Informing incentive-based management of hilsa fish in Myanmar

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Results of a choice experiment

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This study provides key insights for the development of incentive-based conservation schemes for hilsa in Myanmar's Ayeyarwady Delta. The results of a choice experiment suggest on average a willingness to participate in such conservation schemes. Some potential management options for conservation schemes such as additional closed fishing periods and creation of new sanctuaries are more widely accepted than restrictions in net use. We recommend further studies to refine management options and identify appropriate compensation mechanisms that take into account improved ecological knowledge and carefully consider income dependencies and gender disparities along the supply chain.

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Summary

Hilsa fishing serves as an important resource to fishers in Myanmar's Ayeyarwady Delta where hilsa shad's spawning and nursing grounds are located, serving local needs and a national market. There are growing concerns regarding the sustainability of Myanmar's hilsa fishery. Primary factors believed to contribute to this trend include overfishing, often with small-mesh nets, and habitat destruction; with water pollution and climate change exacerbating the problem (Khaing et al., 2018).

Policy options to improve the sustainability of hilsa fishing in Myanmar include incentive-based conservation schemes. These bear some similarity to 'payments for ecosystem services' schemes, which are voluntary transactions between ecosystem service beneficiaries and ecosystem service suppliers that are in the best interest of both parties. However, incentive-based schemes may be developed with the aim of providing economic incentives for abiding by existing and new fishing regulations.

Among the methodological tools available to assess attitudes and preferences of potential participants in incentive-based schemes, 'choice experiments' are increasingly used. Choice experiments are a survey-based stated preference method to find respondents' preferences between various alternatives, such as hypothetical conservation agreements, through which participants agree to undertake changes in resource management that benefit conservation in return for some compensation. This report summarises the results from a choice experiment study conducted with fishing communities in four townships within the Ayeyarwady Delta region of Myanmar as part of an effort to identify opportunities for incentive-based schemes for the conservation of hilsa shad fisheries. The research was undertaken as part of the Darwin-Hilsa[MM] project Carrots and Sticks: Incentives to conserve hilsa fish in Myanmar.

The hypothetical conservation agreements offered to respondents in the choice experiment included three aspects related to hilsa management and two aspects that characterised monetary and in-kind compensation: 1) a new fishing ban that would last for seven days in one, two, or three months in the period from October to December; 2) new sanctuary spaces for juvenile hilsa that would be placed every 9, 6 or 3 miles for a maximum length of 1 mile along the river, with a width of up to half the river; 3) requiring fishers to use nets distributed by the Department of Fisheries with a 4.5 inch mesh from October to December and a ban on all other nets; 4) monetary compensation, with cash payments to range from MMK 75,000 to 350,000 (US$ 53 to 248); and 5) rice as in-kind compensation, in amounts of one, two or three *tinn* (a Myanmar measure of volume commonly used for rice). Payments of both rice and money were to be made as one-off annual payments and management changes would be agreed through written agreements between fishers and the Department of Fisheries. A total of 381 respondents were surveyed during July, October and November 2019 in four townships of the Ayeyarwady Delta: Ngapudaw, Maubin, Mawlamyinegyun and Labutta. Where possible, respondents were chosen to overlap with households that had participated in a previous socioeconomic household survey conducted in April 2018 (Khaing et al., 2018).

The results of this choice experiment provide some important insights for the development of incentive-based conservation schemes for hilsa shad in Myanmar. On average, respondents showed a tendency to choose one of two alternatives representing conservation agreements rather than the 'No agreement' alternative. This indicates a general willingness to participate in this type of conservation scheme, especially given the low rate of 'No agreement' choices; however, such an interpretation should be carefully assessed against the presence of cultural norms, such as cultural ways of expressing consent or dissent.

In terms of the specific proposals for more sustainable hilsa management, the results show that both additional closed periods to facilitate spawning and the creation of new sanctuaries are the most widely accepted management changes. On the other hand, restrictions on net type requiring a larger mesh size (to allow more juveniles to mature) were perceived as most controversial. Creating additional periods when fishing is banned are likely to be more acceptable if they are around the main festival in October (*Thadingyut*). Additional closures in November and December (*Tazaungmon* and *Natdaw*) are likely to require higher compensation. The creation of new sanctuaries is particularly acceptable when sanctuaries are spaced at least six miles apart. Anecdotal evidence suggests

that many fishers are already aware of areas closed off to fishing, including conservation zones. Therefore, it may be possible to implement this change without the need for much compensation. However, this needs to be tested further, based on what experience fishers have of current conservation zones and the benefits and risks of implementing and managing sanctuary areas. Fishers showed the greatest demand for compensation if net use restrictions were to form part of conservation agreements. While changes in net use may be effective in terms of hilsa conservation, this option should be carefully evaluated to better understand the implications in terms of enforcement, markets for fishing gear and livelihoods along the supply chain.

There was limited interest in the offer of in-kind compensation in the form of rice. While the region's abundant supply of rice may partly explain this result, a more detailed exploration of this finding could find out if other forms of in-kind compensation are more viable. Where this includes food items, it may be worth moving beyond staple food items towards items that are perceived to be nutritious and difficult to obtain in local markets.

Breaking down the results by township shows some variations in preferences. For example, in Ngawpudaw respondents did not pay much attention to in-kind or monetary compensation; their earnings from fishing are reported to exceed the amounts offered to compensate for fishing restrictions. For management changes, the results show that fishers were most concerned about restricting net use; that they could accept a fishing ban in the month of October but not in other months; and that they are indifferent to sanctuary areas which are less close together, at every 6 or 9 miles of river length. Results are qualitatively similar for Mawlamyinekyun, Labutta and Maubin townships, except for the fact that respondents were on average more responsive to changes in monetary compensation offered.

Model results based on gender show that apart from changes in nets, female respondents were indifferent to management changes. This is likely due to the disparity of labour practices between men and women within the fish supply chain. While women in the villages tend to be more engaged in repairing nets and selling fish, men are more likely to engage in fishing and boat repair (Khaing et al., 2018).

These findings reveal a number of promising management options to pursue further. Building on this study and improved ecological knowledge (Bladon et al., 2019), we recommend further research to refine potential management changes and to identify appropriate compensation amounts. This should also carefully consider income from fishery and income dependency over the season and provide additional insights into different gender perspectives on incentive-based conservation schemes. Deliberative methods may be particularly helpful, especially if focused on finding a 'fair price' for compensation and engaging fishers in conservation efforts.

1 Introduction

Hilsa shad (*Tenualosa ilisha*, known locally as *Nga Tha Lauk*) is a species of fish found commonly in the Bay of Bengal and surrounding waters. Myanmar is reported to account for 25% of global hilsa catch (Dewhurst-Richman et al., 2016). Hilsa fishing is common both in marine and inland fisheries. The fish travels from marine waters to freshwater rivers for spawning. Bladon et al. (2019) indicate that August to September is the main spawning season in the Ayeyarwady Delta, with additional spawning seasons likely to take place in January to February and April to May. Immature individuals also migrate between marine and freshwater environments (Rahman et al., 2008). Hilsa fishing serves as an important resource to fishers in Myanmar, particularly along the Ayeyarwady Delta, where their spawning and nursing grounds are located. Hilsa fishing contributes greatly to both the fish markets in Myanmar and to subsistence fishing. Overall in Myanmar, fish contributes 20% of household protein intake, with higher contributions in the Ayeyarwady region (Belton et al., 2015), and is mostly small scale, with 87% of registered fishing vessels reported as 'small' fishing boats (DoF, 2018; Khaing et al., 2018). Especially in the Ayeyarwady region, many small-scale fishers rely heavily on hilsa catch for their income (Soe et al., 2018).

1.1 The sustainability of hilsa fishing

There are growing concerns regarding the sustainability of Myanmar's hilsa fishery. While the total life span of hilsa is up to six years, most hilsa are caught at two years or younger (Hossain et al., 2019). This trend is likely due to recent high levels of exploitation. Exploitation rates (the proportion of mortality caused by fishing) have increased significantly from 0.37 to 0.81 since 2012 (Hossain et al., 2019). Primary factors believed to contribute to this trend include overfishing, the use of small-mesh nets and habitat destruction, with water pollution and climate change exacerbating the problem (Khaing et al., 2018).

Policy options to improve the sustainability of hilsa fishing in Myanmar include incentive-based conservation schemes. These are similar to 'payments for ecosystem services' schemes, which are voluntary transactions between ecosystem service beneficiaries and ecosystem service suppliers that are in the best interest of both parties. However, instead of relying entirely on voluntary participation, schemes may provide economic incentives for abiding by existing and new fishing regulations; the compensation of losses due to regulatory measures are expected to be more cost-effective and acceptable than enforcing those measures. The government of Bangladesh has implemented this type of incentive-based scheme to improve hilsa shad fisheries in the Bay of Bengal, providing fishers with in-kind payments of food and support for alternative income generation during fishing ban periods (Islam et al., 2016a; Islam et al., 2016b).

