In terms of shrimp aquaculture sources, such as inland, coastal, and marine ones, inland aquaculture is more likely to be associated with consumers' preferences than marine aquaculture, since in Bangladesh inland aquaculture is more widespread than other types (FRSS, 2016; Shamsuzzaman et al., 2017), followed by coastal aquaculture. The results imply that consumers have more knowledge and are used to consuming more inland-farmed shrimp than other types due to its availability even in urban localities. The WTP estimates, shown in Table 4, show that consumers prefer to pay more for inland-farmed shrimp, at Bangladeshi Taka (BDT) 826/kg, and for the coastal aquaculture type, at BDT 542/kg. Such a finding indicates that consumers' WTP for inland and coastal-farmed shrimp is higher than the mean WTP for farmed shrimp. In the model, the odds of the price are −0.001, which is negatively small, but significant, and indicates that at a higher price consumers' preferences would be lower, which supports the presumption of standard economics.

The interaction term between conventional farming and inland aquaculture is positively significant, meaning that they are complementary. Consumers are more likely to prefer inland

Table 2. Descriptive statistics of the demographic and psychographic variables and the preference patterns for fish

	Bangladesh	Chattogram	Dhaka	Rangpur
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5
Sample size (households)	660	220	230	210
Age (mean ± Standard deviation)	33.03 ± 9.77	31.73 ± 11.56	33.45 ± 8.37	33.93 ± 8.97
Gender (%)				
Male	74.80	53.60	85.20	85.70
Female	25.20	46.40	14.80	14.30
Do not want to mention	00.00	00.00	00.00	00.00
Education in years (mean ± Standard deviation)	13.12 ± 3.97	12.73 ± 3.19	15.73 ± 2.65	10.91 ± 4.45
Income ('000) (mean ± Standard deviation)	29.95 ± 20.96	28.75 ± 20.63	36.81 ± 26.04	23.66 ± 10.03
Profession (%)				
Employed	48.30	33.20	72.60	37.60
Self-employed	21.30	17.30	17.80	29.50
Others	30.40	49.50	9.60	32.90
Overall fish consumption (%)				
Once per week	14.80	13.00	12.60	19.00
More than once per week	85.20	87.00	87.40	81.00
Buy fish from the market (%)				
Wet market	80.30	78.20	70.90	92.90
Supermarket only	04.10	00.00	11.70	00.00
Both	15.60	21.80	17.40	7.10
Agree that farmed fish is safer than wild (%)				
Yes	14.90	24.20	16.50	3.30
No	85.10	75.80	83.50	96.70
I am aware of farmed fish (%)				
Yes	99.20	99.50	99.10	99.00
No	0.80	00.50	0.90	1.00
Through my personal choice of fish, I can contribute to the saving of natural fish stocks from depletion (%)				
Yes	90.50	97.30	97.00	76.20
No	9.50	2.70	3.00	23.80
Where do you eat fish most often? (%)				
Home	98.50	99.10	97.00	99.50
Restaurant	1.50	0.90	3.00	0.50
Fast food/Takeout	0.00	0.00	0.00	0.00
	N = 5,940	N = 1,980	N = 2,070	N = 1,890

Table 3. Estimated results of the exp (coef) of product attributes and consumer preferences for fresh farmed shrimp

	Model (1) with Product Attributes Only		Model (2) with Product Attributes and Their Interactions		Model (3) with Product Attributes and Interactions with the Perceived Knowledge	
Variable	coef	*z*-ratio	coef	*z*-ratio	coef	*z*-ratio
Conventional farming	−0.271***	−7.53	−0.410***	−5.74	−0.346***	−4.43
Organic farming	0.246***	6.89	0.191***	4.24	0.203***	2.62
Inland aquaculture	0.821***	19.62	0.816***	13.11	0.826***	13.23
Coastal aquaculture	0.525***	12.66	0.531***	8.63	0.542***	8.78
Price	−0.001***	−8.94	−0.001***	−3.53	−0.001***	−3.23
Conventional*Inland			0.220**	2.04	0.226**	2.08
Conventional*Coastal			0.183**	2.04	0.180**	2.00
Organic*Marine			0.172**	2.00	0.197**	2.27
Conventional*Low knowledge					−0.069	−0.21
Safe*Medium knowledge					0.162**	2.21
Organic*High knowledge					0.085	1.14
	$N = 5940$, Number of cases = 660, LR χ^2 (5) = 682.21, P (χ^2) = 0.00; Log-likelihood = − 8108.099		$N = 5940$, Number of cases = 660; LR χ^2 (8) = 693.11, P (χ^2) = 0.00; Log-likelihood = −8102.653		$N = 5940$, Number of cases = 660, LR χ^2 (11) = 704.90, Log-likelihood = −8096.754	

*** 1% level of significance, ** 5% level of significance, * 10% level of significance. The safe farming process and marine aquaculture are the reference case.

conventional farmed shrimp. They are also more likely to prefer shrimp which is produced in coastal brackish water. However, the level of the preference for conventionally farmed shrimp produced in inland aquaculture is higher than that for coastal aquaculture. For conventionally farmed shrimp produced in inland freshwater, consumers are willing to pay an extra BDT 226/kg, followed by conventionally farmed shrimp from coastal areas, at BDT 180/kg. Such findings indicate that conventional farming is dominant for inland-farmed fish; therefore, because of its availability, consumers are more likely to prefer conventional inland shrimp. The results also demonstrate that organic farming and mariculture are complementary. In addition, organic shrimp, particularly that produced in mariculture with saline water, is mostly preferred. Therefore, with regard to the organic shrimp production area, there should be more focus on the marine sector than the inland and coastal sectors in order to attract consumers' preferences. Moreover, in the case of organically farmed shrimp, consumers are most likely to pay a higher premium for that originating from the marine sector than for coastal conventional farmed shrimp. Such a finding is supported by Defrancesco (2003) and Stefani et al. (2012), who show that marine farmed fish command price premiums.

A negative insignificant interaction term between conventional farming and consumers' low knowledge indicates that even consumers with low product knowledge do not like to buy conventionally farmed shrimp. They are aware of the conventional farming process, in which high levels of food chemicals and pesticides are used, which can harm public health and even cause loss of life (Ashraf et al., 2019; Rahman et al., 2015). The knowledge of consumers about the product

Table 4. Consumers' marginal willingness to pay (WTP) for 1 kg of fresh farmed shrimp

	Fresh Shrimp		
Variables	WTP	S.E.	Confidence Interval (95%)
Conventional farming	−346.00	144.915	[−664.956, −27.043]
Organic farming	203.00	87.202	[11.061, 394.932]
Inland aquaculture	826.00	236.090	[306.368, 1345.631]
Coastal aquaculture	542.00	171.831	[163.801, 920.198]
Price	–	–	–
Conventional*Inland	226.00	155.268	[−115.744, 567.744]
Conventional*Coastal	180.00	113.550	[−69.922, 429.922]
Organic*Marine	197.00	124.247	[−76.465, 470.465]
Conventional*Low knowledge	−70.00	329.560	[−795.357, 655.357]
Safe*Medium knowledge	162.00	88.052	[−31.802, 355.802]
Organic*High knowledge	85.00	78.814	[−88.469, 258.469]
Number of observations = 5940; Number of groups = 660			

WTP and the standard error (S.E.) estimate with the delta method.

also plays a crucial role in their WTP. Those with low knowledge are less likely to buy conventionally farmed shrimp, as they are worried about the medical residues in them (Solgaard and Yang, 2011).

The significant interaction term between safe farming and medium product knowledge indicates that they are complementary. Consumers with such a level of knowledge significantly prefer safe-farmed shrimp, which indicates that safety labeling will be effective in increasing demand for it. In general, in farmed fish choice consumers look for safety labels (Hoque, 2020). Such findings emphasize safe labeling, which is consistent with several previous studies (Newman et al., 2014; Onozaka and McFadden, 2011; Schjøll, 2017; Xie et al., 2016). People are willing to pay more for safe-farmed shrimp, as the safety labeling associated with the product provides the information that the shrimp are produced under government standards and are safe for consumption. Interestingly, Bangladeshi consumers are willing to pay a higher price premium for safe shrimp over the organic type. Finally, consumers with high product knowledge are more likely to consume organically farmed shrimp. This finding is consistent with the study of Kesse-Guyot et al. (2013) and also emphasizes that those with high levels of knowledge have a greater preference for consuming organic products, and are willing to pay a price premium for them (Kriwy and Mecking, 2012).

Table 5 shows consumers' preferences and their WTP for farmed shrimp in Chattogram, Dhaka, and Rangpur. The results in the Rangpur column show that the main impact of price is insignificantly positive on the probability of choosing farmed shrimp, which contradicts the fundamental economic insight that consumers prefer cheaper shrimp when all attributes are equal. People in Rangpur are the poorest the country; therefore, they are more likely to prefer low priced shrimp. Accordingly, they are willing to pay less for organic shrimp and more for the conventional type. Such results imply that consumers in Rangpur use price as a proxy of fish quality, with a higher price related to higher quality, which is consistent with various previous studies (Carpio and Isengildina-Massa, 2009; Jo and Sarigollu, 2007; Rao, 2005; Zhou et al., 2002). Conventional farming decreases the utility of shrimp to consumers in Dhaka and Rangpur significantly; however, in Chattogram this influence is insignificant. Although consumers in Chattogram and Dhaka are willing to pay less for conventionally farmed shrimp, interestingly those in Rangpur are willing to pay

Table 5. Rank-ordered logit model estimates of Chattogram, Dhaka and Rangpur with fish attributes

Choice of Fish in the Rank-Ordered Logit (ROL) Model						
	Model with fish attributes and interactions between the attributes and socioeconomics variables and their WTP					
	Chattogram		Dhaka		Rangpur	
Variable	Coefficients (S.E.)	WTP	Coefficients (S.E.)	WTP	Coefficients (S.E.)	WTP
Conventional farming	−0.051 (0.129)	−51.00	−0.541*** (0.125)	−270.50	−0.456*** (0.166)	456.00
Organic farming	0.162 (0.137)	162.00	0.500*** (0.167)	250.00	−0.147 (0.148)	−147.00
Inland aquaculture	0.463*** (0.109)	463.00	0.341*** (0.099)	170.50	2.475*** (0.128)	−2475.00
Coastal aquaculture	0.906*** (0.110)	906.00	−0.081 (0.100)	−40.50	1.131*** (0.117)	−1131.00
Price	−0.001*** (0.000)	–	−0.002*** (0.000)	–	0.001 (0.001)	–
Conventional*Inland	0.007 (0.187)	7.00	0.263 (0.185)	131.50	0.025 (0.201)	−25.00
Conventional*Coastal	0.123 (0.151)	123.00	0.513*** (0.153)	256.50	−0.141 (0.166)	141.00
Organic*Marine	0.372** (0.151)	372.00	−0.414*** (0.148)	−207.00	0.930*** (0.156)	−930.00
Conventional*Low knowledge	0.000 omitted	–	0.284 (0.546)	142.00	0.004 (0.433)	−4.00
Safe*Medium knowledge	0.059 (0.127)	59.00	0.019 (0.156)	9.50	0.260* (0.145)	−260.00
Organic*High knowledge	−0.138 (0.129)	−138.00	0.393** (0.163)	196.50	−0.217 (0.143)	217.00
	$N = 1{,}980$, Number of cases = 220, LR χ^2 (10) = 180.70, P (χ^2) = 0.00; Log-likelihood = −2726.051		$N = 2{,}070$, Number of cases = 230, LR χ^2 (11) = 328.19, P (χ^2) = 0.00; Log-likelihood = −2780.328		$N = 1{,}890$, Number of cases = 210, LR χ^2 (11) = 800.59, P (χ^2) = 0.00; Log-likelihood = −2288.088	

Standard errors in parentheses; *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Parameter estimates from the ROL model.

more. Such results mean that consumers in Chattogram and Dhaka are more concerned about conventional farming than those in Rangpur. Nevertheless, people in Rangpur assume that the price of conventional shrimp could be lower, while those in Chattogram underestimate the risks of conventional shrimp consumption.

Organic farming increases the utility of shrimp to consumers in Dhaka significantly. However, it decreases utility to those in Chattogram and Rangpur insignificantly. Dhaka households are more educated, and their income level is higher than in the other two regions. Therefore, these households have more access to different options compared with Chattogram and Rangpur. The results also show that in Dhaka organic farming is effective, as consumers are willing to pay a price premium of BDT 250/kg for farmed shrimp. In Chattogram, there is the potential to increase consumers' utility of organically farmed shrimp, as they are willing to pay BDT 162/kg more for it. However, in Rangpur organically farmed shrimp decrease consumers' utility, as they are willing to pay more for such a product (BDT 147/kg). Furthermore, organically farmed fish only increase the utility of highly knowledgeable consumers in Dhaka, as they are willing to pay a price premium for it. On the other hand, marine organically farmed shrimp significantly increase consumers' related utility in Chattogram and Rangpur. Such findings indicate that organic farmed fish will be accepted in Bangladeshi local markets.

7. Discussion

The preliminary findings of the study are that consumers are more likely to prefer inland aquaculture farmed shrimp, followed by the coastal aquaculture version. Inland and coastal shrimp aquaculture is common in Bangladesh, and producers are more familiar with the farming processes than their mariculture counterparts. Shrimp produced in local agricultural land, low-lying floodplains, and ponds are available in the domestic market (Ahmed et al., 2008; Paul and Vogl, 2012; Rahman et al., 2013). The availability of the shellfish creates a demand from local consumers, who are willing to pay a price premium for both the inland and coastal conventionally farmed product. In addition to local preferences, demand for coastal-farmed shrimp is high in the international market (Rahman et al., 2013). The choice of inland- and coastal-farmed shrimp is motivated by cognitive, affective, and normative views. The cognitive view indicates that consumers perceive that the inland- and coastal-farmed shrimp are most useful and tasty for local households. Consequently, consumers perceive that local shrimp are fresher and are of high quality, requiring less treatment for storage, and less time to reach the market and consumers' tables (Martinez et al., 2010). From the affective point of view, inland- and coastal-farmed shrimp usually represent the shrimp cultivation existing across the various regions of Bangladesh, and provide a strong association with national pride, upbringing, and sense of belonging to the community. According to the normative point of view, the purchasing behavior of inland- and coastal-farmed shrimp is correct and altruistic, as it supports both the country's national economy and the income level of local farmers and marketers (Mauracher et al., 2013).

This study also highlights that consumers are willing to pay more for organic farming processes and less for conventional ones (Table 4), as they are concerned about their health and wish to avoid the pesticides and chemicals used in producing conventional food. The price premium for such organic products is a result of the extra costs associated with the production, certification, and segregation of organic foods, together with the supply and demand for organic food and consumers' perception that the quality of organic products is high, as they have more nutrition and better taste. A consistent finding in the study is that generally consumers are more likely to prefer organic fish and are willing to pay more for it. However, interestingly they prefer safe shrimp to the organic type. Another main finding is that with regard to organic fish, consumers prefer the marine production location. Globally, 54.7% of total aquaculture production originates from marine saline or brackish coastal waters (Datta, 2012) where pure water is naturally available,

which is useful for maintaining environmental standards, food safety, quality, control of medical products and pesticides, and the natural taste and nutrition of shrimp (Maroni, 2000).

Consumers' seafood choice decision is mainly enhanced by their awareness (knowledge) of the product. Those with low knowledge of organically farmed shrimp are willing to pay less for the conventionally farmed version, as it is known that a high level of food chemicals, growth hormones, and artificial fertilizers are used in the production process of the latter. However, highly knowledgeable consumers prefer to consume more organically farmed shrimp, and they are willing to pay more for it. On the other hand, consumers with a medium level of product knowledge prefer the safe farmed product and to be able to see the words "safe" or "safety label" displayed. Furthermore, consumers' WTP for safe farmed fish is higher than for organically farmed fish. Such interesting findings indicate that the organically farmed shrimp market is behind other markets due to the lack of knowledge and awareness and general confusion regarding organic standards (Defrancesco, 2007; Risius et al., 2017; Schlag and Ystgaard, 2013) among people in Bangladesh. Peoples' knowledge level depends on which city they live in. A knowledgeable city encourages collective preferences for sustainable actions (e.g., organic production) (Edvinsson, 2006). For instance, Rangpur households have a low level of education, and have a lower wish to save wild fish stock than the other regions. In addition, they also have a low preference for organic shrimp.

Furthermore, consumers with low knowledge are willing to pay less for conventionally farmed shrimp. The results could be explained by the fact that consumers perceive conventional farmed fish to be associated with lower intrinsic quality due to the use of chemicals in the production process. Such a perception provides evidence that consumers with low knowledge use their emotions to judge that the quality of farmed fish is poorer than that of natural fish (Verbeke et al., 2007b). A higher supply of safe fish from aquaculture increases competition in the fish market and aquaculture sustainability (FAO, 2016) and encourages consumers to consider scientific evidence to judge the quality of farmed fish (Verbeke et al., 2007b). Such supply can also create trust among consumers, as this study found that those with a medium level of knowledge were prepared to pay more for safe farmed fish that are cultured following the standards prescribed by the respective authorities. In this regard, authentic labeling from third parties could be a useful tool to provide practical related information.

8. Conclusions

The contribution of the study is its investigation into consumers' preferences for diversely farmed shrimp in the emerging market of Bangladesh, and how much they are prepared to pay for it. To conduct the research, data were collected from 660 households in Bangladesh using a structured questionnaire with a direct interview method in a choice experiment. Among the respondents, 99.20% were aware of farmed fish, and 90.50% were concerned about the environment and wanted to save natural fish stocks through their personal fish choice. Explorative factor analysis using the varimax rotation method was conducted, through which two factors, "knowledge" and "attitude," were formed based on the factor scores. ROL was also performed and estimated consumers' marginal WTP for nine fish alternatives.