1.2 Choice experiments

Understanding participants' preferences and compensation needs is pivotal to ensuring their acceptance and, consequently, the scheme's effectiveness. Among the methodological tools available to assess potential participants' attitudes and preferences in incentive-based schemes, 'choice experiments' are increasingly widely used (Villanueva, Glenk and Rodríguez-Entrena, 2017; Hanley and Czajkowski, 2019). A choice experiment is a survey-based tool to elicit preferences that asks respondents to make choices between various alternatives. For environmental incentive-based schemes, the alternatives are often hypothetical conservation agreements between participants and a governing institution. Agreements typically include changes to natural resource management, important contractual terms such as contract length or monitoring by the implementing authority, and monetary and in-kind payments. Prospective participants are assumed to only choose one of the agreements on offer, if they expect the compensation to be more than the income they will forgo under the given contractual terms. Respondents have the option, where none of the agreements are expected to yield them net benefits, to indicate that they would not participate with any of the agreements shown.

There are three benefits to using choice experiments to inform the design of incentive-based schemes. First, decision makers learn important information on the relative importance of contractual terms in scheme participation. Second, decision makers are provided with information on participants' compensation needs under varying contractual terms. Third, decision makers can infer likely participation rates depending on contractual terms. All three aspects are important factors driving the efficiency and effectiveness of incentive-based schemes.

Choice experiment studies with prospective participants of incentive-based schemes can also help reveal how perceptions of the importance of contractual terms, compensation needs and stated participation differ across the surveyed population. This knowledge may be used to align the design of schemes with local conditions and individual preferences (Costedoat et al., 2016). Of concern here may be, for example, different preferences for the type of incentive (monetary, in-kind, individual vs. collective) among socioeconomic strata of the population, or differences in preferences for management prescriptions across geographical areas (Bladon et al., 2018).

1.3 A choice experiment study in the Ayeyarwady Delta

This report summarises research that SRUC's Sustainable Ecosystems team was commissioned to do as part of the Darwin-Hilsa[MM] project "Carrots and sticks: incentives to conserve hilsa fish in Myanmar" led by the International Institute for Environment and Development (IIED) and funded through the UK government's Darwin Initiative. The research comprised of supporting the design, implementation and analysis of a choice experiment study conducted with fishing communities in four townships within the Ayeyarwady Delta region of Myanmar. It was part of an effort to identify opportunities for incentive-based schemes for the conservation of hilsa shad fisheries. The research was undertaken in close collaboration with project partners and groups in Myanmar including the WorldFish Centre, Department of Fisheries (DoF), Yangon University and Network Activities Group (NAG). The study contributes to an improved understanding of the socioeconomics of hilsa fishing and complements earlier survey research aimed at socioeconomic benchmarking of fishing communities in the Ayeyarwady Delta by Khaing et al. (2018).

The report is structured as follows: Section 2 provides an overview of the choice experiment design and the data collection and analysis process. Section 3 presents the modelling results and notes from the field. Section 4 concludes with key policy recommendations.

2 Methods

2.1 Choice experiment design

A crucial step in the design of any choice experiment study is selecting the 'attributes' that characterise the hypothetical conservation agreements that participants will need to choose between. In this study we consider: what changes to hilsa fishery management would be suggested to the prospective participants; what type and level of incentive would be offered, and what kind of payment vehicle; and when and how incentives would be paid. Ideally, management changes included in the choice experiment should rest on solid scientific evidence for their effectiveness in improving hilsa sustainability. However, apart from recent work on spawning seasonality that was not available at the time of the study design (Bladon et al., 2019), there is limited information in Myanmar on hilsa ecology – and virtually no specific evidence on the effectiveness of management interventions. Selecting appropriate management changes to facilitate hilsa conservation was therefore largely based on the expert opinion of local partners and the experience of previous incentive-based schemes for hilsa conservation in Bangladesh (Islam et al., 2016a; Bladon et al., 2018).

The following criteria guided the selection process:

- In the absence of firm evidence, there must a plausible mechanism for a management intervention to be effective.
- There must be credible means (at least in theory) to monitor compliance and enforce management interventions.
- It must be possible for management interventions to be implemented within the remit of the Department of Fisheries.
- The management intervention must not fundamentally threaten local livelihoods.
- The terms and conditions of the management interventions (scope, timing etc) can be clearly explained to respondents (fishers).

An initial list of options was compiled during a workshop in Edinburgh in April 2019 and further refined after consultation with local project partners, including the Myanmar Department of Fisheries (see Table 1).

Both monetary and in-kind compensation were considered. Amounts of monetary compensation were initially guided by data from the previous household survey to estimate forgone income, and adjusted after consultation with local project partners. For in-kind compensation, collective incentives were initially considered, such as a dedicated school boat service to improve the safety and reliability of children's journeys to school. Alternative income generating assets such as rickshaws, sewing machines or dairy cows were offered in the Bangladesh hilsa fish scheme (Islam et al., 2016a); however, these were dismissed by the local research team as they could overlap with other local support programmes and would be logistically challenging.

Table 1. Options for hilsa fishery management interventions identified for the choice experiment

MEASURE	MANAGEMENT PROBLEM ADDRESSED	DETAILED DESCRIPTION
Additional closure/ban to assist spawning	Fishing during spawning season	Current closure is from May to July to protect juvenile and brood fish. An additional ban between October and November/December would prevent fishing during a potential additional spawning season and thus help maintain and increase hilsa populations.[1]
Require nets with larger mesh size to protect juveniles	Catching juvenile fish	The current minimum net mesh size requirement is 4 inches, but anecdotal evidence suggests most fishers use smaller mesh sizes. This management change would require fishers to use nets with a larger mesh size than is commonly practised to enable more juvenile fish to escape the catch. Fishers would be required to use nets with a larger mesh size from October to December, and nets would be marked with a unique colour to help monitor compliance. Nets would be distributed by and returned to the local Department of Fisheries stations after use during these months.
Additional sanctuaries to protect juveniles	Catching juvenile fish	Total ban in marked areas in places that could serve as nursery grounds for juveniles (eg deposition areas with lower flow velocity).

A first version of the questionnaire was built around the attribute list in Table 1. It included:

1. A new fishing ban that would last for seven days in one, two or three months in the period October to December
2. New sanctuary spaces for juvenile hilsa that would be placed every 3, 6 or 9 miles along the river with a width of up to half the river, and
3. Requiring an increase of fishing net mesh to 4.5, 5 or 6 inches for three months of the year.

Compensation included monetary payments at six levels: US$ 30, 60, 100, 150, 200 and 300. In-kind compensation was also included in the form of a school ferry for the community to take school-aged children to and from school during the school year.

2.2 The final design

Following feedback from the IIED, WorldFish and NAG correspondents, the attributes and their levels were adjusted for the final survey, which was piloted in Maubin township on 26 and 27 June 2019 (see more details in Section 2.3). The final list of attributes and their levels are reported in Table 2, with detailed information on adjustments below.

The in-kind collective incentive, which initially included the school boat service, was discarded since it would involve complex cross-institutional and cross-ministerial arrangements and regulations. Instead, an in-kind payment in the form of rice compensation was proposed by project partners as it would ensure a direct benefit for the household and would be logistically feasible. However, there were challenges to describing this form of compensation, which involved specific types and qualities of rice; communicating the weight in units that made sense locally; and avoiding potential clashes with food support programmes established in the area after Cyclone Nargis in 2008.

[1] At the time of this study it was uncertain whether or not an additional spawning season takes place in November and December.

Table 2. Final list of attributes and attribute levels used in the choice experiment

ATTRIBUTE	LABEL	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 4
Additional periods of closure	CLOSE	No change	No fishing during *Thadingyut*[2] for 3 days before and 3 days after the full moon, for a total closure of 7 days	No fishing during *Thadingyut* and *Tazaungmon* for 3 days before and 3 days after the full moon in each month, for a total closure of 14 days	No fishing during *Thadingyut*, *Tazaungmon*, and *Natdaw* for 3 days before and 3 days after the full moon in each month, for a total closure of 21 days
Creation of sanctuaries	SANCT	No change	New sanctuary every 9 miles, maximum length 1 mile of river, up to half the width of river	New sanctuary every 6 miles, maximum length 1 mile of river, up to half the width of river	New sanctuary every 3 miles, maximum length 1 mile of river, up to half the width of river
Nets with 4.5-inch mesh required between *Thadingyut* and *Natdaw* (October to December)	NETS	No change	Ban on all other nets, only use nets distributed by DoF with 4.5-inch mesh during *Thadingyut*, *Tazaungmon* and *Natdaw*		
In-kind payment (rice)	RICE	No rice payment	1 *tinn**	2 *tinn*	3 *tinn*
Cash payment (MMK)**	CASH	75,000	150,000	250,000	350,000

Note: The levels of the 'No agreement' alternative were 'No change' in management attributes, and no rice and cash payments. **Tinn* is a Myanmar measure of volume commonly used for rice. The standard weight equivalent of 1 *tinn* ranges from 46 pounds (20.9kg) to 56 pounds (25.4kg). **MMK – Myanmar kyat, MMK 1,000 = US$ 0.7 in June 2019

The final survey design required units and measurements that are understood by small-scale fishers. Attributes referring to management changes therefore used inches and miles (as opposed to centimetres and kilometres). The survey used the Burmese lunisolar calendar, with clearly defined periods giving the full moon as the reference for closure periods. After consultation with local project partners, sanctuaries were defined as covering a maximum of one mile of river length, and up to half of the river width.

Cash payments were listed in Myanmar kyat (MMK). The range of cash payments was set from MMK 75,000 to 350,000 (US$ 53 to 248). The project partners considered the maximum cash payment to be high compared to the potential income lost through compliance with management changes.