The study found that despite limited product knowledge, consumers considered the role of conventionally farmed fish to be negative. Furthermore, medium and high levels of knowledge influenced their choice of safe and organically farmed fish. It was found that consumers preferred to pay more for inland aquaculture farmed shrimp, followed by the coastal aquaculture farmed version, as they had more information about such products and their availability. Organically farmed shrimp increased, while conventionally farmed shrimp decreased, consumers' utility due to health issues and their environmental perception. In particular, consumers preferred organically farmed shrimp cultivated in marine areas and were prepared to pay more for the

product, as they considered that marine saline water was more natural and pure, thus favoring the maintenance of high quality shrimp. The study also found that product knowledge was a critical factor behind consumers' preference for organically farmed shrimp. Those with low knowledge preferred to pay less for conventionally farmed shrimp, as they perceived that they were of low quality because of the greater use of chemicals in the production process. Moreover, highly knowledgeable consumers were prepared to pay more for organically farmed shrimp, while those with medium levels of knowledge preferred safe farmed shrimp, meaning that they trusted this product more, as they had more knowledge of its cultivation under government-prescribed rules. Therefore, consumers were willing to pay more for safe shrimp than for organic shrimp.

With regard to market segmentation, the study found that Dhaka consumers had no preference for conventional inland-farmed fish, but instead preferred the conventional coastal variety. In general, they were willing to pay the highest amount for organically farmed shrimp than any other city in the country; their high level of product knowledge and food consciousness led them to choose organically farmed shrimp. Both coastal- and inland-farmed fish increased the utility of consumers in Chattogram. In relation to organically farmed fish, they believe that mariculture could be the best option. However, organic farming did not significantly increase the utility of farmed shrimp for consumers in Rangpur. Although their WTP for organically farmed fish was positive, their ability to pay was limited because of their poverty.

In general, consumers preferred organic fish farming to the conventional type, but preferred conventional inland-farmed shrimp to the organic marine-farmed version. The study's main contribution is the finding that consumers prefer safe farmed shrimp to the organic alternative. Overall, the positive value attributed to organic farming, but the lower value attributed to organic marine farmed shrimp compared with the conventional inland type indicates that a lack of understanding and low economic status may negatively affect organic fish preferences. In this regard, policymakers, marketers, and producers could improve educational and promotional campaigns so that people can receive balanced information regarding organically farmed fish. As the study found that consumers' preferences for organically farmed shrimp in marine areas are positive, consumers could be persuaded to prefer organic mariculture to conventional inland aquaculture and pay a price premium for it. Therefore, an opportunity might be created for producers to produce and market marine organically farmed fish. Consequently, policymakers and marketers should focus on awareness campaigns and develop promotion policies, such as labeling organic and safe farmed shrimp, which could be undertaken following government and international NGO standards. In this regard, the role of international agencies in promoting organic products would be more useful than that of government authorities. This is because in Bangladesh the existing government certification system for food safety (e.g., Bangladesh Standard Testing Institute [BSTI] approved) is not efficient[2]. Moreover, attention should be paid to creating knowledgeable cities and ways of reducing organic product prices in order to influence people's choices and create suburban organic markets.

The study could be associated linked to attention bias, as it used a choice experiment design in which participants were asked to choose from a limited number of attributes and attribute levels. Therefore, future research could be conducted by following more incentive-aligned valuation methods, such as auctions, real choice experiments, or real contingent valuation methods, to develop WTP estimates. A limitation of the study is that the important and relevant interaction effect of consumers' knowledge level, and the particular city in which they live, on their fish preferences has remained unexplored. Another limitation is that the data were collected from only

[2]The BSTI approves the standard and quality of food products, acting as a government authority. Although BSTI standard certification is often required to launch food products in Bangladesh, many substandard food products have recently been found labeled with "BSTI approved" certification (The Independent, May 13, 2019, https://www.theindependentbd.com/post/199289). Although counterfeit food products have been found labeled with a "Beware of fake products" warning in Bangladesh (Hoque, 2020), the government has not verified the certification scheme with consumers.

three cities in Bangladesh. Therefore, it cannot be stated with certainty that the sample captures all Bangladeshi consumers because of the divergences in economic development, education levels, and food consumption habits in cities around Bangladesh. To represent the varying results, all Bangladesh counties could be included in future research, which will show the potential for organic, safe, and sustainable farmed fish for rural and urban consumers.

Acknowledgments. The authors are thankful to the anonymous reviewers, and the editors for their valued comments and suggestions to the development of this paper.

Conflict of interest. The author(s) declared no potential conflicts of interest.

Funding. The publication charges for this article have been funded by a grant from the publication fund of UiT The Arctic University of Norway.

Data availability. The data that support the findings of this study are available on request from the corresponding author.

Author contributions. Conceptualization, M.Z.H.; Methodology, M.Z.H.; Formal Analysis, M.Z.H. and N.A.; Data Curation, M.Z.H. and Z.M.; Writing—Original Draft, M.Z.H., N.A., Writing—Review and Editing, M.Z.H., N.A., Z.M.; Supervision, M.Z.H. N.A. and Z.M.; Visualization, M.Z.H., N.A., Z.M.; Project Administration, M.Z.H., N.A., Z.M.; Funding Acquisition, M.Z.H.

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Appendix A: Shrimp Production Areas and Poverty Line of Bangladesh

Annual Production of Shrimp/Prawn Farms, 2016 (Metric tons)					Poverty Line, 2016 by Cost of Basic Needs Method (National Upper Poverty Line) (in %)
Division	Bagda	Golda	Other shrimp/prawns	Total shrimp/prawns	
Chattogram	12000	889.81	3374.10	**16263.91**	**3.5**
Khulna	55601	44616.30	9729.90	109947.2	5.2
Barishal	671.70	2252.70	343.66	3268.06	5.5
Dhaka	0.00	797.86	0.60	**798.46**	**3.2**
Rangpur	0.00	7.73	1.95	**9.68**	**11.9**
Rajshahi	0.00	5.03	0.00	5.03	5.6
Sylhet	0.00	3.00	0.00	3	2.6
Mymensingh	0.00	2.40	0.00	2.40	6.4

Sources: BBS (2019a,b).

Appendix B: Farmed Fish Knowledge Scale

Descriptive statistics of consumers perceived knowledge regarding farmed fish

Observations			Mean and S.D. of Scores
Types	Particulars	Statements	
Whole	Evaluation	With requirement fulfillment, a way of getting vitamin by eating farmed fish is more important to me than waiting for wild fish.	6.02 ± 0.65
	Comparison	Genetically engineered farmed fish is not nutritious as nongenetically modified fish.	3.30 ± 1.45
	Ranking	The best thing about farmed fish is its' availability.	6.52 ± 0.50
Single	Evaluation	The widely consumed farmed fish, I think, would be Tilapia.	6.24 ± 0.46
	Comparison	The fat content of farmed 'Shrimp' will not harm you more than the calories.	4.84 ± 1.16
	Ranking	The 'Pangas' is the most economical of all farmed fish.	6.35 ± 0.65

N = 660

Appendix C: Frequency of Consumers' Attitude toward Farmed Fish

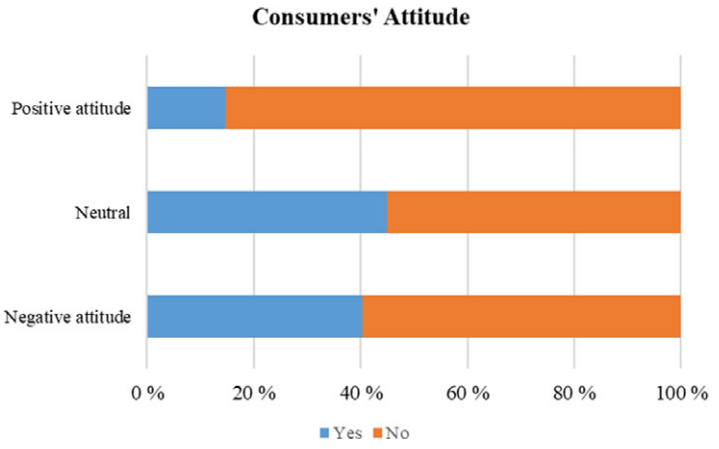

Figure 4. Consumers' attitude toward farmed fish were identified based on binary settings where the horizontal axes indicates the percent of respondents. Respondents' scores of 5 or below were regarded as a negative attitude. In contrast, those who gave scores above 5 were deemed to be a neutral attitude. Finally, scores of 6 and above indicate their positive attitude. The vertical axes measures attitude type.

Appendix D: Percentage of Consumers' Knowledge toward Farmed Fish

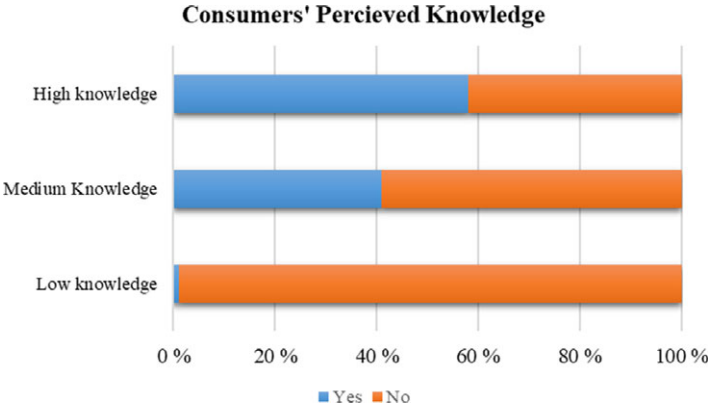

Figure 5. Consumers' knowledge regarding farmed fish was calculated based on binary settings where the horizontal axes indicates respondents' percentage. Respondents' scores of 5 or below were regarded as low knowledge. In contrast, those who gave scores above 5 were deemed to be perceived as medium knowledge. Finally, scores of 6 and above indicate their high perceived knowledge. The vertical axes measures knowledge level.

Cite this article: Hoque MZ, Akhter N, and Mawa Z. Consumers' Willingness to Pay (WTP) for Organically Farmed Fish in Bangladesh. *Journal of Agricultural and Applied Economics*. https://doi.org/10.1017/aae.2021.12

Paper 3

Consumers' knowledge discrepancy and confusion in intent to purchase farmed fish

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Received 12 January 2019
Revised 30 October 2019
Accepted 13 March 2020

Abstract

Purpose – The purpose of the paper is to examine the influence of consumers' perceived knowledge, knowledge discrepancy and confusion on the intention to purchase farmed fish (FF) via a survey design regarding perceptions, buying and consumption practices of urban households in Chittagong, Bangladesh.

Design/methodology/approach – The samples of 498 households were selected from a stratified cluster from the Chittagong city and were interviewed using a structured questionnaire. The data have been analysed using exploratory factor analysis and structural equation modelling.

Findings – The results show that consumers' subjective knowledge (SK) is significant for purchase intention whereas objective knowledge (OK) is not. Again, consumers' SK, OK, knowledge discrepancy and confusion have no influence in forming consumers' attitude towards FF. However, consumers who overestimate their actual level of knowledge hold negative attitude towards FF and vice versa. Furthermore, consumers' OK affects their confusion inversely although it does not influence the purchase intention significantly.

Practical implications – If the marketers can frame a more engaging means of communication and knowledge enhancement plan, consumers' attitude and purchase intention regarding FF will be signified.

Originality/value – This is the first study that fundamentally contributes to the scientific research in that it measures the knowledge discrepancy of consumers regarding FF. In addition, this study substantiates that low objective knowledge leads to confusing consumers at the time of purchasing. The effect of overestimating the level of knowledge as well as underestimating the level of knowledge in explaining the purchase intention of FF would be a supplementary addition.

Keywords Farmed fish, Consumers' knowledge, Confusion, Purchase intention, Emerging market, Bangladesh

Paper type Research paper

1. Introduction

Past couple of decades are marked by an upward trend in the consumption of fishes because of their nutritional value and dietary features. Keeping pace with this trend, an alternative fish farming method other than wild-caught has been becoming a good substitute to meet the excessive demand for fish. Given its health value, farmed fishes (FF) also contain less contamination such as mercury, levels of cobalt, copper and cadmium than do contain those of wild (Claret *et al.*, 2014). Hence, the immense need for aquaculture to meet the demand for fish supply is urged from different actors of the community. However, presently, an increase in socio-environmental conflicts in relation to finfish aquaculture is reported (Ertör and Ortega-Cerdà, 2015). Thus, consumers are worried

Funding: This work has not received any external funding.
Conflicts of interest: The authors declare no conflict of interest.

British Food Journal
Vol. 122 No. 11, 2020
pp. 3567-3583

0007-070X
DOI 10.1108/BFJ-01-2019-0021

about the environmental justice, a claim which can be justified by the use of best available techniques and practices including usage of closed containers instead of open cages, sustainable sourcing of feed, labelling and monitoring systems and an even transparent and participatory governance (Liu *et al.*, 2011). In addition, literature recommends that consumers do not hold a conservative attitude to aquaculture, rather they do acknowledge the significance of aquaculture in alleviating the recent stagnation of fish supply (Ertör and Ortega-Cerdà, 2015).

Consumers of FF have a positive attitude towards general aquaculture, but their attitude gets negatively influenced when the issue of the environment appears (Froehlich *et al.*, 2017). Different reasons including negative media reports, lack of knowledge, ambiguous production process and consumption pattern, etc. (Verbeke *et al.*, 2007a, b) were found behind these mixed and inverse impressions of consumers of FF. This ambiguity leads to confusing the consumers while the awareness and knowledge of consumer confusion are relevant to successful marketing because confused consumers are less likely to make rational buying decisions and to choose products offering the best value for money (Huffman and Kahn, 1998).

In Asia and the Pacific region, aquaculture in terms of production has continued to grow at a rapid rate since 2005. Current trends show that FF species will play a major role in determining whether Asian aquaculture will be successful in achieving its growth potential. In South Asia, Bangladesh is one of the world's leading fish producing countries with a total production of 41.34 lakh MT in 2016–17 (DoF, 2017), ranking third in the world in terms of inland fish production. Moreover, in Bangladesh, aquaculture is set to grow further, and it now provides around half the total market supply of fish for direct human consumption (Shamsuzzaman *et al.*, 2017). However, as an industry, aquaculture is still in its relative infancy, thus knowledge of the nutritional requirements of most fish species is rather limited compared to poultry and other livestock. Moreover, almost all existing literature about aquaculture in Bangladesh belongs to addressing the supply side. Therefore, the demand side, for example, consumers' perceptions of and knowledge regarding FF, has been studied little although the need for gaining insight from the consumers' perception perspective regarding farmed fish has been identified as a particularly key factor. Thus, this study aims to fill in this knowledge gap.

In order to gauge consumers' knowledge towards a particular product, subjective evaluation is a popular technique (Selnes and Grønhaug, 1986). Many researchers applied this method to estimate the consumers' perception of FF focussing on consumers' buying and consumption patterns (Claret *et al.*, 2014), Furthermore, Fernández-Polanco and Luna (2010) in their research investigated the effect of knowledge on consumers' perceptions and consumption of FF. However, they constructed the scale of knowledge with open-ended questions considering demographic factors and consumption habits only, leaving room for further research. In addition, the literature lacked showing of the consumers' knowledge discrepancy and confusion and its effects on attitude and willingness to purchase of FF. Thus, the present study aims to support efforts to estimate consumer intention to buy FF by exploring consumers' knowledge, knowledge discrepancies, confusion and attitude towards aquaculture in general and towards farmed fish in particular. To achieve the objective, the study has assessed the relationship between subjective and objective knowledge, measured their differences (knowledge discrepancy) and examined the effect of knowledge, knowledge discrepancy and consumers' confusion on consumers' attitude and on the purchase intention based on the conceptual model using a questionnaire survey. The study also examined the validity of the relationships between consumers' knowledge, knowledge discrepancy, confusion and evaluations of FF.

The structure of the study is as follows. The review of literature along with the development of hypotheses and a conceptual model was first demonstrated, followed by a

discussion of data and empirical model. Then the research results were discussed. Managerial and policy implications, with concluding remarks, were given and the paper ends up with limitations and direction for future research.

2. Theory and hypotheses development

Consumers' decision-making process in buying a healthy, nutritious and sustainable product is not simple, rather complex. Sometimes consumers hold a positive attitude to a particular product but act inversely at the time of purchasing due to several factors such as price barrier, lack of knowledge regarding product, health benefit, environmental impact, point of sale, sustainability, etc. (Padel and Foster, 2005). Thereby, all consumers' behavioural patterns are not univocally consistent with their interests, preferences or attitudes. However, knowledge is a major catalyst in this regard, and it may influence to reshape consumers' attitude and, in turn, minimize the attitude–behaviour gap.

Accordingly, research corroborates that consumers' perceived knowledge regarding a particular product or choice plays a crucial role in determining consumers' decision-making process (Hoque *et al.*, 2018). Interestingly, despite having low knowledge, consumers hold quite a specific opinion about aquaculture (Verbeke and Brunsø, 2005). To explain this behaviour, research suggests that consumers' perception, in general, regarding farmed fish species may be based on emotion and preconceived belief rather than on objective knowledge (Schlag and Ystgaard, 2013). Because new information can sway the perceptions of the low knowledgeable people (Aertsens *et al.*, 2011), consumers' perception regarding aquaculture can be easily shaped through manipulative data. Hence, we forwarded a model (Figure 1) that incorporates consumers' knowledge (both subjective and objective), knowledge discrepancy, confusion and attitudes towards the purchase intention of FF.

This paper's conceptual model, including hypotheses, is presented in Figure 1.