The best local variety of rice was offered, *paw san* from Pyapon township or Shwe Bo township, in amounts of one, two or three *tinn* (a Myanmar measure of volume commonly used for rice). The standard weight equivalent of 1 *tinn* ranges from 46 pounds (20.9 kilograms) to 56 pounds (25.4kg), with prices ranging from MMK 1,125 to 1,475 per kilogram (US$ 0.8 to 1 per kilogram) . This has a market value of MMK 23,500 to 37,500 per *tinn* of rice (US$ 17 to 27 per *tinn* of rice).

An initial idea of adding an attribute to the survey about the timing of payments was dismissed, to make the choices less complex. Payments of both rice and money were specified as one-off payments once a year in the Burmese month of *Thadingyut* (the seventh month of the Burmese calendar, approximately

[2] *Thadingyut* is the seventh month of the Burmese lunisolar calendar, approximately coinciding with October in the Gregorian calendar. *Tazaungmon* is the eight month, approximately coinciding with November. *Natdaw* is the ninth month, approximately coinciding with December.

coinciding with October), one week before the Festival of Lights celebration. This was suggested to be a time of festivities such as marriages, when supplemental income could be perceived very useful. Respondents were informed that the Department of Fisheries (DoF) would hand out compensation in the form of rice at the nearest township. Monetary payments would also be distributed by the DoF; money could be collected at the township or administered by a mobile phone service such as Wave. Respondents were also informed that changes in rules for hilsa fishing, and compensation for fishers who adhere to the new rules, would be agreed through written agreements between fishers and the DoF.

To aid local respondents' understanding, a local artist provided drawings of aspects of management interventions. These were used alongside descriptions in the text to introduce the idea of hilsa fishery management changes and conservation agreements, and to describe the various choices. Simple graphical depictions of attribute levels also featured in the choice tasks in the survey. Respondents' literacy rate was expected to be high, but visual aids were still thought necessary to help people understand the management interventions and the choice tasks. Figure 1 shows an example graphic used to convey the idea of sanctuaries to protect juvenile hilsa.

Each choice task shown to respondents contained two alternatives representing hilsa conservation agreements. In addition to the two conservation agreement alternatives, a 'No agreement' alternative was added to the choice tasks. Respondents were therefore asked to choose between two hilsa conservation agreements with varying attributes and levels, or non-participation indicated by 'No agreement'. An experimental design was used to create the combinations of attributes and levels in each of the conservation agreements in the choice tasks to be shown to respondents. For a more detailed explanation of the experiment design see Appendix 1.

The final choice experiment design included 36 choice tasks in six blocks, so that each respondent had six choice tasks. We designed it so that at least one of the two management alternatives shown in each choice task required a change from the current status quo, in return for in-kind or monetary compensation. We then tested the design using pre-tests and a small pilot in a village in the Maubin township area. An example of the choice tasks is shown in Figure 2.

We considered it important to include an example choice task at the start of the choice experiment section of the survey to enable participants to understand the information in the choice tasks, even though this could

Figure 1. Artist's impression of sanctuaries to protect juvenile hilsa

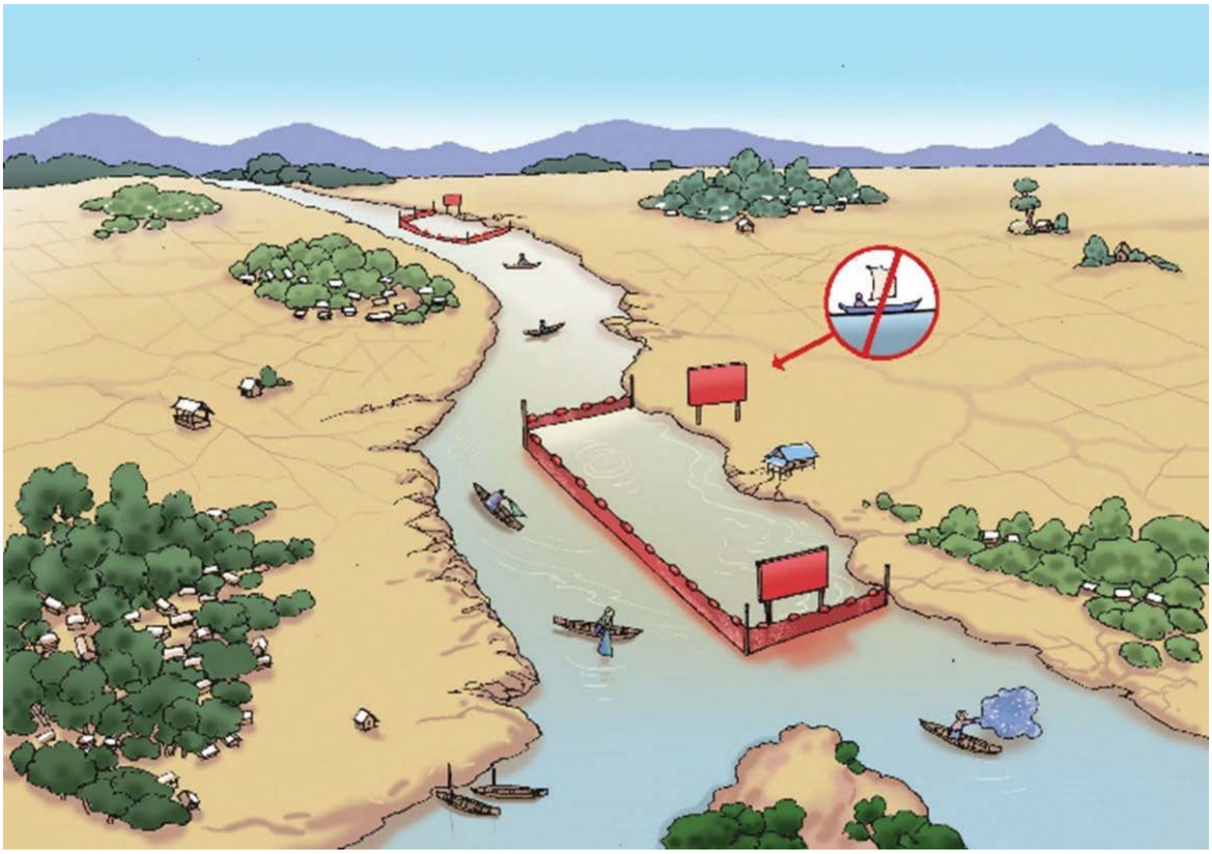
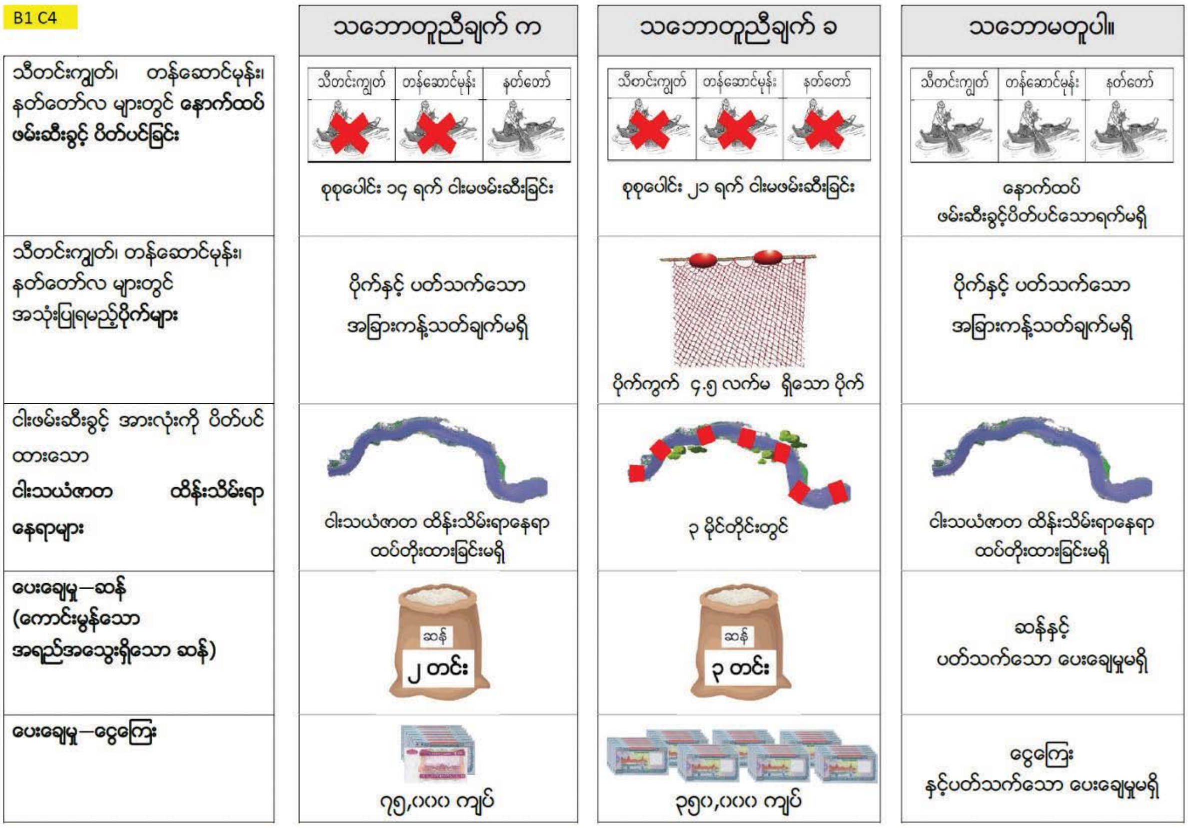


Figure 2. Example choice task



introduce some bias in their decisions (Meyerhoff and Glenk, 2015). If respondents were unable to make a choice in this example task, the interviewers repeated the explanation. Before answering the series of six choice tasks, respondents were reminded to carefully consider the trade-offs between payments and management changes, and the implications for their household, including in terms of income. Respondents were also explicitly reminded to only opt for the offered conservation agreements if they were willing to comply with the proposed management changes, given the level of compensation stated in the agreements.