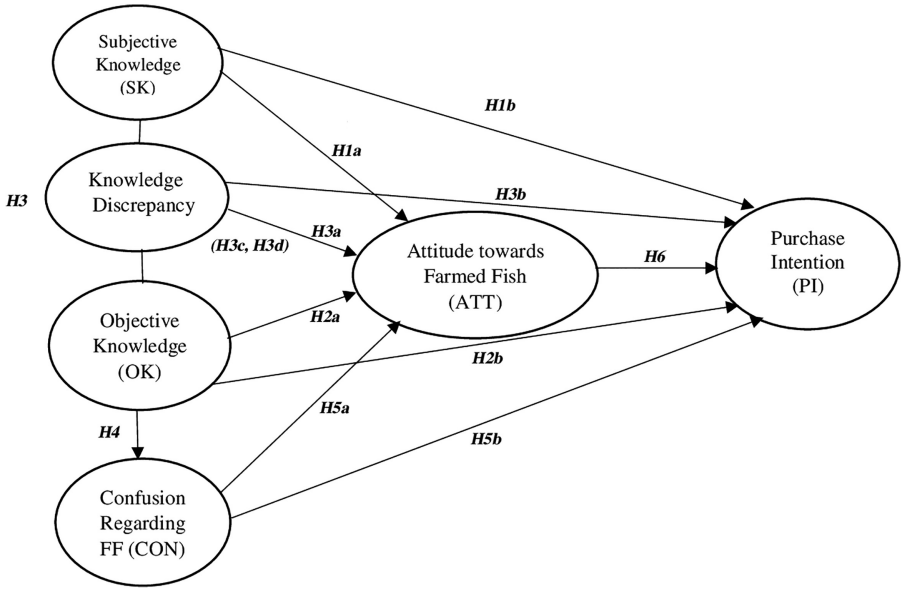

Figure 1.
Conceptual Model: demonstrates the hypotheses drawn in support of the literature with using structural equation model

2.1 Subjective knowledge and objective knowledge

Subjective knowledge is the individual's perception of how much she/he knows (Brucks, 1985). In other words, it refers to people's subjective perceptions of what or how much they know or, they are familiar with a product or choice (Park *et al.*, 1994). On the other hand, Objective knowledge is what a consumer actually knows (Brucks, 1985). Objective knowledge helps in enriching the acquired information and thus in improving confidence (Selnes and Grønhaug, 1986). Both subjective and objective knowledge positively influence consumers' preference for choice attributes that a consumer search for while making a purchasing decision (Brucks, 1985). Therefore, based on the discussion above, the following hypotheses are formulated:

H1a. Subjective knowledge positively influences the attitude towards farmed fish.

H2a. Objective knowledge positively influences the attitude towards farmed fish.

Research suggests that in order to have a favourable repercussion in making a food choice, consumers must have a sufficient level of knowledge or familiarity regarding the attributes of that particular product (Verbeke, 2008). In line with this, therefore, it is expected that both subjective and objective knowledge regarding farmed fish will have a positive impact on the purchase intention of farmed fish.

In order to investigate if this is the case, the following hypotheses are formulated:

H1b. Subjective knowledge positively influences the purchase intention of farmed fish.

H2b. Objective knowledge positively influences the purchase intention of farmed fish.

2.2 Consumers' knowledge discrepancy

People do not always accurately perceive how much or how little they know (House *et al.*, 2004). People, in general, are supposed to consider themselves to be more knowledgeable than they actually are and vice versa (Taylor and Brown, 1988). Regarding FF, this implies that consumers often think they know what a particular FF species stands for whereas in reality their knowledge is merely constructed. Taylor and Brown (1988) also reported that those who tend to believe themselves more knowledgeable are less likely to acquire correct information, ending up with retaining the incorrect information they knew formerly. When it comes to acquiring correct information regarding FF, they may be retained with incorrect knowledge, raising a discrepancy between subjective knowledge and objective knowledge. In light of this discussion, the following hypotheses are forwarded:

H3. Consumers have a discrepancy between their subjective and objective knowledge regarding farmed fish.

H3a. Consumers' knowledge discrepancy has a negative influence on attitude towards farmed fish.

H3b. Consumers' knowledge discrepancy has a negative influence on the purchase intention of farmed fish.

Whether consumers who overestimate their level of knowledge buy more than those who underestimate their knowledge level is unknown, to date, in the area of FF consumption. In addition, studying this relationship seemed like a natural course of action. Recently, Gunne and Matto (2017) used consumers' discrepancy to investigate the influence of knowledge on consumers' green purchase. As symmetric information is needed regarding FF, we believe that knowledge is required to understand the fundamentals of aquaculture. Based on the aforesaid discussion, the following hypotheses are posited:

H3c. Consumers' knowledge discrepancy with overestimate is negatively associated with the attitude towards farmed fish.

H3d. Consumers' knowledge discrepancy with underestimate is positively associated with the attitude towards farmed fish.

2.3 Consumers' confusion regarding farmed fish

Knowledge, a compound esoteric concept embedded in particular social construct, is shaped by various surrounding contexts (Fernie *et al.*, 2003). Concrete knowledge about any particular product decreases the confusion which, in turn, is negatively associated with satisfaction (Matzler *et al.*, 2011). Therefore, the more knowledge people have, the more likely to avoid confusion, and therefore, presumably, the more they will be getting involved with the consumption of farmed fish (Gaviglio and Demartini, 2009). Hence, we formulated the following hypothesis.

H4. Consumers with the low level of objective knowledge regarding farmed fish are more confused than consumers with a high level of objective knowledge.

In particular, lack of knowledge and confusion about farmed fish appears to be the leading barrier to the expansion of the farmed fish market (Verbeke *et al.*, 2007a). Thereby, it can be assumed that the lack of distinguishability (i.e. confusion) leads to affect the attitude and purchase intention of FF. In the light of this discussion, the following hypotheses are forwarded:

H5a. Confusion regarding farmed fish negatively influences attitude.

H5b. Confusion regarding farmed fish negatively influences its purchase intention.

2.4 Attitude and purchase intention

Attitude can be defined as an individual's reaction towards a particular choice or attributes (Milton, 1970). This is a psychological construct important to drive the choice decision (Parker Lessig and Copley, 1974). Consumers' likelihood of purchasing a product is largely defined by the attitude they possess. Hoque *et al.* (2018) found that consumers' perceived knowledge largely comprehended their attitude towards food products which ultimately drove their purchase intention. Considering the above discussion, we hypothesised the following relationship:

H6. Attitude positively influences the purchase intention of farmed fish.

3. Materials and methods

Since the birth of the nation, the Chittagong city is called the "Gateway of Bangladesh" for its key contribution to the foreign trade of the country (Monir, 2017). As this city is considered the commercial capital and is the second largest city of the country, we expect that knowing about the perceived value of FF from the consumers of this city would be interesting to Bangladeshi fish market segmentation and the formulated policy based on the results of this study will be effective. Therefore, the urban zone of Chittagong, Bangladesh was chosen as the sample area for the study. Primary data were collected from the study area, presenting a structured questionnaire administered by enumerators. To collect the representative sample, stratified and clustered random sampling procedures were used. There are 12 administrative areas (Police Station (PS)) in Chittagong City. Each PS includes three or four small administrative areas, called ward, resulting in 41 areas in total. To ask the subjects, ten police stations (Bakoliya, Bayazid, Chandgaon, Hathazari, Khulshi, Patenga, Panchlaish, Double

Mooring, Halishahar) of the city were randomly selected. Then, one ward from each PS was considered randomly to recruit 50 respondents from each PS by using convenient method. Thereby, a total of 500 primary households who prefer fish and are responsible for buying to household were selected randomly. Finally, of all the collected responses, two responses were excluded due to uselessness. To facilitate the overall responses, ten enumerators in association with the researcher administered the overall sampled population considering various demographics and socio-economic characteristics of the consumers and their purchase intention of farmed fish.

The fieldwork was carried out from 01 March 2018 to 30 April 2018. Before the final version of the survey, a pre-test survey on 15 subjects from two PSs (Kotwali and Chandgaon) in the same city was conducted in order to ensure that respondents understood the questions and no semantic and measurement problems exist. As we did not find any major incongruity, we decided to keep the same settings for the final asking. Respondents older than the age of 20 were chosen for the interview. The interview on average took 20 min per interviewee. Descriptive analysis, exploratory factor analysis (EFA) and structural equation modelling (SEM) were the major statistical tools used in the study. The SPSS and AMOS graphics, 25.00 version were used for factor analysis and the path model analysis.

3.1 Questionnaire and measures

A structured survey questionnaire was approached to the respondents. The items for each construct included in the questionnaire were developed based on the relevant literature. The questionnaire was devised into three sections, wherein the first section consisted of questions regarding the measurement of subjective knowledge, objective knowledge and confusion. The second section contained two sections – attitude, and purchase intention. Finally, the third section was designed to record the respondent's demographic information.

The subjective knowledge of FF was measured with five questions using seven-point Likert scale from "strongly disagree" (1) to "strongly agree" (7) with the statement such as "I have in-depth knowledge to evaluate the quality of farmed fish/have more knowledge in comparison to others/am expert in the field of FF/have heard the name of different production methods of FF/know the production process of FF" (Flynn and Goldsmith, 1999; Verbeke *et al.*, 2007b; Pieniak *et al.*, 2013).

Again, five questions were considered to construct the objective knowledge scale. This construct covered consumers' understandings about the price, sources of omega-3, dietary fibre, fat and the availability of farmed fish species (Pieniak *et al.*, 2013). For instance, the answer choices contained such options as "true/false/not sure" to the questions such as "the price of a farmed raised fish is lower than a wild-caught fish of the same species". The answer to the first question was "false", and the rest of them were "true". Hence, "not sure" was considered "incorrect choice", assuming that people who were not sure about the answer would not be able to answer the question correctly. In addition, this also helped to avoid any improvise answer and scepticism.

A new variable named "discrepancy" was constructed to demonstrate the difference between subjective and objective knowledge; a positive discrepancy refers that respondents have higher subjective knowledge than objective knowledge. On the other hand, negative discrepancy signifies the undervaluation of objective (actual) knowledge and the perception of being less knowledgeable than they actually are. The discrepancy level was measured by taking the difference between the Z score of objective and subjective knowledge of each scale. Z score was calculated using the formula, $Z = (x - \text{mean})/\text{SD}$, where x represented the observed value (Burns and Burns, 2008). The rationale behind the application of Z score, in this context, is that it relabels each score in terms of its deviation.

The confusion scale was divided into two categories such as general confusion and specific confusion and was measured using the seven-point Likert scale from "strongly disagree" (1) to "strongly agree" (7). The general confusion of FF was measured by asking close-ended questions for the statement: "I feel confused regarding the overall meaning of farmed fish" (Gunne and Matto, 2017). The specific confusion's construct covered perceived level of confusion related to the risk level, benefit, awareness and lacks information regarding FF (Walsh *et al.*, 2007; Ermeç Sertoğlu and Kavak, 2017). Then, the scale of attitude was constructed with six questions using the seven-point bipolar scale such as bad to good, negative to positive, unfavourable to favourable, dull to exciting, terrible to great and unsatisfied to satisfied (Lord, 1994). Finally, the purchase intention scale incorporated consumers' intent to purchase, intent to pay price, advertisement impact and recommend to others to purchase (Barber *et al.*, 2009; Reinders *et al.*, 2016; Prebensen and Xie, 2017) and has been constructed using the seven-point Likert scale as well.

The EFA considered four questions in the construct of attitude, three questions in subjective knowledge, three questions in confusion and three questions in purchase intention, and each of the constructs has eigenvalues greater than 1 (Table 3) explaining 66.63% of the total variance. However, the items to construct the objective knowledge scale were not latent variables, thus, excluded from the EFA.

4. Results and discussion

4.1 Demographic profile of the respondents

The majority (82.1%) of the respondents was male (Table 1), and the rest 17.9% (89 participants) was 40–50 age group cluster that accounted for 151 members (30.3%). The largest age group belonged to the 20–30 strata, with 191 members (38.4%), followed by the 40–50 age group cluster that accounted for 151 members (30.3%). And the rest 17.5%, 10.0%, 3.2% and 0.6% pertained to the 50–60, 30–40, 60–70 and above 70 age group respectively.

4.2 Measurement model

Kaiser–Meyer–Olkin (KMO) and Bartlett's Test of Sphericity, as suggested by Pallant, 2007, were conducted prior to factor analysis. The KMO test achieved 0.723 (Table 2), and a significant p-value was attained (<0.01) in Bartlett's Test of Sphericity. The measurement model demonstrated an excellent model appropriateness with the data having chi-square (χ^2) = 166.124, degrees of freedom (df) = 106, p-value = 0.00, root mean square error approximation (RMSEA) = 0.046, incremental fit index (IFI) = 0.962, Tucker–Lewis index (TLI) = 0.943, comparative fit index (CFI) = 0.960 and goodness-of-fit index (GFI) = 0.937, and χ^2/df = 1.567.

Afterwards, the EFA was run (Table 3) to test the convergent validity of the proposed constructs and to validate the factor loadings. Furthermore, Cronbach's alpha, which is considered to test the internal consistency, was calculated. For each of the four components, the minimum cut off value of, as suggested by Hair *et al.* (2010), greater than 0.6 was achieved. However, it is well-recommended that Cronbach's alpha be greater than 0.70. On the other side, composite reliability (ρ) is well above the recommended threshold level of 0.70 (Hair *et al.*, 2006). Furthermore, each construct obtained the average variance extracted (AVE) value of above 0.50, indicating the convergent validity for each construct (Hair *et al.*, 2006).

Again, to test the discriminant validity, the AVE of each construct was compared with the respective correlations between the respective constructs (Table 4), and estimates for all variance extracted were greater than their respective squared correlation, suggesting that each construct had its uniqueness and that no multicollinearity problem existed in the data set. Furthermore, a value higher than 0.001 for the determinant of the correlation matrix in the

Categories	Subcategories	Frequency	Valid	Mean	Standard deviation
Gender ($M = 1, F = 2$)	Male	409	498	1.18	0.383
	Female	89			
Age (coded as 1 = "Between 20 and 29"... 6 = "Above 70")	Between 20 and 30	191	498	2.39	1.274
	Between 30 and 40	50			
	Between 40 and 50	151			
	Between 50 and 60	87			
	Between 60 and 70	16			
	Above 70	3			
Income* (1 = <50,000 BDT; 2 = >50,000 BDT)	<50,000	368	498	1.26	0.441
	>50,000	130			
Children (under age of 16) (1 = Yes, 2 = No)	Yes	335	498	0.67	0.470
	No	163			
Education (1 = "0–5"... 3 = ">12")	0–5	68	498	2.31	0.699
	5–12	207			
	>12	223			
Family member (1 = "1–5"... 3 = "10–14")	1–5	326	498	5.00	1.875
	6–10	159			
	10–14	11			
Consumption (1 = "Less than 1/month", ... 7 = "Daily")	Less than 1/month	5	498	4.84	1.180
	1/month	4			
	Several times/ month	81			
	1/week	45			
	Several times/ week	238			
	Almost/daily	93			
	Daily	32			
Shopping (1 = "Wet market"... 3 = "Both")	Wet market	391	498	1.42	0.809
	Super market	5			
	Both	102			
Eating (1 = "Home"... 3 = "Fast food/take out")	Home	481	498	1.05	0.261
	Restaurant	11			
	Fast food/take out	6			
On ten occasions while consuming fish, how many times do they consume FF	0	5	498	5.35	1.841
	1	7			
	2	17			
	3	43			
	4	48			
	5	94			
	6	90			
	7	81			
	8	29			
	9	10			
	10	2			

Note(s): M = male, F = female

Table 1.
Demographic profile of the respondents

model was found (determinant = 0.014), also showing no multicollinearity problems (Field, 2000).

4.3 Structural model

4.3.1 Assessment of fitness for structural model. The study developed a structural equation model (SEM). To gauge the fitness of the model, several goodness-of-fit test statistics were

deployed (Brown, 2006). The results of all indices from each category (i.e. absolute fit measure, incremental fit measure and parsimonious fit measure) met the requirements provided for adequate evidence of model fitness (Table 5), indicating construct validity (Haque *et al.*, 2015).

The assessment of the structural model revealed that the data fit well with the proposed constructs. The χ^2, RMSEA, GFI values were well above the recommended level, suggesting a good absolute fit index. The values for AGFI, CFI and normed χ^2 also satisfy the recommended level, ensuring both incremental and parsimonious fit respectively.

KMO and Bartlett's test		
Kaiser–Meyer–Olkin measure of sampling adequacy		0.723
Bartlett's test of sphericity	Approx. chi-square	2107.474
	df	78
	Sig.	0.000

Note(s): df = degrees of freedom; Sig. = significance

Table 2. Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity

Constructs and items	λ	A	ρ	Eigenvalues	AVE
Attitude		0.83	0.91	3.084	0.72
Terrible to great	0.873				0.78
Unsatisfied to satisfied	0.866				0.76
Dull to exciting	0.865				0.76
Bad to good	0.779				0.66
Subjective knowledge		0.79	0.87	2.421	0.69
Knows a lot than average person	0.848				0.73
Friends consider as an expert in the domain of FF	0.828				0.69
Have deep knowledge to evaluate the quality of FF	0.818				0.67
Confusion		0.68	0.82	1.698	0.60
Lack of information makes confused about FF	0.829				0.69
Little awareness may be caused to be confused about FF	0.764				0.63
Confused about the risk level of FF	0.729				0.52
Purchase intention		0.60	0.79	1.146	0.56
Intend to purchase when next time buy fish	0.795				0.67
Advertisements impact purchase decision	0.756				0.58
Would pay any price	0.684				0.52

Note(s): λ – standardized regression weights; a – Cronbach's alpha; ρ – composite reliability; AVE – average variance extracted

Table 3. Measurement model

Items	Mean	SD	ATT	SK	CON	PI
Attitude (ATT)[a]	4.95	1.24	(0.72)	0.004	0.002	0.029
Subjective knowledge (SK)[a]	4.23	1.38	0.060	(0.69)	0.025	0.009
Confusion (CON) [a]	4.57	1.25	0.048	−0.157	(0.60)	0.001
Purchase intention (PI) [a]	3.34	1.07	−0.171	−0.093	−0.027	(0.56)

Note(s): [a]Measured in seven-point Likert scale, The diagonal values represent AVE. The lower diagonal value represents correlation between the constructs, whereas the upper diagonal values represents squared correlation between the constructs; SD = standard deviation

Table 4. Descriptive statistics and correlations among latent constructs

Category	Indices	Recommended least value	Attained value
Absolute fit	χ^2	$p > 0.05$	Significant at <0.01
	RMSEA	<0.08[a,d]	0.043
	GFI	>0.90[b,c]	0.964
Incremental fit	AGFI	>0.90[e]	0.933
	CFI	>0.90[a]	0.921
Parsimonious fit	χ^2/df (normed χ^2)	<3–5[e]	1.923

Note(s): RMSEA = root mean square error approximation; GFI = goodness-of-fit index; AGFI = adjusted goodness-of-fit index; CFI = comparative fit index
[a]Hair *et al.* (2010); [b]Forza and Filippini (1998); [c]Greenspoon and Saklofske (1998); [d]Awang (2012); [e]Haque *et al.* (2015)

Table 5.
Goodness-of-fit indices

4.3.2 Result of hypotheses test and discussion. To test the hypothesized relationship, several hypotheses were developed and tested in the light of previous research. Table 6 below shows the results to provide support for the acceptance and rejection of the hypotheses.