2.3 Overall questionnaire structure

The questionnaire started with collecting some basic information about respondents, being mindful of the aim to re-interview fisher households previously included in the socioeconomic survey (Khaing et al., 2018; see Section 2.5). This was followed by a step-by-step introduction of each attribute (such as the fishing ban periods), interspersed with related questions on respondents' concerns about hilsa, their awareness of spawning periods, their use of nets and the distance they live from fishing grounds. Following the choice tasks, the questionnaire finishes with a series of questions on respondents' perceived life satisfaction and decision making in the household.

This report focuses on results of the choice experiment and differences in preferences and compensation needs by area (township), social class and gender. Social class is an indicator used previously by the Khaing et al. (2018) survey to allocate respondent households to one of four classes constructed by the Network Activities Group. Social Class 1 is *Chan Thar* ('better off'); 2 is *Ah Lae Ah Latt* ('middle class'); 3 is *Nwan Par* ('poor'); and 4 is *Ah Lon Nwan Par* ('very poor'). Households in the 'better off' class were described as not having concerns about daily survival with a generally higher standard of living and access to alternative livelihoods, while households classified as 'very poor' struggle for their daily survival and have many dependents (Khaing et al., 2018).

2.4 Econometric approach

The choice data was analysed using a 'mixed logit model', a statistical model for examining discrete choices, to investigate respondents' 'willingness to accept' (WTA). WTA is a measure of the minimum amount that a person is willing to accept in compensation for accepting something that is perceived as negative, such as income forgone from adhering to management restrictions. A detailed description of the econometric approach is provided in Appendix 2.

2.5 Sampling and implementation

A total of 381 households were surveyed in four townships of the Ayeyerwady Delta: Ngapudaw, Maubin, Mawlamyinegyun and Labutta, in July, October and November 2019. The surveying period in July 2019 included a pilot in the township of Maubin followed by main data collection in this township. The remaining townships were surveyed between October and November 2019 due to ease of access to villages at the end of the rainy season. Within the four townships, villages were selected for the choice experiment survey based on ease of travel and access during the monsoon season. Selected villages were either accessible via the main road or by car, motorbike or motorboat, and required less than one day of travel. This was mostly due to the timing of the survey, as some of the villages included in the socioeconomic survey were difficult to reach during monsoon season. Figure 3 shows the distribution of surveyed villages within the Ayeyarwady Delta.

Where possible, respondents were chosen to overlap with households that had participated in a household survey conducted in April 2018 (Khaing et al., 2018). Respondents to the Khaing et al. socioeconomic survey had been selected using 'purposive sampling', by asking village leaders to select diverse hilsa fishing households based on social class, location in the village and social networks, among other criteria. If previous respondents or households were unavailable they were replaced. For example, if respondents had moved to Yangon they were replaced by other household members, or if members of the household were unavailable for longer periods of time due to longer fishing explorations they

Figure 3. Location of townships and villages surveyed in the Ayeyarwady Delta

Source: https://earthshots.usgs.gov/earthshots/. The map showing village locations was based on Google Maps were replaced by other fishing households in the same villages. New respondents were added if a target of 18 respondents per village could not be achieved through surveying previous households. Fishing households that were not in the earlier socioeconomic survey were chosen in consultation with the village head. The key criterion for inclusion in the survey was that the new household was heavily involved in fishing. Apart from Maubin, which was the pilot study area and had focused on fishers rather than gender, there was a focus on including female respondents in the townships to better represent their preferences in the overall sample. In general, women in the villages are more engaged with domestic affairs, education and selling fish, while men are more likely to engage in fishing and boat and gear repair (Khaing et al., 2018).

Data collection was conducted by a team of interviewers from NAG: four interviewers in Maubin township and six in the other three townships. Before the fieldwork, all the interviewers took part in a two-day training workshop to introduce them to choice experiments and to run through the questionnaire in detail. The training also covered good interview practice and included role play to practise delivering the survey. The training also served to refine the survey, based on feedback from interviewers and other staff from NAG who attended the workshop. The interviewer team were instructed to give respondents a detailed description of the reasoning behind the programme and the policies being offered. They then asked respondents for verbal consent, which was recorded before proceeding with the rest of the survey.

3

Results and discussion

3.1 Sample characteristics

An overview of the sampled households' characteristics is given in Table 3. A large proportion of households had participated in the previous socioeconomic household survey (Khaing et al., 2018). Mawlamyinekyun and Labutta township surveys achieved a higher rate of female respondents, with over 30%, than Maubin and Ngawpudaw. In terms of social class, Mawlamyinekyun and Labutta townships had a larger proportion of poorer households (4 being the poorest) with more dependency on fishing (Khaing et al., 2018) than Maubin and Ngawpudaw.

3.2 Model results: full sample

Table 4 reports the mixed logit model results for the full sample (for comparison, Table A1 in Appendix 2 shows the results of a model with continuously coded non-monetary attributes). The estimate of the alternative specific constant (ASC)[3] associated with the 'No agreement' alternative, 0.765, is large and significantly different from zero at the 5% level. In other words, a considerable proportion of respondents selected a conservation agreement – rather than no agreement – more frequently than predicted if only information from attributes is used.

Table 3. Distribution of respondents by township: previous survey participation, gender, social class

	MAUBIN	NGAWPUDAW	MAWLAMYI-NEKYUN	LABUTTA
Surveyed households who participated in previous survey* (%)	78.26	84.44	83.33	80.68
Female (%)	13.04	12.22	36.67	30.68
Social Class 1 (%)	0.87	4.44		1.14
Social Class 2 (%)	43.48	43.33	21.11	11.36
Social Class 3 (%)	49.57	37.78	51.11	28.41
Social Class 4 (%)	6.09	14.44	27.78	59.09
Number of respondents	115	90	90	88

Note: *Khaing et al. (2018). Social classes are defined as 1 – better off; 2 – middle class; 3 – poor; and 4 – very poor

[3] The ASC is a constant term added to capture the systematic influence that alternatives may have on respondents' choice that is not captured by information coming from attributes.

Across the sample, there was a low rate of choice for the 'No agreement' alternative (11% of all choices). This may be indicative of a true desire for change. However, such an interpretation should be treated with caution, because the possibility of some form of 'cultural bias' (cultural ways of expressing consent or dissent) cannot be denied. Such forms of behaviour were found in previous stated preference studies in Southeast Asia (eg Whittington, 1998) and may be underpinned by cultural norms. Another interpretation relates to respondents' perceptions of the expected benefits of *any* hilsa conservation programme, irrespective of compensation. For example, some respondents may have perceived the 'No agreement' option as 'missing a chance' to obtain some general financial support for their livelihoods. This may have led to a propensity not to select the 'No agreement' alternative, even if the respondent did not judge as favourable the trade-offs between compensation payments and management changes. The relatively large magnitude (in WTA terms) of the ASC may also be due to the limited influence of the compensation amounts on people's choices.

Closures

In terms of the suggested closures (fishing bans) in addition to the one already in place between May and July, the results make intuitive sense. The estimate for longer closures (eg CLOSE_21) is negative and of a greater magnitude compared to shorter closures. This can be explained by the fact that longer closures are associated with less access to the fishing grounds and therefore greater need for compensation. It is interesting that the estimate for a 7-day closure is not statistically significant. This closure would take place around the main festival in October, where fishers may be more heavily engaged in non-fishing activities and therefore may perceive the additional closure in this period less likely to reduce potential income from fishing. The data suggest that a closure in this period would therefore represent a relatively widely accepted management option that would not require much compensation. It is noteworthy that there is a considerable variation in preferences for a 21-day closure (split across three months). This suggests that compensation needs vary considerably: a 21-day closure has a low level of acceptance for some, while it is more acceptable for others.