As seen from Table 6 and Figure 2, of the total 13 hypotheses tested, five hypotheses were found to be statistically significant. In H1b, subjective knowledge was found to be significantly and positively influencing the purchase intention ($\beta = 0.12$, SE = 0.053, CR = 1.780 and $p < 0.10$) while in hypothesis H2b, objective knowledge had a positive impact on the purchase intention (PI), but the influence was not statistically significant, hence was

Structural path		Standardized path co-efficient (β)	SE	CR	*p*-value
SK → ATT	H1a	0.11	0.060	1.603	0.109
SK → PI	H1b	0.12	0.053	1.780	0.075*
OK → ATT	H2a	−0.05	0.389	−0.690	0.490
OK → PI	H2b	0.05	0.337	0.749	0.454
Discrepancy (SK ≠ OK)	H3	$F = 4.78$	0.055	*N*/A	0.029*
Discrepancy (SK ≠ OK) → ATT	H3a	0.08	0.171	1.139	0.255
Discrepancy (SK ≠ OK) → PI	H3b	−0.05	0.148	−0.655	0.512
Positive discrepancy (SK > OK) ↔ ATT	H3c	$r = -0.039$	0.035	N/A	0.074*
Negative discrepancy (OK > SK) ↔ ATT	H3d	$r = 0.119$	0.045	N/A	0.524
CON → ATT	H5a	0.05	0.043	1.145	0.252
CON → PI	H5b	0.05	0.039	1.190	0.234
OK → CON	H4	−0.07	0.257	−1.664	0.096*
ATT → PI	H6	0.18	0.039	3.956	0.000***
Correlations (r)		*Pearson correlation*			*p-value*
SK and OK		0.35			0.000***
No. of family member and purchase intention		0.29			0.513
Income and purchase intention		0.038			0.395
Education and purchase intention		−0.123			0.000***
Age and purchase intention		−0.162			0.000***
Gender and purchase intention		−0.056			0.209
Presence of children and purchase intention		0.057			0.202

Note(s): ***Significant @ 1% level of significance. *Significant @ 10% level of significance; SK = subjective knowledge; OK = objective knowledge; CON = confusion; ATT = attitude; PI = purchase Intention; *r* = correlation; N/A = not applicable; SE = standard error; CR = critical ratio; *p* = probability value

Table 6.
Results of structural equation modelling: standardized path estimates

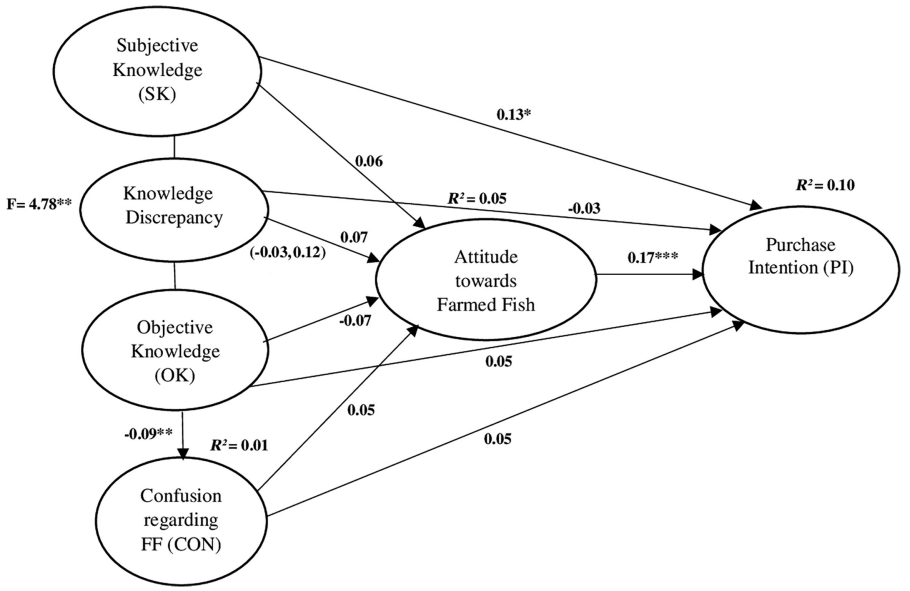

Figure 2.
Results of hypotheses test on conceptual model

not accepted. These findings are in line with the study carried out by Pieniak *et al.* (2010b), that reported subjective knowledge had a positive and significant impact on fish consumption frequency while objective knowledge had a positive but comparatively weaker association with such. Similarly, these findings corroborate with previous studies exploring the impact of knowledge in explaining food consumption behaviour in general (Radecki and Jaccard, 1995; Pieniak *et al.*, 2010a) and fish consumption behaviour in particular (Rortveit and Olsen, 2007). Hypotheses H1a ($\beta = 0.11$; SE = 0.060; CR = 1.603; $p > 0.10$) and H2a ($\beta = -0.05$; SE = 0.389; CR = −0.690; $p > 0.10$) were not accepted, implying both subjective knowledge and objective knowledge did not significantly influence the attitude towards FF consumption.

The study also hypothesized that consumers had a level of discrepancy between their subjective knowledge and objective knowledge (H3), and the results revealed that the level of subjective knowledge and objective knowledge differed significantly for the scores of corresponding respondents. To test the hypothesis, Levene's test for equality of variances (Table 7) was applied wherein $F = 4.78$, $t = -28.068$, df = 496, SE = 0.056 and p-value was below 0.05. Regarding FF, this result implies that consumers often think they know what a

						Levene's test for equality of variances			
		N	Mean	SD	SE	*F*	Sig.	*t*-value	Sig. (two-tailed)
Discrepancy	SK < OK	227	−0.855	0.676	0.045	4.78	0.029	−28.07	0.000
	SK > OK	271	0.716	0.573	0.035				

Note(s): SK = subjective knowledge; OK = objective knowledge; *N* = number of population; SD = standard deviation; *F* = *F* value; Sig. = significance level

Table 7.
Levene's test for equality of variances

particular FF species stands for, while, in reality, their knowledge is merely constructed and vice versa. This finding is in line with the study by Gunne and Matto (2017).

The study did not accept hypothesis H3a and hence was rejected ($\beta = 0.08$; SE = 0.171; CR = 1.139; $p > 0.10$), indicating knowledge discrepancy had no influence in forming attitude towards the purchase intention. Again, in hypothesis H3b, the result showed that knowledge discrepancy influenced purchase intention negatively but the influence was not found statistically significant ($\beta = -0.05$; SE = 0.148; CR = −0.655; $p > 0.10$). In hypothesis H3c, the Pearson correlation test was conducted to test the correlation between positive knowledge discrepancy and attitude. The result provided a negative relationship ($r = -0.039$, SE = 0.035; $p < 0.10$) between them. Hypothesis H3d revealed a positive association between negative discrepancy and attitude, but the result was not statistically significant ($r = 0.119$, SE = 0.045; $p > 0.10$). The findings suggest that when people tend to overestimate their actual level of knowledge, they bear a negative attitude towards FF, supporting the findings that perception regarding FF is based more on emotion than on facts (Verbeke *et al.*, 2007b; Schlag and Ystgaard, 2013).

However, as observed from hypotheses H5a ($\beta = 0.05$; SE = 0.043; CR = 1.145; $p > 0.10$) and H5b ($\beta = 0.05$; SE = 0.039; CR = 1.190; $p > 0.10$), confusion merely affected the attitude and purchase intention of FF respectively. Therefore, the study failed to accept these hypotheses. Consequently, this result contradicting the findings derived from green product purchase behaviour reveals that confusion regarding eco-levels inhibited the purchase likelihood of green products (Gracia and De Magistris, 2007). Because consumers' attitude and behaviour are culturally dependent concepts, it is normal to observe differences in the conceptualization of consumer confusion because of cultural differences (Ermeç Sertoğlu and Kavak, 2017). In addition, the actual level of confusion consumers encounter in the time of purchasing FF may not be as same as the confusion level they had during the time of response (Gunne and Matto, 2017).

H4 ($\beta = -0.07$; SE = 0.257; CR = −1.664; $p < 0.10$) revealed that people who possessed lower objective knowledge about FF were more confused while buying FF than people who held higher objective knowledge. This finding supports the fact that concrete knowledge (objective knowledge) about product decreases confusion (Matzler *et al.*, 2011), and more knowledgeable people tend to get less confused in purchasing FF (Gaviglio and Demartini, 2009).

Finally, the study also reported a significant and positive association, by accepting hypothesis H6 ($\beta = 0.18$; SE = 0.039; CR = 3.956; $p < 0.01$), between attitude and purchase intention. In addition, this finding also corroborates with basic attitudinal research that attitude precedes purchase intention (Fishbein and Ajzen, 1975; Hoque and Alam, 2018).

This study also attempted to explore the impact of controlling variables such as demographic factors on purchase intention. The results reported that both education ($r = -0.123$, $p < 0.001$) and the age of households ($r = -0.162$, $p < 0.001$) had a negative, significant correlation with the purchase intention of FF. Previous literature report that age, gender, education and income are associated with the fish consumption frequency (Kaimakoudi *et al.*, 2013). Finally, this study reported a significant correlation between subjective knowledge and objective knowledge ($r = 0.35$, $p < 0.001$), replicating the findings of previous studies (Carlson *et al.*, 2009; Pieniak *et al.*, 2010a).

4.3.3 Mediating effect. In hypothesizing whether attitude could mediate the relationship between subjective knowledge and purchase intention (PI), knowledge discrepancy and PI, objective knowledge and PI and confusion and PI, we found the result to be insignificant ($p > 0.10$) with SOBEL test statistic value of 1.634, 0.453, −0.115 and 1.105, respectively. Similarly, confusion did not significantly ($p > 0.10$) mediate the relationship between objective knowledge and attitude and between objective knowledge and PI with SOBEL test statistic value of −0.268 and −0.269 respectively. Hence, the study concludes that attitude

and confusion did not play any mediating role in explaining the indirect effect of the said variable on attitude and/or PI.

5. Conclusion

This contribution has been examined the influence of the knowledge, knowledge discrepancy and confusion on consumer's attitude and purchase intention of farmed fish. To address the research questions, a total of 13 hypotheses were generated and tested. A survey with a structured questionnaire using a direct interview method was conducted to collect the relevant data. The knowledge, confusion, attitude and purchase intention scales were formed and then were regressed with SEM to observe whether the knowledge, knowledge discrepancy and confusion had any effect on consumers' attitude and purchase intention of farmed fish. The obtained results indicated that subjective knowledge positively influenced the purchase intention of farmed fish. However, objective knowledge was not found to have any statistically significant effect on purchase intention of farmed fish. Furthermore, both objective and subjective knowledge could not contribute significantly to forming the attitude towards farmed fish.

A crucial finding derived from this study was that subjective knowledge and objective knowledge were distinct constructs and each had a dissimilar effect on both attitude and purchase intention. Furthermore, the nonconformity between the level of subjective and objective knowledge suggested a discrepancy of the knowledge level held by the consumer. This could be attributed to the argument that people may bear low knowledge than they perceive or they may underestimate their actual level of knowledge.

The result also revealed that consumers who overestimated their knowledge were found to bear a negative attitude towards farmed fish, while consumers who underestimated their actual (objective) knowledge had positive although statistically not significant, attitude towards farmed fish. That means we can say that when consumers lack the actual knowledge they perceive farmed fish to be unfavourable, but when they have true knowledge they do not do so. Thus, the information regarding aquaculture mat not have been conveyed to them properly. However, the discrepancy does not bear any significant effect on purchase intention.

Most participants had a low or moderate level of objective knowledge pertaining to farmed fish. A higher level of objective knowledge reduced confusion towards farmed fish. This finding necessitates the so imminent importance of gathering knowledge as to provide support for the aquaculture to be flourished. Surprisingly, the consumers with confusion did not differ in their attitude and purchase intention, and confusion had no bearing on attitude and purchase intention as well. Finally, attitude towards FF had a positive, significant effect on purchase intention.

5.1 Implications and directions for future research

From the managerial perspective, the study substantiates with accentuating the fact that consumers have poor knowledge about aquaculture, suggesting that an information-based strategy from consumers' perspective should be framed through effective means of communication. Also, the results reported by the study would have several implications. First, a more engaging consumer knowledge enhancement plan should be framed. Second, if the knowledge and information are provided from credible sources, the inherent perception could be shaped positively resulting in greater knowledge levels (Fortin and Renton, 2003). Marketers and other stakeholders can leverage the research findings as an opportunity to build a way to provide effective knowledge to benefit the users and to add value to the community. Previous literature lacks adequate support, until today, to address the relationship between objective

knowledge and confusion, which, in turn, may impact the attitude and purchase intention of farmed fish. To marketers, these findings may work as a word to gain a competitive advantage in commercializing aquaculture products. The distinct contribution of this study, which is yet to be recognized by the researcher, at least in the case of farmed fish, is probably the measurement of a discrepancy of the knowledge held by the consumers. Ion addition, the effect of overestimating the level of knowledge as well as underestimating the level of knowledge in explaining purchase intention of farmed fish would be a supplementary addition in the field of research, aiding the stakeholders of the aquaculture to have a new dimension in recognizing the consumer behaviour from a different perspective.

The sample size should have been large. However, the model fitness and statistical indicators demonstrated good credentials for this baseline research although more effective methods are encouraged. Consideration of a greater dimension of knowledge including environmental, sustainability, food safety and nutrition is encouraged in further research. Consideration of a diverse sample area will ensure more representativeness for future studies. Future studies can also examine the effect of emotion, specific beliefs, perceived risks, trusts, etc. as an explanatory variable, in addition to factors outlined by the study. We took into account the effect of knowledge discrepancy on attitude and purchase intention, but the magnitude of this positive and negative discrepancy was not considered. Hence, further examination can take this issue into account.

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Paper 4

Consumers' Willingness to Pay for Fish Safety Inspection in Bangladesh

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Abstract

Consumers are entitled to eat safe food, so authorities should ensure that this right is preserved by enacting regulations and ensuring compliance through enforcement activities. Safety inspection is key to the enforcement system. Therefore, this paper presents an analysis of consumer responses to a regulatory scheme for safe seafood. The regulations consist of national and local authority enforcement and subsequent follow up activities to ensure that all wild and farmed fish in all product formats are safe. We collected primary data from two major cities in Bangladesh, Dhaka and Chittagong. The data were analysed using conditional and generic multinomial logit models to identify different utility ratios. We find that consumers expect safety control information at a low mental cost or effort. They value fish safety inspection highly in their affective reaction, whereas this value is lacking in their cognitive response. The individual parameter estimates show that consumers' preferences for both wild and farmed fish are significantly positive. They are most likely to reject frozen fish and be willing to pay less for it. Wild-caught fish creates utility for consumers without any food safety inspection, but this is not the case for farmed, frozen fish. The lack of authorised food safety inspection significantly decreases utility, suggesting a positive market potential, particularly for farmed fish with local authority safety certification.

Keywords: Food safety, Willingness to pay, Consumer perception, Fisheries and aquaculture, Emerging economy, Bangladesh.

JEL Classification: Q22

1. Introduction

The rapid growth of agro-farming has led to many unjust works requiring significant natural resources, including energy and water. In this context of unsustainable growth, food security is a critical concern for sustainable food consumption (Hoque and Alam, 2018; Roy et al., 2018). The challenge of food security is to guarantee that people have access to the food they require, free from chemical, physical and biological contaminants (Hanning et al., 2012). Without food safety, we cannot have food security (Thea et al., 2017), and food safety thus needs to be addressed and improved without delay (Reisch et al., 2013). Food security can be ensured by tightening trading hygiene requirements (FAO, 2018) or imposing additional charges and safety requirements on imports (Ababouch, 2006). This might increase food or business costs (Akinbode, 2012), some of which will be transferred to consumers in the form of higher prices.

Consequently, there is an urgent need to assess consumers' willingness to pay (WTP) to control food safety (Akinbode, 2012).

Consumers are concerned about the safety of their food intake. Following various food-safety scandals (Trienekens and Zuurbier, 2008), customer's perceptions of safety can also impact a country's image (Madichie and Yamoah, 2006). Consumers in developed countries are aware of food safety and risk issues. In many developing countries, food safety remains the responsibility of consumers (Tjaart and Schillhorn, 2005). One of the significant challenges for developing countries is stricter food safety requirements (Henson et al., 2000). For many of these countries, food price, taste, and buying convenience seem to play a more significant role than food safety issues (FAO, 2015). Although developing countries have neglected food safety and the development of food safety systems (Grace, 2015), consumers in these markets are likely to become increasingly aware of such issues as incomes continue to grow and if urbanisation continues at the current rate (Ortega and Tschirley, 2017). Seafood from fisheries and aquaculture is crucial for ensuring future food safety and security for households in emerging economies; seafood is an essential source of proteins, vitamins, and micronutrients for many families (Garcia et al., 2010).

There has been a steady growth in the production, consumption, and export of farmed fish, in developing countries, particularly in Asia (Claret et al., 2014), and more specifically in China and India, and emerging markets such as Thailand, Indonesia, Vietnam and Bangladesh (Dey, 2000). This growth has mostly been driven by rising incomes and urbanisation in South Asian countries such as Bangladesh (FAO, 2018). Bangladesh has become the fourth largest fish producing economy globally (FAO, 2016; OECD, 2020) and is ranked third in aquatic biodiversity (Shamsuzzaman et al., 2017). It has an extensive coast, with a rich delta feeding massive capture and culture fisheries. From 2005 to 2016, the country's per capita fish consumption increased by 49%, reaching 22.85 kg in 2016 (HIES, 2016), higher than the average global consumption of 20.3 kg per capita (FAO, 2018). Regrettably, these high fish production and consumption levels are not accompanied by food safety schemes or rigorous hygiene inspections (Rahman et al., 2012).

People classify foods to construct order in a complex food environment and use these classifications to make everyday food choices (Tanis et al., 2000). Since 93% of Bangladeshi households buy and consume fish frequently (Hoque, 2020), classifying fish into wild, inland farmed, and coastal farmed is likely crucial to consumers' fish choice. However, Bangladesh's

highly fragmented fish supply chain comprises thousands of small farmers and many traders, intermediaries, and retailers, most of whom operate with little or no supervision. Together this poses a significant challenge to implementing food safety regulations. As a result, many fish safety problems may be found at the farm, preserving and storage level. Many farmers have practised traditional fish farming using toxic pesticides (Rahaman et al., 2012).

Furthermore, producers and fish vendors unethically use formaldehyde to preserve the fish and seafood from microbial spoilage, as happens in various wet markets (Rahaman et al., 2012). When food is not safe, human development may not occur; therefore, the agenda of emerging economies concerning peoples' access to safe and sufficient food all year round is essential for sustainable development (UN, 2015). Therefore, fish food safety inspections as part of food control are critical to ensure overall food safety and security in emerging markets such as Bangladesh (FAO, 2004).

In an attempt to guarantee food safety, up until 2013, the Bangladeshi food authority had enacted 15 different types of rules and regulations in the form of a penal code, ordinance, and acts (Ali, 2013). However, these rules and regulations are not effective in dealing with food safety problems (Islam and Hoque, 2013). To overcome such problems, the Bangladeshi government has recently adopted the USAID-funded Global Food Security Strategy (GFSS) plan to feed the future involved in food safety and security. In addition, the Management of Aquatic Ecosystems through Community Husbandry (MACH[1]) programme was initiated to achieve safe and sustainable local fisheries management. Government authorities have also enacted mobile courts to frequently intervene to implement the food safety scheme (Hoque, 2020). Although the Bangladeshi government has been attempting to reform laws, establish effective monitoring systems, and strengthen food safety regulations, the primary weak links in the implementation remain (Chowdhury, 2011; Ali, 2013). Therefore, the rapid growth of Bangladesh's fisheries and aquaculture has occurred with less recognition or global acceptance (Hoque, 2020). An effective national food control system is required to protect domestic consumers' safety (FAO and WHO, 2003), and almost all food safety initiatives, government or private, should be nationally centralised. However, these national/central authorities could

[1] In Bengali, fish is called mach. In this case, MACH is an USAID project aimed at supporting the effective management of floodplain resources (e.g., fisheries and aquaculture products) to ensure the sustainable supply of food to the poor of Bangladesh.

be delegated to the local level (Reilly et al., 2009), as local authorities are more suitable for food control and can identify the areas of highest risk for consumers and make effective use of resources (Mari et al., 2013; FSA, 2019). Although publicised as a strict approach to remedying food safety concerns, it is unclear whether these latest efforts and fish safety inspections by national and local governments will make fish food safer and improve the country's image.

Consumer demand for food safety is likely to be an essential driver of public policies and industry-led efforts to reduce information asymmetry related to food attributes and improved food safety (Ragasa, 2019). Although food safety is receiving increased attention from economists, researchers and policymakers, the literature on the demand for food safety inspections in food control in developing countries is scarce (Birol, 2009; Ortega and Tschirley, 2017). Little attention is focused on issues affecting fish quality and the inspection systems of fishery product exports or on consumers' concerns over food safety inspections and their preferences for authority over food control and fish products in Bangladesh. Furthermore, fish consumption behaviour in Bangladesh has not been assessed rigorously (Chowdhury, 2019). Since little is known about this field, its various issues and the clear knowledge gap motivated us to conduct this study. The study's main objective is to support efforts to attain a potential market for fisheries and aquaculture products and formulate an effective policy for food control by predicting consumer preferences and making useful estimates of demand for whole fish.

Therefore, the targeted respondents in this study are households in the two major cities of Dhaka and Chittagong, employing a between-subject design. Respondents were interviewed in an experimental procedure; specifically, we used a choice experiment approach to collect the data and examine preference heterogeneity using descriptive analysis, a conditional logit, and a generic multinomial logit (MNL) model. The study will help predict the heterogeneity in overall fish preferences and in organising a rational market structure in emerging markets that could help identify potential policy implications for fisheries and aquaculture management and provide insights for further research. The study will assist policymakers in drafting and implementing more effective food safety regulations, restoring consumer confidence and re-establishing Bangladesh as a leading exporter of food-safe fish products worldwide.

The structure of the study is as follows. Section 2 contains the literature review, and we then present the theoretical framework. Section 4 details the data collection and methods, and the econometric model is set out in Section 5. The model data are then discussed, and subsequently,

the research results are addressed, followed by the concluding remarks and suggestions for further research directions.

2. Literature Review

Food safety issues arise from the critical problem of asymmetric information between consumers and producers concerning product-specific attributes (Ortega et al., 2011). Such issues can arise from information asymmetry pertaining to food safety requirements and the deceptive claims of marketers. For instance, unsubstantiated 'green' claims cause reputational harm and make consumers suspicious of the behaviour of suppliers (Peattie, 2001). Moreover, due to the absence of authoritative attributes, consumers cannot determine a product's relevant qualities (e.g. sustainable fish production) even after consuming it; balanced information is, therefore, essential (Monier-Dilhan, 2016).

This information problem is even more severe in developing and emerging markets due to their large populations and the lack of reliable safety information. In developing markets, food safety information is often neglected (Grace Delia, 2015) but this information is almost entirely lacking in emerging markets (Carlucci et al., 2015). Negligence and a lack of food safety information lead to a reduction in consumer trust in food safety (Lin et al., 2020) and an inaccurate perception or little awareness of the level of risk. Despite the low awareness of food safety risks, consumers demand food products of high and consistent quality at competitive prices (Trienekens and Zuurbier, 2008; Lin et al., 2020). In response to the proliferation of food values, many public and private standards on food safety and quality have been developed (Trienekens and Zuurbier, 2008), with credible third-party certification being an essential factor in consumer's demand for food safety (Birol, 2010). The information gap between market players can be bridged, and the increased inefficiencies that arise from information asymmetry addressed (Ortega et al., 2011) through quality certification (e.g. safety labelling), the traceability of products origins (Ortega et al., 2011), consumer access to food product attributes (Danso et al., 2017), and increased trust in information and its sources (Hoque and Alam, 2018). Hussain et al. (2017) suggest food safety measures fulfil a useful management function and minimise the risks created by asymmetric information.

Currently, the environment is a source of significant risk associated with seafood safety. Contamination of seafood can occur before harvest or at any point from harvest through to final preparation (Amagliani et al., 2012). Accordingly, aquatic food security and credibility are achieved with a sufficient safe, sustainable, shockproof and sound seafood supply (Jennings et

al., 2016). In response, governmental and health authorities have become very concerned about the quality and safety of seafood, increasing regulation, and adopting stringent hygiene measures to stop contaminants (Jessie, 2018). Seafood consumption has become an essential part of a balanced and healthy diet (Trondsen et al., 2003). as it is significantly related to public health (Baki et al., 2018); health benefits include lower instances of cardiovascular disease (Verbeke and Vackier, 2005). In addition, fish is an essential source of quality protein and is cheaper than other animal protein sources for which there is an efficient market structure.

In fish markets, internal cues, such as the sensory characteristics of fish, are critical determinants of fish consumption. These cues are also vital to evaluate the freshness of a fish product (Carlucci et al., 2015). However, sensory characteristics are product specific, and it is not easy to establish that these are fundamental for all fish. For this reason, several studies use attitudes towards fish as a proxy for sensory perception. This is because an attitude is a psychological tendency to evaluate objects in degrees of, for example, good–bad or pleasant–unpleasant, and this attitude can thus be positive (liking) or negative (disliking) (Eagly and Chaiken, 1998). However, consumers' attitudes toward fish products are rapidly changing due to demographic and socioeconomic changes. Therefore, conjoint analysis is widely used in psychometrics, economics, and marketing to assess and estimate consumers' preferences and demand for market and seafood products (Anderson, 1993; Roheim et al., 2011).

The expansion in the consumption and commercialisation of fish products have, in recent decades, been accompanied by a growing interest in food safety, nutrition, and waste reduction. Therefore, consumers prefer precise information when purchasing fish, including its visual elements, origin, price, format, and freshness (Brécard et al., 2009). Additionally, consumer fish choice is strongly affected by habits that emerge and are reinforced through experience (Scholderer and Trondsen, 2008). Consumers' perception of fish while purchasing also depends on the convenience and availability of products. When preferred fish products are not available, and the possible alternatives appear to be weak substitutes, consumers decide not to buy anything (Carlucci et al., 2015). Despite being a poor substitute for wild-caught fish, aquaculture has gradually grown to meet the excess demand, meaning that more than 220 species of finfish and shellfish are now cultured (Naylor et al., 2000).

In addition to improving local food supply, aquaculture can also improve food security and nutrition through the availability of low-cost fish and increasing employment opportunities and income (FAO, 2013). Countries must be accountable for what seafood consumers consume

rather than what they produce to ensure food security and nutritional quality for a growing world population despite stagnant production in capture fisheries and in light of increasing aquaculture production (Guillen, 2019). The demand for and consumption of cultured fish depends on not only credible information but food safety systems and communication of the safety performance requirements of farms, their sustainability indicators, exports of farmed fish, consumer knowledge and perceptions of farmed fish, WTP and equitable distribution of fish to the population (Dey, 2000; Trienekens and Zuurbier, 2008; Lagerkvist et al., 2013; Hussain et al., 2017; Hoque and Alam, 2020; Hoque 2020).

Although there is extensive literature on consumer behaviour in developed economies in relation to fisheries and aquaculture (Carlucci et al., 2015) and on food safety systems (Grace, 2015), there is little for developing and emerging economies. Although the level of fish consumption is low for people in developing economies, they consume a higher share of fish protein in their diet (FAO, 2018). The domestic fish farms and fish markets of developing and emerging countries in Asia are important, with the dominant market being for whole fish traded as fresh, iced and frozen. However, the influence of the production method and price on the consumer perception of such fish has been little studied in developing countries (Carlucci et al., 2015) and South Asian markets, including Bangladesh (Alam and Alfens, 2019; Hoque, 2020). No study focuses on the impact on consumers' fish preferences of food safety inspections in fish control. This study attends to these gaps and analyses the segmentation of the Bangladeshi retail finfish market.

In the local Bangladeshi markets, the price of wild fish is higher than that of inland-farmed fish, with the price of coastal-farmed fish lower than that of inland-farmed fish. The literature shows that households with a high level of income buy more fresh fish than those with lower levels of income (Nauman et al., 1995). Therefore, it is logical to assume that high-, medium- and low-income consumers are most likely to buy wild, inland-farmed, and coastal-farmed fish, respectively. In addition, in local Bangladeshi markets, consumers with an average level of knowledge regarding farmed fish are most likely to prefer safe fish; this farmed fish is lower in quality than the organic version (Hoque et al., 2021b). Accordingly, it would be reasonable to assume that a consumer with little knowledge would prefer conventionally farmed fish.

The literature also indicates that low-income consumers are most likely to choose conventional or unlabelled farmed fish (Hoque, 2020). Therefore, high, medium, and low-income consumers are likely to prefer whole fish that has been subject to a national-level food

safety inspection (NFSI), local-level food safety inspection (LFSI), or with no authorised food safety inspection (NoFSI), respectively. Based on the similarity to our just-stated hypotheses, we also propose the same explanation for the association between the rate of fish consumption (high, medium, or low) and the level of authority of food safety inspections (NFSI, LFSI, or NoFSI). Accordingly, the value consumers give to food safety inspection authorities can be assessed by their frequency or level of fish consumption.

3. Bangladeshi Fish Markets and Food Safety Inspections

Consumers in emerging middle-class markets, including Bangladesh, focus more on food safety (Xu et al., 2012; Sudhir et al., 2015). A series of globally- and locally-known food safety scandals has increased awareness of Bangladesh's inefficient food safety measures and inspection systems. Most foodstuffs in its economy are less safe than in other places, and this problem persists at every level of the food chain, from preparation to consumption (Ali, 2013). The food security system remains vulnerable because of the limited coverage of safety schemes, vulnerability to natural disasters, and fluctuation in prices (Roksana et al., 2014). Additionally, impure, rotten and perishable food waste is turned into toxic foods and stored, sold and served to consumers in an unhygienic atmosphere (Ali, 2013). The same conditions are true, and to a greater extent, for aquaculture and fisheries products (Rahaman et al., 2012).

Fisheries and aquaculture products are key dietary components for the population (Raknuzzaman et al., 2016) and are ranked third among Bangladesh's export commodities (IMED, 2013). In the growth of the fisheries and aquaculture sector in Bangladesh, there has been extensive product differentiation between wild, inland-, coastal, and marine-farmed fish, and in some cases, these products have been marketed with rice or vegetables (FAO, 2016; Hernandez et al., 2018). Globally, 15% of the total animal protein in people's diet comes from fish; this figure is 50% in developing countries and 60% in Bangladesh (Pijl and Duijn, 2012; DoF, 2018). Although fish is an essential source of food and provides nutrition security and income for many people in Bangladesh (Saiful, 2016), the safety standards in the fish supply chain are inadequate (Pijl and Duijn, 2012) and complex due to its many stakeholders. In the extended value chain, fish is traded in the primary market (involving fish farmers and local collectors), secondary market (involving wholesalers and local suppliers) and retail market (involving sellers and ultimate consumers). In the retail market, fish are traded in both open or wet markets and hyper- or supermarkets. Due to the product's importance, in terms of market volume, and its significant role in the socioeconomic condition of millions of people in

Bangladesh, authorities need to pay proper attention to the retail sector to ensure the quality and safety of the fish and fish-products produced and marketed (Paul, 2018). The Bangladeshi Fish Inspection and Quality Control wing of the fisheries department have been working since 1997 to sustain a fish-product safety system.

Numerous measures might be required to control food adulteration and ensure the marketing system is effective and strategic. The Bangladesh Food Safety Network is a privately formed network of organisations that implements several educative programmes and communication campaigns for food safety advocacy and awareness; the network aims to increase public consciousness of food safety and foster a safe food movement. Recently, the Bangladesh Safe Food Authority began collecting domestic market data regarding food adulteration to manage the food safety programme effectively. To minimise the risks of the existing system of food safety control, the Bangladeshi government has set food standards and risk assessment procedures in consultation with the Codex Alimentarius Commission.

Following this process, twenty food analysis laboratories formed the National Food Safety Laboratory Network to improve the testing of food samples. An Information, Education and Communications action plan has also been adopted to enhance the food hygiene and safety awareness of households, schoolchildren, food vendors, and advocacy groups. Furthermore, a Food Safety Unit has been formed to develop effective policies and to institutionalise and ensure the good governance of the existing food safety control system. Finally, a pathogen-specific surveillance system tracks food-borne illnesses following the food safety guidelines introduced for the farmed finfish supply chain.

Bangladesh has perhaps the highest number of food safety laws, regulations and initiatives in the world to regulate the safe delivery to consumers of food, including fish and fish products. These diverse regulations and inspections show multi-sectoral responsibility for food control (FAO, 2004), which entirely excludes the HACCP and Codex standards (Banglapedia, 2015). Increasing safety standards formulation capacity based on risk will contribute to the institutionalisation and good governance of food control systems and food safety practices in value chains. Increasing these standards will also change household attitudes, resulting in demand in Bangladesh for safe fish (FAO, 2017). However, the existing control frameworks suffer from abysmal implementation (Chowdhury, 2011), stemming from regulatory failures, a lack of information to consumers (Ali, 2013), and a lack of consumer verification. Therefore,

this study explores how consumers value food safety and what their preferences are for fish safety inspections to help design an effective food regulation policy.

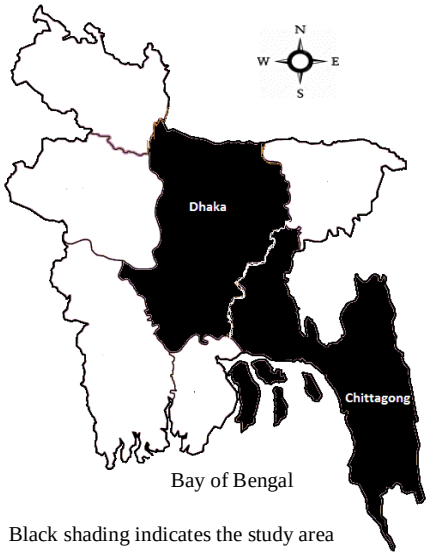
4. Data collection and measures

One of the most common carp species, Rui (*Labeo rohita*), is a widely produced, popular and extensively consumed fish in Bangladesh. It is both wild-caught and farm-raised, produced in both inland freshwater and brackish water, and contributes to around half of total fish consumption (Khan et al., 2020). Since our main interest is to investigate how seafood safety inspection as part of fish control affects consumers' choices and their WTP, we focus on Rui to isolate the effect of a specific consumer choice. We use an experimental research design to collect data, with direct interviews with randomly selected households. The data were collected in Dhaka and Chittagong (see Fig. 1), which are chosen because their per capita fish consumption is higher than that of other cities in the country (Needham and Funge-Smith, 2014). Furthermore, as the capital city, Dhaka makes a significant contribution to the country's economy and is characterised as the 'Business Hub of Bangladesh,' and the commercial and port city of Chittagong makes a crucial contribution to foreign trade. Furthermore, people living in these cities are relatively wealthy compared to those in the rest of the country. These cities are thus suitable for our attempt to explore the growing consciousness of food safety control in emerging markets (HIES, 2016).

To construct a representative sample, we employ stratified cluster sampling processes. The fieldwork in the two study areas was undertaken from 12 January to 27 March 2019. Before the final version of the survey was completed, we conducted a pre-test survey of 42 subjects from Dhaka and 36 from Chittagong to confirm that they understood the questions and that there were no semantic or measurement problems. We found no significant obstacles, and the same settings were employed for the final version.