Required net mesh size

Changes to fishing net use had a very strong influence on choices made by respondents. This confirms findings from our earlier pre-test and reports from the field and suggests that the restriction on fishing nets faces a large degree of opposition; and would require the largest compensation amount. It is possible that, for some respondents, having a larger mesh net was deemed entirely unacceptable. Changes in mesh size

Table 4. Results of mixed logit model of willingness to accept each attribute, full sample

ATTRIBUTE	WTA ESTIMATE	STANDARD ERROR	
Mean			
ASC_NA	−0.765	0.137	**
CLOSE_7	0.101	0.209	
CLOSE_14	−0.569	0.248	**
CLOSE_21	−1.041	0.291	**
NETS	−0.341	0.048	**
SANCT_3	−0.570	0.273	**
SANCT_6	−0.094	0.243	
SANCT_9	0.344	0.229	
RICE_1	−0.015	0.215	
RICE_2	0.363	0.217	*
RICE_3	0.233	0.267	
CASH[a]	0	–	
Standard deviation			
ASC_NA	−0.621	0.104	**
CLOSE_7	0.086	0.535	
CLOSE_14	−0.008	0.460	
CLOSE_21	−2.434	0.537	**
NETS	0.593	0.106	**
SANCT_3	1.277	0.458	**
SANCT_6	0.034	0.528	
SANCT_9	−0.674	0.498	
RICE_1	0.031	0.472	
RICE_2	0.068	0.567	
RICE_3	0.645	0.700	
CASH	0.694	0.115	
Number of individuals	383		
Number of observations	2,297		
LL (final)	−1,635.001		
Rho-square (0)	0.352		

Notes: **Significant at 5% level; *Significant at 10% level; [a]fixed to zero to constrain triangular distribution to positive domain; ASC_NA – alternative specific constant associated with "No agreement"; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; CASH – money as compensation; LL – value of the log-likelihood function requirements would therefore have to be highly effective compared to other conservation methods to be worth taking forward initially. Further in-depth exploration is needed of the reasons for opposition to this change.

Sanctuaries

For the proposal of sanctuary areas to protect juvenile hilsa, the results in Table 4 suggest that respondents would have less need for compensation the further apart the sanctuaries were placed. In other words, fishers are less concerned about sanctuaries when they are placed further apart. In line with field reports, respondents show the most concern about sanctuaries being placed as close as three miles from each other, primarily because this could interfere with the prevalent fishing practice of drift netting (Leadbitter, 2017). Like the seven-day closure in October, there is a considerable degree of variation that may arise from differences in local fishing practices and the resulting differences in how fishers perceive the implications of closely spaced sanctuaries. On average, there appears to be no compensation need for sanctuaries spaced at a greater distance, particularly if they are nine miles apart. Therefore, sanctuaries spaced at an acceptable distance, taking into account primary fishing grounds' proximity to villages, could be a promising management measure to explore. This is similar to Bangladeshi fishers' perceptions of sanctuary spaces, where 80% of respondents stated that they perceive sanctuaries as acceptable (Islam et al., 2016b). Some fishers are already attempting to use sanctuary spaces within their own communities; fishers from Hta Ni Daunt in Maubin township reported three areas that they as a community do not use for fishing, in order to protect the available stocks. These areas are close to the village, all approximately one mile in length, and are along sand banks where juveniles are located.

Rice as compensation

None of the estimates for in-kind (rice) compensation is statistically significant, suggesting a high degree of indifference, even though fishers may have been expected to prefer to have more rice than less. Standard deviation terms are also not significant, suggesting a limited variation in respondents' preferences. It is unclear what exactly underpinned this result. One reason may be that the amounts offered were, on average, perceived as insufficient to trigger a response – possibly because current and expected rice supplies may be good. The underlying reasons could be further validated in the field; and alternative forms of in-kind compensation explored through discussion and rapid appraisals with different strata (social class, gender) of fishers.

Cash as compensation

The WTA estimate for the cash compensation is significant and positive, suggesting that on average larger amounts of monetary compensation increased the likelihood that fishers chose a conservation agreement. Reports from the field (see more below) suggest that at least some of the fishers perceived the amounts of cash compensation to be too low compared to the income they expected to forgo from abiding by the management changes specified in the hypothetical conservation agreements. Together with a low degree of choice of the 'No agreement' alternative, this may indicate that some respondents have ignored information on cash compensation when making their choices. This is known as 'attribute non-attendance' and would result in an upwards bias of willingness to accept estimates (eg Scarpa et al., 2009; Glenk et al., 2015). It should therefore be taken into account when interpreting the estimates for policy purposes.

Table 5 shows estimates of mean marginal willingness to accept per household and year for the various survey attributes. The perceived need for compensation is highest for the proposed change to nets with a lower mesh size, followed by the proposed additional closed period of 21 days over three months. The next highest level of required compensation is for a closed period of 14 days and the establishment of sanctuary areas spaced every three miles, which are both of a similar magnitude.

Table 5. Mean marginal willingness to accept attributes, full sample model

ATTRIBUTE	WTA PER HOUSEHOLD AND YEAR (IN MMK 1,000)*
CLOSE_7	n.s.
CLOSE_14	56.92
CLOSE_21	104.06
NETS	340.70
SANCT_3	57.03
SANCT_6	n.s.
SANCT_9	n.s.
RICE_1	n.s.
RICE_2	n.s.
RICE_3	n.s.

Note: *in other words, compensation required for management change; n.s. – not significantly different from zero at the 5% level; WTA – willingness to accept; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; *MMK 1,000 = US$0.7 (average exchange rate June 2019).

3.3 Model results: by township

The data was also analysed separately by township. The results of this analysis are shown in Table 6 and an overview of marginal willingness to accept estimates is provided in Table 7. There were issues with the convergence of the 'willigess to accept' space model for Ngawpudaw, so data for this township was analysed in 'preference' space. This analysis reveals that the estimate for monetary compensation was not significantly different from zero – in other words respondents were indifferent to changes in monetary compensation – which meant that the willingness to accept for changes in management attributes or in-kind compensation could not be estimated. Field observations by the survey team confirm that respondents in this township paid little attention to in-kind or monetary compensation, because their estimated earnings from fishing exceed the offered level of compensation for the proposed fishing restrictions. In terms of preferences for management changes, the results also confirm observations from the field that fishers were most concerned about using nets with larger mesh size, that they would accept a fishing ban in the month of October but not other months, and that they are indifferent to sanctuary areas that are placed every 6 or 9 miles of river length. Some fishers, however, were concerned about closely spaced sanctuaries (every 3 miles) in case these areas overlapped with fishing grounds.

Results are qualitatively similar for Mawlamyinekyun and Labutta townships, except that on average respondents were responsive to the various amounts of monetary compensation offered. Interestingly, fishers in Mawlamyinekyun seem to particularly welcome sanctuary areas placed every 9 miles, as the negative WTA estimate for this attribute level suggests – in other words, fishers may perceive some sanctuaries as beneficial and thus not require additional compensation. Some fishers in Mawlamyinekyun also reported that the greatest monetary compensation offered in the choice experiment is insufficient. They suggested that compensation should be in the area of MMK 450,000 or 500,000 for closed periods of 21 days spanning three months, because these months are very profitable, with earnings of between MMK 150,000 and 200,000 (US$ 106 to US$ 142) for seven days of fishing. Similar statements were made by fishers in Labutta township.

Results for Maubin township are qualitatively similar to results for the full sample of management changes: closures in October are accepted without additional compensation needs, while additional closed periods in November and December would require compensation. Only sanctuary areas that are placed close together would be a concern that required compensation. In line with results across other townships, changes to a smaller mesh size net are perceived to be the most problematic, drawing the greatest compensation requirements. There is a major difference in the response of Maubin township's interviewees to in-kind compensation in the form of rice. Estimates are significantly different from zero for two and three

Table 6. Mean marginal willingness to accept attributes, by township

	MAUBIN	MAWLAMYINEKYUN	LABUTTA
ATTRIBUTE	WTA PER HOUSEHOLD AND YEAR (IN MMK 1,000*)		
CLOSE_7	n.s.	n.s.	n.s.
CLOSE_14	104.79	n.s.	n.s.
CLOSE_21	182.05	n.s.	n.s.
NETS	237.60	421.74	190.27
SANCT_3	87.32	n.s.	n.s.
SANCT_6	n.s.	n.s.	n.s.
SANCT_9	n.s.	–104.80	n.s.
RICE_1	n.s.	n.s.	n.s.
RICE_2	–73.13	n.s.	n.s.
RICE_3	–77.95	n.s.	n.s.

Notes: n.s.: not significantly different from zero at the 5% level; WTA – willingness to accept; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; *MMK 1,000 = US$0.7 (average exchange rate June 2019).