The primary respondents are household members older than 21 in charge of what other household members eat; these householders are more likely to be responsible for fish buying than others in the family. The purpose of the research was specified in a motivational letter to the participants, who were interviewed in the local language, Bengali, and answered a set of questions and responded to the survey. On average, each interview took 20 minutes. Before beginning the survey, the survey's contents were reviewed and approved by the Ethical Review Board, University of Chittagong, Bangladesh.

Fig. 1. the study area



Black shading indicates the study area

The first section of the questionnaire (see Appendix A) centred on fish choice based on fish attributes focused on fish safety control. Six sets of choices were presented in a table, and the respondents were requested to choose one from each (see Fig. 2). In each set, three fish options with four attributes were presented to assess consumers' choices. Furthermore, we included an additional 'opt-out' choice in each selection to allow for none of the other choices being found suitable. The choices in the experimental design were affected by the fish production method (wild, inland farmed, coastal farmed); the product form (fresh, frozen, iced); type of food safety inspection (national authority, local authority, no authorised safety inspection); and price per kg of the Rui (BDT 360, BDT 280, BDT 200) (see Table 1). A focus group discussion was arranged to ensure the estimated values were logical and relevant to the local economy to accurately estimate the fish attributes and alternatives. Based on time and budget constraints, 450 households were targeted as respondents. Of these, we omit 28 as they provided partial or incomplete information. Therefore, a total of 422 households are included in the between-subject design. The sampling distribution is as follows: Dhaka south (113); Dhaka north (100); Chittagong south (103); and Chittagong north (106). Ultimately, we obtain a data set of $n = 422 \times 6 \times 4 = 10{,}128$ observations.

Figure 2. Example of a choice set

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

Election number- #	**Option A**	**Option B**	**Option C**	**Option D**
Attribute				
Production method	Wild	Coastal farmed	Wild	None of these
Product form	Frozen	Iced	Iced	
Food safety control	No authorised safety inspection	National-level food safety inspection	Local-level food safety inspection	
Price/kg	BDT 200	BDT 360	BDT 280	
I would choose:	☐	☐	☐	☐

Table 1: Fish attributes and levels for the choice experiments.

Fish attribute	**Description**	**Levels/Alternatives**
Production method	The fish come from seas, rivers, and other natural bodies of water. Alternatively, they can be raised in inland ponds or other freshwater bodies, in coastal areas in brackish water, or in the sea in saline water.	Wild-caught, inland-farmed, coastal-farmed.
Product form	The nature of the product purchased by consumers.	Fresh, frozen, iced.
Fish safety control	A regulatory activity (e.g., safety inspection) by an authority (national or local) that provides consumer protection and ensures that during production, handling, storage, processing and distribution of the fish is safe.	National-level food safety inspection (NFSI); local-level food safety inspection (LFSI); and no authorised food safety inspection (NoFSI)
Price	This is an economic indicator of the cost of purchase and what consumers would pay for one kg of fish. Here it is denoted in the Bangladeshi currency, globally coded as BDT (Bangladeshi taka).	BDT 360/kg, BDT 280/kg, BDT 200/kg

With four factors and three levels, a total of 3^4 (81) hypothetical products can be created by connecting the attributes listed above. For useful analysis, the study employs an orthogonal fractional factorial design. The computer program SPSS (Version 26) provides the minimum number of six choice sets, with 18 product profiles. Following Balcombe et al. (2010), the participants were instructed to think about the choice scenarios as if they were real. We used a text script in the questionnaire to provide relevant information on fish attributes during the choice experiment to reduce the bias that could result from a hypothetical experiment (Murphy et al., 2005).

When buying fish, the attributes perceived by consumers affect their preferences. When they value a product and judge the quality of its attributes accurately, they will buy it (Caswell, 1998). Accordingly, how consumers perceive fish attributes is assessed with a simple attitude ranking survey, in which their valuing of fish attributes are assessed on a seven-point Likert scale ranging from 1 (*strongly disagree*) to 7 (*strongly agree*), thus revealing their perceptions of what the attributes meaning. Scores of four or five are treated as a neutral perceived value, scores of three or below are considered a negative perceived value and scores of six or above represent a positive perceived value (Hoque, 2020). However, in the Likert-type statements,

the respondents could rate all the attributes as equally important (Phillips et al., 2002). Therefore, to gain in-depth insights, their evaluations of fish attributes are assessed in an attitude ranking survey (see Appendix A).

Hence, consumers ranked the fish attributes according to their perceived role in their fish choice from 1 (*most important*) to 4 (*least important*). Preference ranking can also effectively elicit consumer valuation based on conjoint analysis (Millar and Millar, 1996; Phillips et al., 2002). However, attitude and preference ranking involve different theoretical frameworks and methods. Therefore, we then also compare the outcomes of the two approaches to determine the relative importance of each fish attribute ranking. The relative importance of attributes is measured by the ratio of the range of utility (e.g., Rank 1) change for different attribute levels to the sum of such fields for all fish attributes.

5. Econometric Model

In economics and marketing, conjoint analysis is widely used to assess and estimate consumers' preferences and demand for market goods (Anderson, 1993). In this study, we consider consumers' perceived value of food safety inspection and fish attributes, together with their fish-shopping experiences in a conjoint experiment. Generally, an individual chooses an alternative (the most preferred item) to maximise their utility, and other options are not chosen, indicating their mutual exclusiveness (Train, 2009). When respondent *n* observes choice set *k* with *j* alternatives, then the utility of alternative *j* for respondent *n* can be defined as:

$$U_{nkj} = x'_{kj}\beta + \varepsilon_{nkj} \quad (1)$$

where β represents a vector of the importance of the attributes (x) for consumers in assessing their utility. The error term ε_{nkj} captures the influence on the respondent's utility of unobserved factors. Respondents had four choices: Option A, Option B, Option C, and Option D (do not buy either). Thus, a conditional logit model is used to estimate the preference (Hensher et al., 2005; Roheim et al., 2012) where the probability of respondent *n* choosing product *j* of choice set *k* can be written as:

$$P_{nkj} = \frac{e^{\beta_j x_j + \gamma_{nj} x_j z_n}}{\sum_k e^{\beta_j x_j + \gamma_{nj} x_j z_n}} \quad (2)$$

In the economics literature, it is common to use the discrete choice model to choose between several alternative products (Train, 2009). This mathematical function predicts an individual's choice based on relative attractiveness or utility (Mehndiratta and Hansen, 1997). This model

provides an analytical advantage; the logit model is often used for modelling the relationship between a categorical outcome and one or more numerical or categorical predictor variables. As a popular and widely used logit model, the MNL model generalises the logistic regression to more than two problems, providing log odds of the nominal outcome as a linear combination of the predictor variables that estimate a consumer's choice based on relative attractiveness or utility (Mehndiratta and Hansen, 1997). The MNL model implicitly assumes independence from irrelevant alternatives (IIA) where violation of the IIA assumption is not a serious shortcoming (Guadagni and Little, 1983). In this study, the household choice for whole Rui is modelled using the disaggregate fish demand approach with a generic MNL model, in which the probability that respondent *n* chooses alternative *j* of choice set *k* is

$$P_{nkj} = \frac{\exp\left(x'_{kj}\beta\right)}{\sum_{i=1}^{J}\exp(x'_{ki}\beta)} \qquad (3)$$

In addition, if the *N* respondents evaluate the same set of *k* choice sets, the log-likelihood function for the MNL model becomes:

$$\ln\big(L(\beta)\big) = \sum_{n=1}^{N}\sum_{k=1}^{K}\sum_{j=1}^{J} y_{nkj}\ln\big(P_{nkj}\big) \qquad (4)$$

In Eq. 4, the dummy variable y_{nkj} equals one when respondent *n* prefers alternative *j* from choice set *k*, and zero otherwise. Individually respondents' choices are linked to individual-specific explanatory variables (Franses and Paap, 2001). These denote the ratio of the probability of choosing the options and the value of the various fish attributes, such as wild, inland farmed, fresh, food safety inspected. The responses in each choice set from four unlabelled options (1 = Option A, 2 = Option B, 3 = Option C, and 4 = Option D) is truncated into a multivariate binary choice exposing generic model (Hoque, 2020). For instance, the six multivariate dummy variables for the six responses were coded as equal to one if Option A is chosen and zero otherwise. Nonetheless, in the choice sets, as 'Option D' is 'None of these' and that the alternative specific constant (ASC) is equal to one when 'Option A', 'Option B', and 'Option C' is chosen, and zero if 'Option D'. Based on Eq. (4), the maximum likelihood estimates $\hat{\beta}$ for the parameter and the vector are obtained by maximising the log-likelihood function, indicating that the parameters estimated in the model are useable for the probability of making a choice. A positive parameter suggests that the explanatory variable is likely to

increase the likelihood of choosing the respective fish attribute. A negative parameter indicates that the predictor value tends to curtail the choice probability (Zhang and Khachatryan, 2019).

Marginal values based on estimated parameters reflect the WTP for product attributes. According to Train (2009), the estimate can be calculated as the negative ratio of the coefficient of an attribute variable ($\beta_{attribute}$) to the price coefficient (β_{price}); the formula is as follows:

$$\mathrm{WTP}_{attribute} = -\frac{\beta_{attribute}}{\beta_{price}} \qquad (5)$$

Consumers' WTP is accounted for by choice modelling (Model 2), which is measured hypothetically. Each marginal value represents consumers' WTP for a particular attribute related to the specific fish types while holding all else constant.

6. Results

The participant demographics and socioeconomic variables are presented in Table 2. Of the participants, most are male (78%), aged between 30 and 39 years old (40%), and with more than 12 years of education (83%). Culturally, men in Bangladesh (almost 80% in this case) are responsible for purchasing food for their families (Schaetzel et al., 2014). Most households (70%) have children and between two and five family members in total (77%). The mean monthly income of 30% of the respondents is between BDT 30,000 and BDT 50,000 (US$ 1=BDT 84). Only 6.60% of the respondents are housemakers, while 54% are employed.

The descriptive statistics also show that 65% of the households eat fish several times per week, and 25% do so daily. Almost 80% of the respondents do fish shopping for their families, with 52% buying their fish from a wet market. The results also reveal that very few respondents (8%) are registered members of any volunteer environmental organisation or club. Approximately 15% of the total fish purchased were bought from supermarkets.

Table 2. Descriptive statistics of the demographic and psychographic variables and the preference patterns for whole rui.

Sample size (households)	n = 422
Age (%)	
20 to 29	10.70
30 to 39	39.80
40 to 49	30.10
50 to 59	13.50
60 to 69	05.70
70 or older	00.20
Gender (%)	
Male	78.20
Female	21.80
Education (%)	
0 to 5 years	02.80
5 to 12 years	13.50

Over 12 years	83.60
Children (age 1–16) in the household (%)	
Yes	70.40
No	29.60
Number of family members (%)	
Fewer than 2	02.10
2 to 5	77.00
Over 5	20.90
Household monthly income in Bangladeshi Taka (BDT) (%)	
Under 30,000	17.10
30,000 to 50,000	29.90
50,000 to 70,000	20.90
70,000 to 90,000	14.70
Over 90,000	17.50
Profession (%)	
Jobholder	54.00
Businessperson	21.60
Housemaker	06.60
Direct services	16.10
Other	01.60
Overall fish consumption (%)	
Once per month	00.50
Once per week	09.70
Several times per week	65.40
Daily	24.60
Do you do fish shopping for your family? (%)	
Yes	79.10
No	20.90
Where do you buy the fish? (%)	
Wet Market	51.70
Supermarket only	01.70
Both	46.70
Registered member of an environmental club (%)	
Yes	8.10
No	91.90
Existence of a high value of food safety inspection amongst those respondents who are environmental club members (%)	
Yes	67.65
No	32.35
Percentage of fish that consumers buy from supermarkets (mean ± St.dev.)	14.92 ± 20.78
N = 10128	

A monthly income of less than BDT 50,000 is low, 50,000 to 89,000 is medium, and 90,000 and above is a high level of income. Fish consumption once per week is low, several times per week is medium, where daily is high.

This study investigates the effects of product attributes, interactions between the attributes, and socioeconomic variables on the choice of whole Rui through two econometric models. As specified in Eqs. (2) and (3), the conditional logit (CL) model and MNL regression are estimated to measure the impact of the attribute variables on fish choice, with the results reported in Table 3. Both the CL and MNL analyses first test the model fit by examining the chi-square of the final model (see Table 3, final row). Eq. (4) illustrates the estimated parameters in the MNL model; these are the marginal effects of the observed explanatory variables on the logarithm of the success odds ratio. The odds ratio shows the exponential outcomes of the corresponding parameters. As the sign and magnitude of the two models' coefficients are almost identical, we consider Model 2 with ASC for ease of analysis. The outcomes demonstrate that the ASC is insignificantly positive, meaning that, overall,

consumers prefer whole fish. However, the odds of the price are −0.005, which is significantly negative, implying that consumers' preferences for whole fish would be lower at a higher price.

The individual parameter estimates show that, in response to the coastal-farmed version, wild fish are valuable in increasing the utility of consumers, as evidenced by their willingness to pay a price premium of BDT 299.20/kg. This finding is in line with Hoque (2020) for Bangladesh and Uchida et al. (2014) for Asia and is consistent with studies in Europe and the Americas (Holland and Wessells, 1998; O'Dierno et al., 2006; Wirth et al., 2007; Davidson, Pan, Hu, and Poerwanto, 2012; Nguyen et al., 2015; Rickertsen et al., 2017).

Compared to the coastal-farmed version, inland-farmed fish also significantly increase the utility of consumers, who are willing to pay a price premium. The literature reveals that consumers prefer inland freshwater to sea fish (Galib, 2011), whereas a more significant number of North Carolina consumers prefer saltwater-farmed seafood (Drake et al., 2006). In Europe, the value consumers place on farmed fish is positively related to food safety (Claret et al., 2014). Most consumers perceive no difference between farmed and wild fish, with availability a salient feature of a preference for the former (Verbeke et al., 2007; Claret et al., 2014). However, consumers' WTP is much higher for wild than farmed fish (Davidson et al., 2012).

Table 3: Estimated results of the exp (coef) of product attributes and socioeconomics, and consumers' preferences.

Explanatory variables	Choice of whole rui in the					
	Conditional logit (CL) model			Multinomial logit (MNL) model		
	Model (1) with fish attributes, interactions between the attributes and socioeconomic variables			Model (2) with fish attributes, interactions between the attributes and socioeconomic variables		
	Coef	WTP	CI	Coef	WTP	CI
ASC	--	--	--	0.040 (0.356)	8.00	[−135.62, 151.62]
Wild	1.395*** (0.194)	348.75	[108.11, 589.38]	1.496*** (0.195)	299.20	[123.32, 475.07]
Inland-farmed	0.732*** (0.196)	183.00	[51.86, 314.13]	0.786*** (0.198)	157.20	[58.22, 256.17]
Fresh	0.237 (0.178)	59.25	[−51.66, 170.16]	0.243 (0.183)	48.60	[−39.42, 136.62]
Frozen	−0.901*** (0.222)	−225.25	[−368.11, −82.38]	−0.943*** (0.226)	−188.60	[−295.18, −82.01]
NFSI	0.506** (0.245)	126.5	[−10.27, 263.27]	0.259 (0.163)	51.80	[−15.67, 119.27]
NoFSI	−3.829*** (0.606)	−957.25	[−1490.53, −423.96]	−3.927*** (0.608)	−785.40	[−1155.53, −415.26]
Price	−0.004*** (0.001)	--	--	−0.005*** (0.001)	--	--
Opt-out	−2.221*** (0.353)	−555.25	[−719.81, −390.68]	−2.368*** (0.362)	−473.60	[−571.22, −375.97]
Wild*Fresh	1.254*** (0.300)	313.50	[203.48, 423.51]	1.355*** (0.309)	271.00	[190.02, 351.97]
Wild*Frozen	1.715*** (0.289)	428.75	[229.46, 628.03]	1.818*** (0.296)	363.60	[223.61, 503.58]

Wild*NoFSI	1.205**	301.25	[−44.27, 646.77]	1.074*	214.80	[−48.48, 478.08]
	(0.601)			(0.603)		
Inland-farmed*Fresh	0.479**	119.75	[−29.62, 269.12]	0.526**	105.20	[−13.72, 224.12]
	(0.239)			(0.246)		
Inland-farmed*Frozen	0.268	67.00	[−86.38, 220.38]	0.254	50.80	[−71.90, 173.50]
	(0.275)			(0.281)		
Inland-farmed*	0.533	133.25	[−207.91, 474.41]	0.504	100.80	[−173.75, 375.35]
NoFSI	(0.681)			(0.684)		
Wild*High income	−0.026	−06.50	[−71.64, 58.64]	−0.020	−4.00	[−50.41, 42.41]
	(0.126)			(0.113)		
Inland-farmed*Medium income	−0.374**	−93.50	[−187.30, 00.30]	−0.410***	−82.00	[−151.88, −12.11]
	(0.158)			(0.150)		
Coastal-farmed*Low income	0.174	43.50	[−30.21, 117.21]	0.190	38.00	[−15.79, 91.79]
	(0.137)			(0.125)		
Price*Wet market	−0.002***	−00.50	[−00.90, −00.09]	−0.0004*	−0.08	[−0.18, 0.022]
	(0.000)			(0.000)		
Price*Supermarket	−0.003	−00.75	[−01.74, 00.24]	−0.001	−0.20	[−00.57, 0.170]
	(0.002)			(0.001)		
NFSI* High income	−0.005	−01.25	[−64.43, 61.93]	−0.006	−1.20	[−46.57, 44.17]
	(0.123)			(0.110)		
LFSI*Medium income	0.272*	68.00	[−13.16, 149.16]	0.285**	57.00	[−0.83, 114.83]
	(0.143)			(0.129)		
NoFSI*Low income	−0.482**	−120.50	[−237.63, −3.36]	−0.492***	−98.40	[−185.78, −11.01]
	(0.195)			(0.189)		
NFSI* High consumption	−0.150	−37.50	[−160.96, 85.96]	0.125	25.00	[−36.76, 86.76]
	(0.236)			(0.148)		
LFSI*Medium consumption	0.578**	144.50	[−00.65, 289.65]	0.326**	65.20	[−3.23, 133.63]
	(0.242)			(0.153)		
NoFSI*Low consumption	0.715	178.75	[−435.44, 792.94]	0.665	133.00	[−335.50, 601.50]
	(1.180)			(1.130)		
Number of observations = 10,128, Number of groups = 422	Pseudo-R^2 = 0.3048, LR Chi^2 (25) = 3038.41, Prob. (Chi^2) = 0.000			Pseudo-R^2 = 0.2791, LR Chi^2 (25) = 3179.00, Prob. (Chi^2) = 0.000		

Standard errors in parentheses; *** p<0.01, ** p<0.05, and * p<0.1. Parameter estimates from the MNL model; ASC = Alternative Specific Constant; NFSI = National-level Food Safety Inspection; LFSI = Local-level Food Safety Inspection; NoFSC = No authorised Food Safety Inspection; WTP, standard error (S.E.), and confidence interval (C.I.) estimated with the delta method.

Second, the results reveal that in response to iced fish, the utility of fresh fish increases for consumers and their marginal WTP is positive. Consumers' preference for fresh fish is also consistent with previous studies in both developed and developing economies, such as India (Debnath et al., 2012), China (Hu et al., 2014), Kenya (Musa et al., 2012), France (Nguyen et al., 2015), Denmark (Solgaard and Yang, 2011), and Malaysia (Ahmad Hanis et al., 2013). Freshness is also an essential attribute for Asian consumers in the Northeastern United States (Thapa et al., 2015). In addition, in comparison to iced fish, frozen fish decreases the utility of whole rui for consumers, meaning they are only willing to buy it at a reduced price. This result is consistent with Davidson et al. (2012).

Third, in response to the food safety inspection of local authorities, NFSI does not significantly increase fish utility. Moreover, compared to local-level inspection, not having an inspection greatly reduces the utility of fish for consumers. The results also demonstrate that consumers' WTP for NoFSI is negative, and more significantly so than the WTP of the opt-out

group. With either no or inadequate food safety regulation, consumers are unable to assess fish products (Lawley et al., 2012). Again, a high price premium was recorded for farmed fish with Aquaculture Stewardship Council certification (Xuan, 2021). It appears the application of scientific national-level food safety regulations are required to meet world-class safety standards (Cato, 1998).

In this study, the effects we consider are those be analysed by creating interaction terms between product attribute variables (Davidson et al., 2012). Without these interacted terms, the results can be interpreted as capturing the average perceived value of the product attributes for the sample (Train 2009). In the interaction analysis, the interaction of production method and product form could provide substantial information for consumer food-product utility. For instance, the wild and fresh attributes together increase consumers' utility, indicating they are complementary. As the attributes increase utility individually, it is expected that together they will increase consumers' utility. Such a finding is relevant to the outcomes of Roheim et al. (2012).

Furthermore, the wild and frozen attributes are valued individually and increase or decrease consumers' utility, respectively. However, this attribute information significantly increases consumers' utility when the attributes wild and frozen are provided together. This indicates they are complementary and that consumers have a strong preference for wild fish in the frozen form. Individually, the NoFSI attribute reduces the utility of fish for consumers. When this and the wildness attribute are considered together, wild fish significantly increase consumer utility, but the inland-farmed version does not. A recent study in France also shows that consumers perceive wild fish as best for safety and health (Rickertsen et al., 2017). However, it is only in the fresh form that the inland-farmed version increases utility; consumers are willing to pay a price premium of BDT 105.20/kg.

The model's interaction effect also shows that high-income consumers are willing to buy wild fish at a low price. The significant negative interaction effect between inland-farmed fish and a medium level of income implies that they are substitutes; the coastal version increases utility to consumers insignificantly, but they are willing to pay a price premium of BDT 38.00/kg. Previous studies demonstrate that both inland- and coastal-farmed fish significantly benefit Bangladeshi consumers (Hoque et al., 2021b). In addition, the interaction term between price and the wet market is negatively significant, meaning that consumers are willing to buy whole fish in the wet market at a low price. Presently, compared to wet markets, modern

retailers (e.g., supermarkets) sell higher quality products at higher prices (Schipmann et al., 2011).

The model's interaction effect also indicates that a positive and significant interaction term between LFSI and a medium level of income is significantly positive and complementary. In this complementary effect, LFSI increases the utility of fish to consumers. Due to the introduction of local GAP standards, minimum food safety and hygiene is required for the control of the marketplace (Havinga, 2015, p.78). The China Food and Drug Administration has introduced local governance regulations to develop a legal and regulatory system to address food safety risks (Jensen and Zhou, 2015, p.181). Similarly, in terms of fish consumption level, consumers are most likely to prefer LFSI. On the other hand, fish with NoFSI produces consumer disutility, in which the effect of NFSI is insignificantly negative.

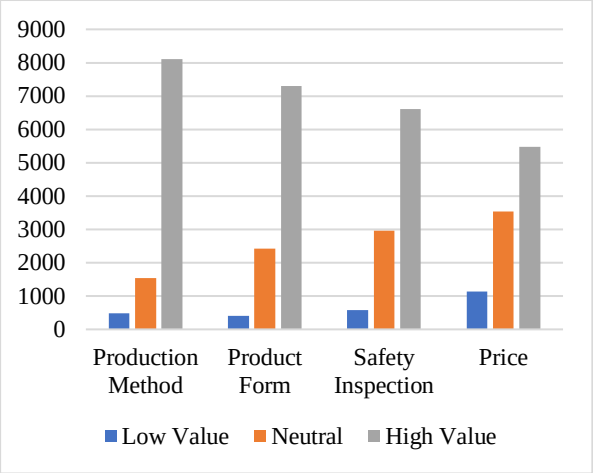
7. Consumer Perceptions of Fish Attributes

Although consumers value the production method as the most important attribute in fish choice (in the attitude rating and ranking), their perceptions of food safety were heterogeneous. Consumers weighted safety inspection as second in the rating and third in the attitude ranking. More mental effort is required to answer ranking than rating questions (Verint, 2013). This neurocognitive process reflects the psychological cost (e.g., mental concern or mental resistance) of information processing during perception (Trujillo, 2019). The outcomes demonstrate that in the attitude ranking, where a high mental cost (friction or anxiety) is involved in responding, consumers perceive a lower value for food safety inspection than in the attitude rating. This indicates that consumers prefer safety information that is legible, clearly and consistently presented and with a low mental processing cost. Food safety regulators that develop educational materials should thus include the required safety information to reduce consumers' mental costs, to obtain strong form efficiency in the fisheries and aquaculture market.

In comparing two attitude objects, attitude ranking is superior to attitude rating (Harzing, 2009). Attitude rankings represent consumer's direct experiences of attitude objects that might produce affective reactions linked to consumer behaviour and directly influence their preferences (Millar and Millar, 1996; Phillips et al., 2002). Such behaviour greatly affects consumers' consideration of product attributes and their intrinsic enjoyment of the consumption (Millar and Millar, 1996). Consumers value the method of fish production and food safety inspection as the first and second most crucial fish-choice attributes (see Fig. 4, Table 3).

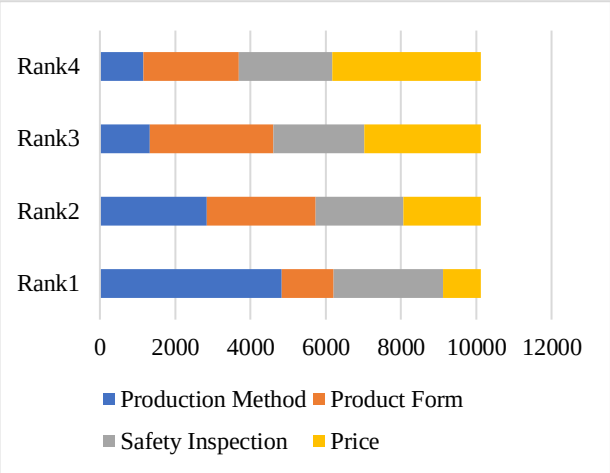
In the preference ranking, consumers perceive fish attributes indirectly by means of predicted objects that produce cognitive reactions linked to their instrumental behaviour (Millar

Fig. 3. Percieved value of fish attributes which affect their fish choice



Each bar in the diagram indicates the frequency of consumers' attitude rating of fish attributes. The vertical axis shows the number of the respondents.

Fig. 4. Rank distribution of the four attributes according to the importance in consumers' fish choice



Each bar in the diagram indicates the percentage of consumers' attitude ranking of fish attributes. The vertical axis measures rank.

and Millar, 1996; Phillips et al., 2002). This behaviour allows consumers to form their attitudes to fish attributes based on cognition and beliefs rather than affectively driven actions and intrinsic enjoyment (Millar and Millar, 1996). In such instrumental behaviour, consumers perceive the fish production method to be most important, with safety inspection as the fourth most important attribute. However, they perceive fish safety inspection as the second most crucial attribute in attitude ranking in relation to their consumption behaviour. Therefore, consumers' perception of fish safety inspection related to their affective reaction for intrinsic enjoyment is higher than their reactions based on cognition and beliefs. Such a low belief

perception of fish safety inspection indicates that Bangladeshi consumers' do not have a high level of belief in the existing fish safety control, with affective drivers greatly influencing their consumption of fish at a high rate. From the affective perspective, fish and fishery products have a strong association with national pride, upbringing, and a sense of belonging to the community (Hoque et al., 2021b), which helps make Bangladesh a fish-eating nation.

Table 4. The relative importance of fish attributes (Numbers in parentheses indicate ranking)

Framework for Operationalisation and Conceptualisation		**Attribute**				**Total**
		Price	**Production method**	**Product form**	**Safety inspection**	
Operationalisation of safety inspection	Types of rankings and their characteristics					
Relative importance (based on the most important attribute in fish choice; 1= yes, 0 = otherwise)	Attitude ranking: direct experiences, affective reactions, consummatory behaviour, intrinsic enjoyment.	9.95 (4)	47.14 (1)	13.94 (3)	28.97 (2)	100.00
Relative importance (based on the predicted expected utility from fish attributes)	Preference ranking: indirect experiences, cognitive reactions, instrumental behaviour, cognition and beliefs.	−0.79 (3)	432.36 (1)	151.19 (2)	−482.75 (4)	100.00

8. Discussion

Bangladesh has a high-level frequency of fish consumption, and consumers' fish choices are heterogeneous. Generally, consumers prefer wild fish to the farmed version, and they are willing to pay a price premium for wild fish for its positively valued taste and safety attributes. Even a lack of authorised safety inspections increases consumers' utility from wild fish, clearly suggesting that they find wild fish safe; the existing food safety inspection is not required by consumers. Individually, the attribute 'fresh' increases consumers' utility insignificantly, while that of attribute 'frozen' decreases utility significantly. Interestingly, when the attributes of production method and product form are combined, consumers value wild fish in frozen form more than in fresh form, indicating their strong preference for wild fish, irrespective of the product form (fresh or frozen).

Many wild fish are caught at sea, and the process from the point of catch to the table is relatively long. Therefore, it is not easy to find wild fish in fresh form. Such inconvenience in obtaining wild fresh fish leads consumers who prefer the wild version to mostly depend on the frozen alternative. In addition, in the urban areas of Bangladesh, fish produced in inland freshwater is treated as local, indicating a similar attitude to consumers in European and the Mediterranean (Jaffry et al., 2004; Brécard et al., 2009; Claret et al., 2012; Mauracher et al.,

2013), in their preference for locally farmed fish (e.g., inland freshwater fish) over coastal- and marine-farmed versions (Hoque et al., 2021).

In addition to the fish production method (wild vs farmed), the fish form (fresh vs frozen) also plays a vital role in consumers' fish choices. When the attribute 'fresh' is considered alone, it increases consumer utility. However, consumers are less likely to prefer the frozen fish, indicating they are willing to pay a premium for the fresh fish. Alternatively, they are willing to buy the frozen fish product at a lower price. These findings imply that whole fish in fresh form will be popular in local Bangladeshi markets.

Furthermore, a new form of fish or a new measure for frozen fish is required to increase fish utility to consumers. Despite the market opportunities for new fish products, Bangladeshi consumers traditionally have a fixed affinity for consuming the fish available in local markets. They have already formed the habit of eating fish, with a high level of affection for fish consumption (Hoque, 2020). As the supply of fresh fish is limited, to meet the high demand, consumers also prefer alternative fish forms, such as frozen, iced, and dried.

Bangladeshi consumers are highly experienced in handling and processing whole fish. There is also a fish-handling service available for a fee at the point of sale, which motivates people to eat whole fish. Therefore, consumers have a marked preference for whole inland-farmed fish in fresh form. In addition, they assume frozen farmed fish traded in the local markets is below average in terms of taste and safety. Although consumers' WTP for farmed fish in frozen form is positive, the availability of such fish will not significantly increase the number of buyers.

An effective trading strategy is required for farmed frozen fish, for example, authorised food safety inspections; these may help to significantly improve consumer's utility from fish. Farmed fish is not considered suitable in terms of health and safety, but it may be the best option for environmental sustainability and fish welfare (Rickertsen et al., 2017). Although farmed fish raises food safety concerns, there is a tendency to underestimate food safety risks. This factor, a high level of demand for fish, and a certain affinity for fish consumption (e.g., ASC), mean that consumers are willing to pay a premium for inland-farmed fish.

Surprisingly, consumer's WTP for non-inspected inland-farmed fish, which is the status-quo (BDT 100.80), is higher than for inland-farmed frozen fish (BDT 50.80). It is notable that consumers in traditional market outlets perceive a low level of food health risk (Hoque et al., 2021b). Because there is a limited or absent supply of safety-inspected fish, even the absence

of an authorised food safety inspection may increase consumers' utility from fish in the domestic market. Such a conventional or uninspected fish preference may be one kind of forced choice. In the absence of the preferred seafood and its unsuitable substitutes, in developed countries, consumers do not buy any fish product at all (Carlucci et al., 2015); however, this is not applicable in an emerging economy such as Bangladesh. Consumers' high level of fish consumption and established habits may influence them to prefer whole finfish, even if no safety inspection has been made. However, due to the higher levels of income and education now prevailing, Bangladeshi urban households are becoming gradually more conscious of food safety and sustainability in their fish choices (Hoque, 2020).

As food security and safety are vital, and fisheries and aquaculture are essential in the food economy, a fish safety system is now central and provides opportunities for consumers to estimate their demand for fish that is safety-inspected that which is not. In local Bangladeshi markets, NFSI increases fish utility to consumers. NoFSI decreases consumer utility from fish, clearly implying that for consumers wanting safe farmed fish, the existing or additional food safety inspections are mandatory. Although food elements should be labelled and the necessary information provided to consumers, this is not the case in local fish markets, specifically in wet markets in Bangladesh (Hoque, 2020). Therefore, consumers' overall value of fish safety in Bangladeshi local markets is low, and they are only willing to buy whole rui in the wet market at a lower price.

Although preferences and perceptions are key elements in the analysis of market demand, price and income are also important issues. The parameter estimates show that, based on income, consumers are less likely to prefer inland-farmed fish, meaning that they are highly price-sensitive to farmed fish. Therefore, because of the higher price of inland-farmed fish, consumers choose coastal-farmed fish. Food safety is a vital information cue when buying fish (Pieniak et al., 2013); however, consumers are rarely able to find any safety information when buying fish in Bangladeshi local markets.

Additionally, to boost the lifespan and appearance of fish, it is common practice for vendors to spray fish with chemical preservatives, including formalin (Goon et al., 2014). As a result, consumers are suspicious and worried about fish safety, and fish farmers face the challenge of having to engage in communication campaigns because of the low consumer loyalty to their products (Gaviglio and Demartini, 2009). The overall negative evaluation of the Bangladeshi fisheries sector posing a significant threat to households' income and food security and requires

immediate action by policymakers (Ghose, 2014). The results also show that LFSI increases fish utility to consumers, and their MWTP is positive. However, our most interesting finding is that consumers are less likely to prefer fish with NoFSI, meaning they expect active and reliable safety inspections. The research shows that in terms of safety and hygiene issues, production methods, and nutrition value (Claret et al., 2016), the availability of information also influences consumers' fish preferences (Siret and Issanchou, 2000). Such findings in the literature confirm that whole fish with LFSI will be popular in local markets in emerging economies such as Bangladesh.

Currently, Bangladeshi market food safety issues are causing a severe crisis of trust, and the existing national-level certification system for food safety (e.g., BSTI approved) is extremely inefficient (Hoque et al., 2021b). Even the government has not verified this scheme through consumers, and many substandard food products have been found labelled as 'BSTI approved'. Additionally, many counterfeit food products are traded in the local markets cynically labelled with the warning "Beware of fake products" (Hoque, 2020). Therefore, to increase consumers' trust level, Bangladesh's food safety regulators should provide unique inspection resources to supervise the safety of fish and other seafood sold in ostensibly trustworthy markets and must not permit exemptions to inspections. In China, despite the inefficient safety certification system for milk (Zhang et al., 2010), consumers are willing to pay a premium for safe, traceable fish products over non-traced products of uncertain safety (Feng et al., 2009).

Another interesting finding is that consumers are not sensitive to food safety risks relating to fish consumption levels. Even with NoFSI, they prefer to consume a certain level of fish that is, in fact, higher than that preferred for fish with an NFSI. Such discrepancies in the perceptions of food safety risk may lead to potential market failures, despite the focus on a health-driven approach to food safety (Lagerkvist et al., 2013). On the one hand, consumers are concerned about food safety, and on the other, they underestimate the threats of safety risks, revealing a gap between their expectations and perceptions regarding food safety inspection (Lin et al., 2020). Such behaviour shows emotional responses to, or experiences of, fish consumption. These responses could be turned into emotional preferences and further the potential of fisheries and aquaculture (Hoque et al., 2021a) and support the cultural connotation of consumption "Fish eater Bangali (Mach-e-bhat-e-Bangali)".