Table 7. Results of mixed logit models, by township

	MAUBIN			NGAWPUDAW[B]			MAWLAMYINEKYUN			LABUTTA		
ATTRIBUTE	WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR	
Mean												
ASC_NA	−0.885	0.281	**	−0.425	0.100	**	−0.796	0.293	**	−0.373	0.127	**
CLOSE_7	0.419	0.339		0.072	0.367		0.404	0.527		−0.122	0.254	
CLOSE_14	−1.048	0.325	**	−0.956	0.469	**	0.297	0.720		0.403	0.479	
CLOSE_21	−1.821	0.428	**	−0.855	0.536		−0.768	0.681		0.649	0.675	
NETS	−0.238	0.050	**	−0.273	0.085	**	−0.491	0.156	**	−0.190	0.049	**
SANCT_3	−0.873	0.345	**	−0.263	0.493		−0.422	0.654		−0.345	0.407	
SANCT_6	−0.263	0.341		−0.035	0.397		−0.018	0.572		0.116	0.359	
SANCT_9	0.043	0.311		0.027	0.331		1.048	0.626	*	0.459	0.323	
RICE_1	0.361	0.289		−0.246	0.327		−0.752	0.681		0.055	0.286	
RICE_2	0.731	0.307	**	0.322	0.373		−0.111	0.653		0.045	0.327	
RICE_3	0.780	0.335	**	0.157	0.458		−0.398	0.736		−0.095	0.409	
CASH[a]	0.000	–		0.000	–		0.000	–		0.000	–	
Standard deviation												
ASC_NA	0.978	0.282	**	0.335	0.084	**	0.345	0.143	**	−0.251	0.090	**
CLOSE_7	0.022	0.642		0.696	0.903		−0.013	0.837		0.025	0.386	
CLOSE_14	0.008	0.438		0.034	0.964		−0.150	1.155		−0.024	0.622	
CLOSE_21	1.744	0.696	**	−1.131	0.639	*	2.718	1.181	**	−2.199	0.729	**
NETS	−0.358	0.106	**	−0.494	0.105	**	−0.810	0.291	**	−0.369	0.100	**
SANCT_3	0.461	1.014		1.634	0.640	**	1.591	0.949	*	1.230	0.541	**
SANCT_6	−0.001	0.453		−1.349	0.606	**	0.045	2.129		0.010	0.336	
SANCT_9	−0.076	0.866		1.021	0.674		−0.102	1.452		−0.001	0.386	
RICE_1	0.022	0.642		0.062	1.192		0.568	1.665		−0.358	0.727	
RICE_2	−0.009	0.635		0.082	1.006		1.529	0.856	*	0.028	0.478	
RICE_3	−0.509	1.158		−1.048	0.660		−0.183	1.645		−0.242	0.807	
CASH	0.753	0.199	**	0.311	0.233		0.707	0.259	**	1.191	0.302	**
Number of individuals	115			90			90			88		
Number of observations	690			539			540			528		
LL (final)	−506.914			−389.867			−338.36			−338.464		
Rho-square (0)	0.331			0.342			0.43			0.417		

Note: All models in WTA space except for the Ngawpudaw model, which is estimated in preference space; ** Significant at 5% level; * significant at 10% level; [a] fixed to zero to constrain triangular distribution to positive domain; [b] model in preference space. ASC_NA – alternative specific constant for 'No agreement'; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; CASH – money as compensation; LL – value of log-likelihood function *tinn* of rice being offered as part of conservation agreements, suggesting willingness to accept some in-kind compensation. In monetary terms, respondents of Maubin township value compensation in the form of rice between MMK 73,000 (US$ 52) for two *tinn* of rice (RICE_2) and MMK 78,000 (US$ 55) for three *tinn* of rice (RICE_3). Both estimates are within the range of market value for the type of rice on offer, which ranges between MMK 23,500 (US$ 17) and 37,500(US$ 27) per *tinn*. This indicates that there is no particular advantage for institutions governing an incentive-based conservation scheme to use in-kind compensation rather than money as compensation.

3.4 Model results: by social class

In terms of differences in preferences and willingness to accept across social class, model results shown in Table 8 and WTA estimates shown in Table 9 indicate qualitatively similar results. However, there are differences in estimates of willingness to accept, for additional closed periods.

For 'better off' and 'middle class' respondents (Social Class 1 and 2), willingness to accept estimates for 14-day and 21-day closures are statistically significant, meaning that households in these groups require some compensation amount in return for the implementation of these closures. A 21-day closure attracts significant compensation needs for 'poor' (Social Class 3). None of the willingness to accept estimates for closed periods is significantly different from zero for 'very poor' respondents (Social Class 4). Coefficients for closely spaced sanctuaries (every three miles) are all negative but not significantly different from zero, in other words respondents were not concerned about these measures, but there is significant heterogeneity around the mean for 'poor' respondents. This means that acceptability of these measures varies greatly across members of this social class. Preferences for in-kind compensation as part of conservation agreements may be expected to differ depending on social class; less wealthy households may be expected to show a greater demand for additional in-kind compensation. However, only one coefficient (two *tinn* of rice) is significant for 'better off' and 'middle class' respondents across all three models, confirming an overall limited interest in rice as a form of in-kind compensation.

The differences between social classes are difficult to explain. Fishers in the poor and very poor classes (3 and 4) also spend more hours during the day fishing than the higher social classes (Khaing et al., 2018), suggesting that a change in net mesh size could potentially further increase the amount of time they must spend fishing during the day, possibly beyond acceptable limits. This may explain the stronger focus of poorer households on changes in net size.

Table 8. Mean marginal willingness to accept attributes, by social class

	SOCIAL CLASS 1 AND 2	SOCIAL CLASS 3	SOCIAL CLASS 4
ATTRIBUTE	WTA PER HOUSEHOLD AND YEAR (IN MMK 1,000)*		
CLOSE_7	n.s.	n.s.	n.s.
CLOSE_14	116.64	n.s.	n.s.
CLOSE_21	142.57	99.04	n.s.
NETS	349.90	360.8	283.70
SANCT_3	n.s.	n.s.	n.s.
SANCT_6	n.s.	n.s.	n.s.
SANCT_9	n.s.	n.s.	n.s.
RICE_1	n.s.	n.s.	n.s.
RICE_2	-86.58	n.s.	n.s.
RICE_3	n.s.	n.s.	n.s.

Note: WTA – willingness to accept; n.s. – not significantly different from zero at the 5% level; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; *MMK 1,000 = US$0.7 (average exchange rate June 2019).

Table 9. Model results of mixed logit models of willingness to accept attributes, by social class

	SOCIAL CLASS 1&2			SOCIAL CLASS 3			SOCIAL CLASS 4		
	WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR	
Mean									
ASC_NA	−0.874	0.299	**	−0.669	0.175	**	−0.730	0.243	**
CLOSE_7	0.213	0.426		0.420	0.348		−0.489	0.332	
CLOSE_14	−1.166	0.442	**	−0.359	0.374		−0.037	0.539	
CLOSE_21	−1.426	0.533	**	−0.990	0.425	**	−0.570	0.660	
NETS	−0.350	0.094	**	−0.361	0.075	**	−0.284	0.076	**
SANCT_3	−0.829	0.518		−0.464	0.387		−0.376	0.493	
SANCT_6	−0.460	0.457		−0.151	0.346		0.434	0.475	
SANCT_9	−0.076	0.418		0.373	0.330		0.739	0.481	
RICE_1	0.370	0.376		0.048	0.313		−0.567	0.473	
RICE_2	0.866	0.410	**	0.046	0.363		0.402	0.375	
RICE_3	0.455	0.488		0.403	0.376		−0.345	0.545	
CASH[a]	0.000	–		0.000	–		0.000	–	
Standard deviation									
ASC_NA	0.801	0.253	**	−0.528	0.125	**	0.545	0.173	**
CLOSE_7	0.024	1.156		0.374	1.231		−0.020	0.622	
CLOSE_14	−0.006	1.126		−0.024	0.480		0.107	1.185	
CLOSE_21	−2.340	1.006	**	2.198	0.752	**	3.325	1.086	**
NETS	0.618	0.212	**	−0.588	0.147	**	0.526	0.167	**
SANCT_3	1.546	0.965		−1.168	0.610	*	1.033	0.794	
SANCT_6	0.103	1.345		−0.016	0.607		−0.038	0.762	
SANCT_9	−0.933	0.833		0.250	1.152		−0.895	0.685	
RICE_1	0.023	0.685		0.167	0.769		−0.247	1.816	
RICE_2	0.087	1.385		−0.008	0.837		−0.026	1.012	
RICE_3	0.014	1.233		1.009	0.765		−0.133	1.108	
CASH	0.602	0.195	**	0.774	0.187	**	0.822	0.245	**
Number of individuals	124			162			97		
Number of observations	744			971			582		
LL (final)	-544.719			-671.797			−399.372		
Rho-square (0)	0.334			0.370			0.375		

Notes: ** Significant at 5% level; * significant at 10% level; [a] fixed to zero to constrain triangular distribution to positive domain. ASC_NA – alternative specific constant for 'No agreement'; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; CASH – money as compensation; LL – value of log-likelihood function

3.5 Model results: by gender

Model results based on gender (male/female) are reported in Table 10 and associated mean marginal willingness to accept estimates in Table 11. Apart from changes in nets, none of the mean WTA estimates for management changes or in-kind compensation are significantly different from zero for female respondents. For male respondents, WTA estimates for longer closures (14 and 21 days), changes in net mesh size and closely spaced sanctuary areas (3 miles apart) are significantly different from zero and slightly higher in magnitude than those for the full sample.