People are reluctant to buy the greenest products (Young et al., 2010; Brécard, 2017), with green consumers giving these low priority. Similarly, the introduction of LFSI for whole rui

offers a policy approach to change consumer behaviour (Hoque, 2020). In recent years, a combined government and private monitoring mechanism has been introduced to improve seafood safety and restore consumers' trust in fishery products in Bangladesh (Economic Review, 2018). These are mostly reactive and based on completed fish product inspections. In addition, these reactive inspections are ineffective and poorly implemented. As the efforts are not complete or sufficient to ensure fish safety security in local markets, a preventive and risk-based inspection focusing on the entire fish chain should be implemented to better manage fish safety control. Such risk-based safety inspections could support the authorities in formulating an effective food safety policy with a proper institutional framework for its operationalisation (FAO, 2004) and resources allocated to the areas with the more significant safety risks.

9. Conclusion

We assessed consumers' perceptions of fish attributes using three different attitude measurement and scaling techniques: attitude rating, attitude raking, and preference ranking. The typical value of the fish attributes assessed across all estimation techniques indicates that the production method (wild or farmed) greatly influences people in their fish choice. A heterogeneous value for fish safety inspection suggests that consumers expect information regarding food safety control at a low mental cost. Consumers beliefs regarding fish safety inspections in safety control are low, whereas the effects of affection on fish choice are high.

Second, the results indicate that for most consumers, wild fish is still perceived as having better overall quality than the farmed equivalent. When consumers find it difficult to locate fresh wild fish in the marketplace, and if the price is relatively high, they are more likely to prefer frozen wild fish. Although wild fish may not involve food safety inspection, consumers are most likely to buy such fish. Interestingly, consumers prefer frozen wild fish to fresh wild fish because of its availability in the local market.

Third, only fresh-farmed fish increases consumer utility. Farmed fish in frozen form and with no authorised food safety inspection is not appealing but becomes attractive if there is a local-level food safety inspection. Alhough consumers have mixed perceptions of fish that has passed an NFSI, they are willing to pay a premium for fish with a local-level food safety inspection. This suggests the market potential for farmed fish if it is certified by the local authority. Interestingly, when no fish with a food safety certification is available, they are still interested in conventional or uninspected wild fish.

Consumers' WTP behaviour shows that they are willing to pay less for inland-farmed fish. Therefore, coastal-farmed fish could offer an alternative to meet the high demand from urban households. Additionally, inland fresh-farmed fish with a local municipality inspection would be an excellent alternative to scarce wild fish. This may support the claim that safety-inspected farmed fish could become prevalent in Bangladeshi fish markets. More focus should be placed on the relative importance of consumers' preferences for particular attributes, such as production methods, product forms, food safety inspection authorities, and the potential interaction effect among fish attributes. Accordingly, effective information strategies addressed to the general public should be developed to support and increase farmed fresh fish and safe fish consumption. This would reduce the negative impact of traditional fish preservation practices on selling methods and reduce unsustainable fish consumption. Such outcomes and policy recommendations would provide essential information to cities such as Dhaka and Chittagong to improve Bangladeshi consumers' general perceptions of policymakers and major potential food traders (domestic and foreign).

In this study, we considered two major cities, covering the country's southern and central urban households; North Bengal was excluded. However, we suspect that the results would vary considerably for diverse geographical locations and cultures. For example, the preference for wild over farmed fish is likely to be improved in the west and southern parts, and the wild fisheries in the Bay of Bengal expanded. Therefore, it is not easy to generalise from our results. Another caveat is that the design of choice experiments varies from study to study, including concerning the range of prices used to cover the potential WTP. We employed stratified cluster sampling, which is a systematic tool, suggesting the results can be used to draw a more robust conclusion. Similar studies could be conducted in future that include food safety labelling and cover more of Bangladesh; these could potentially cover major urban areas to account for the significant differences between economic conditions in rural and urban households.

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PART III: Appendices

Appendix A

Consumers' Willingness to Pay for Organically Farmed Shrimp in an Emerging Market
A Survey Questionnaire, April 2019
Please give the tick mark on the best option only.

PK1: With requirement fulfilment, way of getting vitamin by eating farmed fish is more important to me than waiting for wild fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

PK2: Genetically engineered farmed fish is not nutritious as non-genetically modified fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

PK3: The best thing about farmed fish is its' availability.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

PK4: Pangas is the most economical farmed fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

PK5: The widely consumed farmed fish, I think, would be Tilapia.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

PK6: The fat content of farmed Shrimp will not harm you more than the calories.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

General Attitude:

How would you describe your feelings about Farmed Shrimp in general on the following scale?

Bad	❶	❷	❸	❹	❺	❻	❼	Good
Negative	❶	❷	❸	❹	❺	❻	❼	Positive
Unfavourable	❶	❷	❸	❹	❺	❻	❼	Favourable
Dull	❶	❷	❸	❹	❺	❻	❼	Exciting
Terrible	❶	❷	❸	❹	❺	❻	❼	Great

Relevant information (textual and visual) about the production methods of aquaculture/Farmed Fish:

Organic Farmed Fish: As organic fish, there is no or limited use of pesticides, chemical fertilizers and other chemical inputs in the production process that lead an aquaculture to get a sustainable growth in the fisheries industry.
Safe Farmed Fish raising: Prawn fish that under controlled in the coastal regions. Pesticides residues, heavy metals and microorganism contents within food are under government standard and safe for consumers but not sustainable (X. Yu et al. (2014), Food Policy, 45, pp. 80–87).

Conventional Farmed fish: Refers to raising and breeding aquatic animals hereafter Prawn fish by sharing many pesticides, more than enough traditional fishmeal to increase the growth of fish rapidly with no safety control.

Marine Aquaculture: refers to the breeding, rearing, and harvesting of Prawn that can take place generally in the open ocean. In mariculture, the medium is purely that of seawater, as no freshwater is added to make it brackish.

Coastal Aquaculture: This aquaculture includes in shore & off shore operations, as well as culture in those ponds or lakes near a coast where brackish water culture is also undertaken.

Inland Aquaculture: refers to raising and breeding aquatic animals hereafter Prawn fish by the use of ponds, reservoirs, lakes, rivers, and other inland waterways in freshwater.

Consumers Preferences: (approach in randomized design)

Please Rank (1 to 9) the nine types of Fish Label according to your willingness to buy.

A

Conventional Farmed Fish

Inland

৳ 399/Kg

Rank: _____

B

Organic Farmed Fish

Coastal

৳ 599/Kg

Rank: _____

C

Conventional Farmed Fish

Marine

৳ 599/Kg

Rank: _____

D

Organic Farmed Fish

Inland

৳ 499/Kg

Rank: _____

E

Safe Farmed Fish

Inland

৳ 599/Kg

Rank: _____

F

Conventional Farmed Fish

Coastal

৳ 499/Kg

Rank: _____

G

Safe Farmed Fish

Coastal

৳ 399/Kg

Rank: _____

H

Safe Farmed Fish

Marine

৳ 499/Kg

Rank: _____

I

Organic Farmed Fish

Marine

৳ 399/Kg

Rank: _____

General Information:

a) Age: _____
b) Gender: ☐ male ☐ female ☐ Don't want to mention
c) Monthly income (Taka) : _____
d) Education of years: _____
e) Profession: ☐ Self-employed ☐ Service ☐ Others
f) Fish consumption: ☐ 1 time per week ☐ more than 1 time per week
g) I buy farmed fish from: ☐ Wet market ☐ Supermarket ☐ Both
h) Agree that farmed fish is safer than wild: ☐ Yes ☐ No
i) I am aware of farmed fish: ☐ Yes ☐ No

j) Through my personal choice of fish, I can contribute to the saving of natural fish stocks from depletion: ☐ Yes ☐ No
k) Where do you eat fish most often? ☐ Home ☐ Restaurant ☐ Fast food/Takeout

Appendix B

Consumer's Willingness to Pay for Food Safety Inspection in Bangladesh: A Survey Questionnaire-February, 2019

Dear Respondents,
This questionnaire survey is a part of my Doctoral research. This survey is about the choice of fish, and the aim is to measure the effect of food safety inspection and price on buying decision. Please fill in the first choice that comes to your mind since this is probably closest to your real purchase behaviour in markets. There are no risks or benefits related to filling in this survey, and all the information you provide remains very confidential. Notice, all data will be used anonymously for academic purpose as suggestions to estimate consumer preferences.

The survey is a direct interview method and mostly self-report choice questions. It will be divided into two parts. First, we will ask you to choose one type of fish among three alternatives in the six choice sets. In the second phase, we will ask to answer some demographic questions. It will take around 20 minutes to fill in this questionnaire.

Thank you in advance for your cooperation.

Best Regards,

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Section 1: Choice Experiment
Instructions

- You will view details about three types of fish at a time on a choice card.
- Examine the design details—such as the variety of attributes or price—that you usually use to make a buying decision.
- Indicate which of the three fishes you would choose; only one choice is allowed. You can also indicate that you would not choose either fish in that particular three types.
- Please think carefully about each decision as though your choices were real.
  Below is an example of a choice scenario:

Imagine you are in the market and will buy Rui fish that you usually buy: There are four choices A, B, C and D. You are asked to choose the one you would most likely buy. Again, only one option is allowed.

Example	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Wild	Wild	Inland Farmed	None of these
Product form	Frozen	Fesh	Frozen	
Food safety control	National-level food safety inspection	Local-level food safety inspection	No-authorised safety inspection	
Price/kg	TK 200	TK 280	TK 360	
I would choose:	☐	☐	☐	☐

Figure: Example of a choice set

Please read the relevant text information regarding fish attributes carefully, then begin the survey:

- **Price:** Price of 1 kg of the type of fish you have selected (Bangladeshi Taka)
- **National-level food safety inspection**: A regulatory safety inspection by national authority to provide consumer protection and ensure that fishes during production, handling, storage, processing & distribution are safe. For instance, the regulatory functions of IPH (Institute of Public Health), Dhaka, and the BSTI (Bangladesh Standard Testing Institutions).
- **Local-level food safety inspection:** A regulatory safety by the local authority to provide consumer protection and ensure that fishes during production, handling, storage, processing & distribution are safe. For instance, the regulatory functions of the executive magistrate and health officer of Dhaka City Corporations and Chittagong City Corporations.
- **No-authorised safety inspection**: There is no authority to provide safety protection to consumers and ensure that fishes during production, handling, storage, processing & distribution are safe.

Now we will begin the survey; please tick (√) your choice in the following choice sets.

Election-1	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Inland Farmed	Coastal farmed	Coastal farmed	None of these
Product form	Fresh	Fresh	Iced	
Food safety control	National-level food safety inspection	Local-level food safety inspection	No-authorised safety inspection	
Price/kg	TK 200	TK 200	TK 200	
I would choose:	☐	☐	☐	☐

Election-2	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Inland Farmed	Wild	Coastal farmed	None of these
Product form	Fresh	Fresh	Iced	
Food safety control	National-level food safety inspection	Local-level food safety inspection	No-authorised safety inspection	
Price/kg	TK 200	TK 200	TK 200	
I would choose:	☐	☐	☐	☐

Election-3	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Inland Farmed	Wild	Coastal farmed	None of these
Product form	Frozen	Fresh	Fresh	
Food safety control	Local-level food safety inspection	No-authorised safety inspection	National-level food safety inspection	
Price/kg	TK 200	TK 280	TK 280	
I would choose:	☐	☐	☐	☐

Election-4	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Coastal farmed	Wild	Inland Farmed	None of these
Product form	Frozen	Iced	Iced	
Food safety control	Local-level food safety inspection	National-level food safety inspection	No-authorised safety inspection	
Price/kg	TK 280	TK 200	TK 280	
I would choose:	☐	☐	☐	☐

Election-5	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Wild	Coastal farmed	Wild	None of these
Product form	Frozen	Iced	Iced	
Food safety control	No-authorised safety inspection	National-level food safety inspection	Local-level food safety inspection	
Price/kg	TK 200	TK 360	TK 280	
I would choose:	☐	☐	☐	☐

Election-6	**Option A**	**Option B**	**Option C**	**Option D**
Attributes				
Production method	Inland Farmed	Inland Farmed	Wild	None of these
Product form	Fresh	Frozen	Fresh	
Food safety control	No authorized safety inspection	National-level food safety inspection	Local-level food safety inspection	
Price/kg	TK 360	TK 280	TK 360	
I would choose:	☐	☐	☐	☐

Please rate the following statements by giving the tick mark on the best agreeing (one) option only

Statements	Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
Production method (e.g., wild or farmed) affects my choice of fish	❶	❷	❸	❹	❺	❻	❼
Production form (e.g., fresh or frozen) affects my choice of fish	❶	❷	❸	❹	❺	❻	❼
Safety inspection affects my choice of fish	❶	❷	❸	❹	❺	❻	❼
Price affects my choice of fish	❶	❷	❸	❹	❺	❻	❼

Section 2: Personal Characteristics

a) Age: ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59 ☐ 60-69 ☐ 70 years or older
b) Gender: ☐ Male ☐ Female
c) Income/month (Taka) : ☐ <30,000 ☐ 30,000-50,000 ☐ 50,000-70,000 ☐ 70,000-90,000 ☐ > 90,000
d) Child (age 1-16) in household: ☐ Yes ☐ No
e) Number of family member: ☐ less than 2 ☐ 2 to 5 ☐ more than 5
f) Your education of years: ☐ 0 to 5 years ☐ 5 to12 years ☐ above 12 years
g) Your profession: _____
h) Do you do most of the food shopping for your family? ☐ Yes ☐ No
i) Overall fish consumption: ☐ Less-than once/month ☐ once/month ☐ once/week ☐ Several-times/week ☐ Daily
j) I buy fish from: ☐ Wet market ☐ Supermarket ☐ Both
k) In general, what is the percentage of fish that you buy from supermarkets? ☐ %
l) Are you a registered member of any environmental organization? ☐ Yes ☐ No

Finally, please rank the following four attributes according to the importance of your fish choice (1=most important to 4=least important)

Attribute	Production method	Product form	Safety inspection	Price
Ranking				

Appendix C

Knowledge Discrepancy, Confusion, and Intention to Purchase Farmed Fish: A Survey Questionnaire, March 2018

Section-1: It is involved in making answers to some questions based on your knowledge, beliefs and attitude towards Marine Farmed Fish.

Please give the tick mark on the best choice only.

Product Knowledge: Subjective and Objective

Part-I: Subjective Knowledge (Strongly Disagree, Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Agree, Strongly Agree)
SK1: I have in depth knowledge to evaluate the quality of farmed fish.
SK2: Compared to an average person, I know a lot about farmed fish.
SK3: My friends consider me as an expert in the domain of farmed fish.
SK4: I have heard of most of the new aquaculture method that are around.
SK5: If I had to purchase the farmed fish today, I would need to gather very little information in order to make a wise decision.

Part-II: Objective Knowledge (Yes/No/Not sure)**:**
OK1: The price of a farmed raised fish is lower than a wild caught fish of the same species.
OK2: Farmed Fish is a source of omega-3 fatty acids.
OK3: Farmed Fish is a source of dietary fiber.
OK4: Farmed Pangas is a fatty fish.
OK5: The Tilapia eaten in Bangladesh is predominantly farmed.

Part-III: Confusion: general
CON0: I feel confused regarding the overall meaning of Aquaculture/farmed fish (Yes/No).

Part-IV: Specific Confusion (Strongly Disagree, Disagree, Somewhat Disagree, Neutral, Somewhat Agree, Agree, Strongly Agree)
CON1: I feel confused regarding the risk level of farmed fish consumption.
CON2: I feel confused regarding the health benefit from farmed fish consumption.
CON3: Little awareness of farmed fish production made me confused about the effectiveness of farmed fish.
CON4: Lack of information or knowledge of aquaculture made me confused about farmed fish.

Section 2: Attitude
How would you describe your feelings about Farmed Fish on the following scale?
(Bad to Good, Negative to Positive, Unfavorable to Favorable, Dull to Exciting, Terrible to Great, Unsatisfied to Satisfied).

How would you describe your feelings about Farmed Shrimp in general on the following scale?

Bad	❶	❷	❸	❹	❺	❻	❼	Good
Negative	❶	❷	❸	❹	❺	❻	❼	Positive
Unfavourable	❶	❷	❸	❹	❺	❻	❼	Favourable
Dull	❶	❷	❸	❹	❺	❻	❼	Exciting
Terrible	❶	❷	❸	❹	❺	❻	❼	Great
Unsatisfied	❶	❷	❸	❹	❺	❻	❼	Satisfied

Intention to Purchase:

ITP1: I intend to purchase the farmed fish next time I buy fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

ITP2: I would pay any price for farmed fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

ITP3: Environmental advertisements impact my purchase.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

ITP4: Based on my experience, I likely agree to recommend others to eat farmed fish.

Strongly Disagree	Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree	Strongly Agree
❶	❷	❸	❹	❺	❻	❼

Section 3

General Information: Please fill in the gaps and give the tick mark on the right option only.

a) Name of the respondent:
b) Contact Number:
c) Short Address:
d) Age of the head of household:
e) Gender: ☐ Male ☐ Female
f) Income/month (Taka or Rupee) : ☐ Less than 50,000 ☐ Above 50,000
g) Presence of children (age 1-16) in household: ☐ Yes ☐ No
h) Number of Family member:
i) Your education of years: ☐ 0 to 5 ☐ 5 to12 years ☐ above 12 years
j) Your profession: ☐ Self-employed ☐ Service
k) In consumption, I don't classify the fish in wild and farmed: ☐ Yes ☐ No
l) Overall fish consumption:
☐ Less-than1/month ☐ 1/month ☐ Several-time/month ☐ 1/week
☐ Several-times/week ☐ Almost/daily ☐ Daily
m) Shop for fish: ☐ Wet market ☐ Supermarket ☐ Both
n) Where do you eat fish most often? ☐ Home ☐ Restaurant ☐ Fast food/Takeout
o) "On ten occasions when you consume fish, how often are these farmed" (share of farmed fish):

❶ ❷ ❸ ❹ ❺ ❻ ❼ ❽ ❾ ❿, ☐ don't know

Thank you! To give me some from your valuable time!!