Table 10. Results of mixed logit models in willingness to accept attributes, by gender

	FEMALE			MALE		
ATTRIBUTE	WTA ESTIMATE	STANDARD ERROR		WTA ESTIMATE	STANDARD ERROR	
Mean						
ASC_NA	−0.527	0.198	**	−0.883	0.200	**
CLOSE_7	0.236	0.376		0.090	0.263	
CLOSE_14	0.217	0.526		−0.901	0.295	**
CLOSE_21	0.127	0.623		−1.489	0.371	**
NETS	−0.216	0.061	**	−0.397	0.073	**
SANCT_3	0.008	0.508		−0.830	0.317	**
SANCT_6	−0.062	0.417		−0.155	0.296	
SANCT_9	0.569	0.399		0.289	0.294	
RICE_1	−0.513	0.444		0.169	0.250	
RICE_2	0.213	0.400		0.370	0.276	
RICE_3	0.278	0.431		0.121	0.361	
CASH[a]	0.000	–		0.000	–	
Standard deviation						
ASC_NA	−0.569	0.180	**	0.651	0.140	**
CLOSE_7	−0.034	0.714		−0.045	0.595	
CLOSE_14	0.019	0.526		−0.028	0.614	
CLOSE_21	−1.139	0.635	*	3.090	0.873	**
NETS	0.419	0.128	**	0.679	0.159	**
SANCT_3	1.043	0.637		−1.124	0.656	*
SANCT_6	−0.004	0.843		−0.031	0.640	
SANCT_9	−0.062	0.800		−0.693	0.607	
RICE_1	−0.003	0.395		0.100	0.912	
RICE_2	−0.726	0.744		0.001	0.593	
RICE_3	0.001	0.843		−0.807	0.806	
CASH	0.946	0.264	**	0.615	0.134	**
Number of individuals	82			299		
Number of observations	492			1793		
LL (final)	−337.415			−1276.512		
Rho-square (0)	0.376			0.352		

Notes: ** Significant at 5% level; * Significant at 10% level; [a] fixed to zero to constrain triangular distribution to positive domain; ASC_NA – alternative specific constant; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; CASH – money as compensation; LL – value of log-likelihood function

A direct comparison between results for male and female respondents is difficult. The subsample of female respondents is smaller than the subsample of male respondents. This decreases the likelihood of observing whether or not attributes had a significant influence on the choice between conservation agreements, and therefore that coefficients would be significantly different from zero. However, the differences in preferences may also be due to the disparity in labour practices between men and women within the fish supply chain. While women in the villages tend to be more engaged in repairing nets and selling fish, men are more likely to engage more in fishing and boat repair (Khaing et al., 2018). Thus, while there is a lack of female participation in traditional fisher roles, their representation in the larger supply chain is not insignificant. Notably, there is no difference in preferences for in-kind compensation between male and female respondents.

Table 11. Mean marginal willingness to accept attributes, township models

	FEMALE	MALE
ATTRIBUTE	WTA PER HOUSEHOLD AND YEAR (IN MMK 1,000*)	
CLOSE_7	n.s.	n.s.
CLOSE_14	n.s.	90.13
CLOSE_21	n.s.	148.87
NETS	215.75	397.26
SANCT_3	n.s.	83.02
SANCT_6	n.s.	n.s.
SANCT_9	n.s.	n.s.
RICE_1	n.s.	n.s.
RICE_2	n.s	n.s.
RICE_3	n.s.	n.s.

Note: WTA – willingness to accept; n.s. – not significantly different from zero at the 5% level; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*.* MMK 1,000 = US$ 0.7, exchange rate for June 2019.

3.6 Notes from the field

This section summarises further impressions and information gathered during the course of the fieldwork. It collates some anecdotal evidence that provides perspective for the choice experiment results, but also points to additional areas of interest that might warrant attention for designing and implementing an incentive-based hilsa conservation scheme in the region.

Alternative income generation

The first thing to note is that paddy cultivation is the main alternative livelihood for fishers in all townships surveyed. In addition, in one of the villages in Labutta township most people also cultivate mung beans. This has led to the decline in fish catches, due to the use of agrochemicals in the farmland area near fishing grounds. Apart from farming, net and mat weaving are alternative livelihoods, particularly for women, in some villages of Mawlamyinekyun township. In Ngapudaw and Labutta township respondents mentioned migration to Yangon or neighbouring countries, such as Malaysia and Thailand, as an alternative way of earning a livelihood.

Awareness of hilsa stocks

Interviewers noted that most fishers have perceived a decline in stock over the last decade. Respondents linked this to multiple causes, including an increase in the number of fishers, trawl fishing at the mouth of the river and the use of agrochemicals in farming. In Labutta township, respondents also added that building dams and bridges, and capturing with tiger nets has led to changes in the water course, reducing the availability of hilsa.

Fishing governance

Field observations suggest that the perceived authority of the Fisher Development Association (FDA) varies across townships. It was perceived to be stronger in Mawlamyinekyun township than Ngapudaw, Labutta and Maubin townships. In Mawlamyinekyun township, FDA members carry out patrols to monitor conservation zones and detect illegal fishing or fishing techniques, such as the use of poison or electric shocks. The township has several conservation areas and all villages included in the survey are aware of them. In Ngapudaw township, respondents reported that illegal fishers often manage to circumvent the rules. Overall, in Maubin, fishers were interested in discussions about enforcing and regulating the fishing laws that are already in place, but felt that at least some responsibility for unsustainable hilsa fishery should be attributed to large-scale trawler fishing in estuaries and the sea. Fishers also discussed illegal practices such as using poison or electrocution to catch fish, and suggested that more regular monitoring of these practices could also help prevent fish stock decline.

Net mesh size

The use of nets remains an interesting area to explore further. Field observations suggest that most fishers in the area use a triple-layer trammel net for fishing, which are nominally illegal yet widely distributed and used. Many owned nets also fall below the legal mesh size of four inches. In Maubin, much of the discussion during surveying was about nets, especially their availability on the market. Many fishers argued that vendors should be prohibited from selling fishing nets that do not comply with regulations, rather than imposing regulations on fishers who use the purchased nets. A similar experience was recorded in Bangladesh, where fishers reported that manufacturers of microfilament nets still produce and sell the nets (Islam et al., 2016a). In some villages in Labutta, fishers indicated that their inability to buy any fishing nets meant that many had to abandon their traditional fishing livelihood and migrate to Yangon.

Overall, respondents across all townships were willing to engage in discussions about hilsa management and conservation but were concerned about the monitoring and enforcement of rules.

4 Conclusions and recommendations

The results of this choice experiment study provide some important insights for the development of incentive-based conservation schemes for hilsa shad in Myanmar. The hypothetical conservation agreements offered to respondents entailed three management-related attributes and two attributes offering monetary and in-kind compensation. On average, the respondents – fishers in four townships in the Ayeyarwady Delta – showed a tendency to choose one of the two conservation agreement alternatives shown in each choice task rather than the 'No agreement' alternative. This indicates a general willingness to participate in this type of scheme. However, this interpretation should be carefully assessed against the presence of cultural norms, notably a tendency to agree even though actual views are more critical or nuanced (see Whittington, 1998).

Looking at each of the proposed attributes for more sustainable hilsa management, the key findings are:

Additional closed periods to facilitate spawning are likely to be more acceptable if implemented around the main festival in October (*Thadingyut*). Additional closures in November and December (*Tazaungmon* and *Natdaw*) are likely to require higher compensation. Generally, the period from October to December is of great importance to fishers in terms of income generation. This needs to be considered when identifying appropriate compensation amounts.

Restricting nets to those with a larger mesh size to assist juveniles to mature was perceived as the most controversial change. Fishers showed the greatest demand for compensation if net use restrictions were to form part of conservation schemes. Fishers in some townships (eg Labutta) and some socioeconomic groupings (eg women) tended to focus entirely on this management attribute. While changes in net use for limited periods of time may be very effective in terms of hilsa conservation, any change in the status quo should be carefully evaluated to better understand the complexity of interactions between rules and their enforcement, markets for fishing gear, and the implications for fishing household livelihoods.

Creating new sanctuaries closed to fishing to assist spawning and juvenile growth was the most widely accepted management change in the hypothetical conservation schemes. This particularly applies to sanctuaries spaced at least six miles apart to avoid conflicts with current fishing practices, namely drift netting. Anecdotal evidence suggests that many fishers are already aware of areas closed off for fishing, including conservation zones. Therefore, it may be possible to implement this change without the need for much compensation. More investigation is needed to find out if there is consensus among fishers about the acceptance of sanctuaries, and what experience fishers have of current conservation zones. It would also be worth exploring the benefits and risks of implementing and managing sanctuary areas. Benefits could include better local awareness and stewardship and, if coupled with payments to fishers for conservation activity, improved livelihoods. Risks may include conflicts arising from enforcing fishing bans in these areas.

Although the choice of **compensation means and amounts** was informed by local stakeholders, the results suggest that their influence in the choices among conservation agreements was limited. It is likely that this resulted in some fishers ignoring compensation attributes when making their choices; for example, on average Ngawpudaw township respondents showed indifference to monetary compensation. This could be explored through further modelling, taking this choice behaviour with respect to compensation into account.

There was limited interest in **rice as in-kind compensation**. Interestingly, it was the township with on average better-off respondents (Maubin) that showed the most interest in rice as in-kind compensation, and there was no significant difference in response to in-kind compensation between male and female respondents. While this may be explained by the abundance of rice in the region, there is probably a need for a detailed exploration of this finding and to see if other forms of in-kind compensation are more viable. Where this includes food items, it may be worth moving beyond staple food items towards those that are perceived to be nutritious and difficult to obtain in local markets.

The results also highlight the need to strengthen local institutions, and cooperation between institutions in different sectors, to address other threats to hilsa fishery beyond overfishing. These include harmful fishing techniques, water diffuse pollution from farming and over-dependency on fishing due to a lack of alternative livelihoods. Cooperation between different institutions and stakeholders is likely to be required to address issues that have different spatial dimensions and often span different governance levels.

This study has appraised several management changes to include in an incentive-based conservation scheme for hilsa fish in the Ayeyarwady Delta, Myanmar. The findings reveal a number of promising management options to pursue further. However, due to the limited influence that changes in compensation amounts had on respondents' choices, the estimates of 'willingness to accept' compensation should not be used directly to define the amount of compensation provided in a scheme. We recommend further qualitative study to refine the potential management changes to consider, and to identify appropriate in-kind and monetary compensation amounts. This type of study should also build on more in-depth ecological knowledge to identify the most effective management interventions (Bladon et al., 2019; Merayo et al., 2020), carefully consider income from fishery and income dependency over the season (Khaing et al., 2018) and provide additional insights from women on incentive-based conservation schemes. Deliberative methods may be particularly helpful, especially if focused on finding a 'fair price' for compensation and ways to engage fishers in conservation efforts (Spash, 2008; Bartkowski and Lienhoop, 2018).

Appendices

Appendix 1. Choice experiment design

With five attributes (four attributes with four levels, and one attribute with two levels), the full factorial comprised a total of 1,024 possible combinations of attribute levels across two alternative hilsa conservation agreements ($(4^4 \times 2)^2$). To reduce the number of choice tasks shown to respondents, we used a Bayesian efficient design specified to optimise D-error for a multinomial logit model (ChoiceMetrics, 2014) with 36 choice tasks, blocked to six versions so that each respondent faced six choice tasks. Dominant alternatives in choice tasks were avoided in the experimental design generation. We imposed restrictions to ensure that at least one of the management attributes required a change from the status quo in return for in-kind or monetary compensation payments. Priors for the Bayesian design were specified as uniform distributions with signs and boundaries based on theoretical expectations, pre-tests and a small pilot study in a village in the Maubin township area. We expected positive signs for payments (ie higher payment amounts would be preferred to lower payment amounts) and negative signs for management restrictions (ie respondents would prefer less over more restrictions); and a relatively greater compensation requirement for restrictions in required mesh size between the Burmese months of *Thadingyut* and *Natdaw* compared to creating sanctuaries. An example of the choice tasks is shown in Figure 2.

Appendix 2. Econometric approach

The model

Choice data is analysed using a mixed logit model in willingness to accept (WTA) space. All models are estimated in R using the Apollo package, Version 0.0.8 (Hess and de Palma, 2019). The mixed logit model accounts for heterogeneity in preferences following a statistical distribution to be specified by the analyst. In our case, we assume marginal willingness to accept (WTA) for non-monetary attributes to be distributed normally. The use of a triangular distribution for non-monetary attributes was tested but resulted in similar and qualitatively equivalent results.

For the attributes related to additional closures (CLOSE), sanctuary creation (SANCT) and in-kind compensation (RICE), actual measurement units could be used in the model. For example, for SANCT these would be [0,3,6,9] referring to miles that sanctuaries would be apart. Resulting WTA estimates would then refer to a one-unit change to the attribute (for example, in the case of SANCT, to a 1-mile change in the distance between newly created sanctuary areas). We provide this model using actual measurement units for comparison for the overall sample, but otherwise specify coefficients to relate to discrete changes from 'No change' or 'No payment' to one of the attribute levels. First, this approach allows for non-linear effects in response to attributes. Second, it allows attribute levels that may not require compensation to be identified, or – more generally – that have not had a significant influence on fishers' decisions. Both of these aspects are useful in terms of policy implications.

Detailed econometric approach

Fishers were asked to choose in a series of choice tasks between three alternatives. Two alternatives described conservation agreements with non-monetary attributes involving changes in hilsa management and in-kind compensation $\boldsymbol{x}$, and a monetary attribute p. The third alternative referred to 'No agreement' and indicates non-participation in the conservation scheme given the offered trade-offs between management changes and compensation.

Following random utility theory, a utility function is characterised by the attributes of the experimental design in a linear and additive fashion, in addition to a random error term ε. The utility function U for fisher n and alternative i in choice task t can then be written as:

$$U_{nit} = -\alpha_n \, p_{nit} + \boldsymbol{\beta}_n{}' \boldsymbol{x}_{nit} + \varepsilon_{nit} \tag{1}$$

where α, $\boldsymbol{\beta}$ are parameters to be estimated for the payment attribute main effect and the non-monetary attribute main effects, respectively. The random error term ε is assumed to be identically and independently distributed (*iid*) and related to the choice probability with a Gumbel distribution with error variance $\mathrm{Var}(\varepsilon_{ni}) = \mu_n{}^2(\pi^2/6)$. μ_n denotes a respondent specific scale factor.

By dividing equation (1) by μ_n, we derive a scale-free utility function with a new error term that is constant across respondents (Train and Weeks, 2005):

$$U_{nit} = (\alpha_n/\mu_n)p_{nit} + (\boldsymbol{\beta}_n/\mu_n)'\boldsymbol{x}_{nit} + \varepsilon_{nit} \tag{2}$$

where ε_{nit} is *iid* with constant error variance $\pi^2/6$. If $\gamma_n = \alpha_n/\mu_n$ and $\boldsymbol{c}_n = \boldsymbol{\beta}_n/\mu_n$ are parameters to be estimated, a model in preference space is derived (Train and Weeks 2005). Re-specification of the utility function in willingness to accept (WTA) space allows direct estimation of the distributions of marginal WTA for non-monetary attribute effects. Because marginal WTA for management changes and in-kind compensation is $\boldsymbol{w}_n = \boldsymbol{c}_n/\gamma_n$, the utility function in WTA space is:

$$U_{nit} = \gamma_n \, p_{nit} + (\gamma_n \, \boldsymbol{w}_n)'\boldsymbol{x}_{nit} + \varepsilon_{nit} \tag{3}$$

Let the sequence of choices over T_n choice tasks for respondent n be defined as $\boldsymbol{y}_n = (i_{n1}, i_{n2}, \ldots, i_{nT_n})$. The mixed logit model enables estimation of heterogeneity across respondents by allowing γ_n and $\boldsymbol{w}_n$ to deviate from the population means following a random distribution. The unconditional choice probability of respondent n's sequence of choices (y_n over T_n choice tasks) is:

$$\Pr(\boldsymbol{y}_n/\gamma_n, \boldsymbol{w}_n) = \int \prod_{t_1=1}^{T_n} \frac{exp(-\gamma_n p_{nit} + (\gamma_n \, w_n)'x_{nit})}{(\sum_{j=1}^{J} \exp(-\gamma_n \, p_{njt} + (\gamma_n \, w_n)'x_{njt})} \; f(\boldsymbol{\eta}_n \,|\, \boldsymbol{\Omega}) d\boldsymbol{\eta}_n \tag{4}$$

where $f(\boldsymbol{\eta}_n \,|\, \boldsymbol{\Omega})$ is the joint density of the parameter vector for cost and non-monetary attributes, $[\gamma_n, \boldsymbol{w}_n]$, η_n is the vector comprised of the random parameters, $\boldsymbol{\Omega}$ denotes the parameters of these distributions (eg the mean and variance).

The integral in Equation (4) does not have a closed form and thus requires approximation through simulation (Train, 2003), which were based on 10,000 Sobol draws. To ensure positivity of the marginal utility of income, the payment attribute parameter is assumed to follow a triangular distribution with the lower bound constrained to equal zero. An alternative is the log-normal distribution. We opt for the triangular distribution to avoid well-known problems with long tails of the log-normal distribution. The marginal WTA coefficients of the remaining non-monetary attribute effects are assumed to follow a normal distribution. An alternative specific constant (ASC) for the 'No agreement' option is also specified as a random coefficient following a normal distribution.

Appendix 3. Model results for continuously coded attributes

Table A1. Model results of mixed logit model in WTA space with continuously coded non-monetary attributes

	WTA ESTIMATE	STANDARD ERROR	
Mean			
ASC_NA	–1.132	0.228	**
CLOSE	–0.032	0.021	
NETS	–0.439	0.076	**
SANCT	0.082	0.039	**
RICE	0.014	0.113	
CASH[a]	0	NA	
Standard deviation			
ASC_NA	0.873	0.163	**
CLOSE	0.208	0.044	**
NETS	0.896	0.168	**
SANCT	0.266	0.085	**
RICE	0.017	0.543	
CASH	0.461	0.081	**
Number of individuals	383		
Number of observations	2297		
LL (final)	-1641.036		
Rho-square (0)	0.35		

Note: ** significant at 5% level; * significant at 10% level; [a] fixed to zero to constrain triangular distribution to positive domain; ASC_NA – alternative specific constant associated with 'No agreement'; CLOSE – fishing bans for 7, 14 or 21 days; NETS – only DoF large-mesh nets to be used at certain periods; SANCT – juvenile hilsa sanctuaries placed every 3, 6 or 9 miles along the river; RICE – rice as compensation in 1, 2 or 3 *tinn*; CASH – money as compensation; LL – value of log-likelihood function

Abbreviations and acronyms

ASC	alternative specific constant
DoF	Department of Fisheries
FDA	Fisher Development Association
IIED	International Institute for Environment and Development
MMK	Myanmar kyat
NAG	Network Activities Group
SRUC	Scotland's Rural College
WTA	willingness to accept

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This study provides key insights for the development of incentive-based conservation schemes for hilsa in Myanmar's Ayeyarwady Delta. The results of a choice experiment suggest on average a willingness to participate in such conservation schemes. Some potential management options for conservation schemes such as additional closed fishing periods and creation of new sanctuaries are more widely accepted than restrictions in net use. We recommend further studies to refine management options and identify appropriate compensation mechanisms that take into account improved ecological knowledge and carefully consider income dependencies and gender disparities along the supply chain.

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