Myanmar's artisanal hilsa fisheries

How much are they really worth?

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Network Activities Group

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Current national statistics do not capture the true value of Myanmar's hilsa fisheries. As a result, investment in the sustainable and inclusive management of its artisanal hilsa fisheries is limited. This study estimates the economic value of artisanal hilsa fisheries in Myanmar, using artisanal income data to estimate use value and a benefit transfer to estimate non-use value. Over ten years, implementing an incentive scheme that compensates artisanal fishers for compliance with new fishing regulations could yield a net benefit of between US$790 million and US$1.1 billion, with benefits outweighing costs by up to nine times. These benefits include an annual 5% increase in the income of artisanal fishers and maintenance of the existence value placed on hilsa by the wider population. Although this is a rough approximation of benefits compared with costs, it clearly demonstrates that an incentive scheme would be an economically beneficial management option.

Contents

Acronyms and abbreviations

BCR	benefit–cost ratio
BDT	Bangladeshi Taka
CE	choice experiment
CVM	contingent valuation method
ES	ecosystem service/s
MMK	Myanmar Kyat
NPV	net present value
PES	payment for ecosystem services
PPP	purchasing power parity
WTA	willingness to accept
WTP	willingness to pay

Glossary

Administration costs: Fixed costs that are incurred in controlling and directing a specific project or organisation. In this context, these costs include governmental salaries for the people involved in the project.

Benefit–cost ratio (BCR): The relationship between the relative costs and benefits of a project, expressed in terms of the present value of benefits (the total discounted value of the benefits over time) divided by the present value of costs (the total discounted value of the costs over time). A BCR greater than 1.0 reflects economic benefits outweighing the costs.

Benefit transfer method: This process takes an estimation from one context and applies it to a similar environment. The original context, referred to as the 'study site', is used to derive estimates for the site about which the new information is needed, referred to as the 'policy site'.

Choice experiment: This is a stated preference method based on the idea that consumers have preferences between different goods or services, depending on the attributes that the goods or services possess and the utility that the consumers derive from these attributes.

Contingent valuation method (CVM): This is a stated preference method that asks people to directly report their willingness to pay for a specific good or service, in order to determine the economic value of nonmarket resources.

Distance decay: The effect of willingness to pay declining as distance from the good or service to be paid for increases.

Environmental valuation: The practice of assigning a monetary value to nature and its goods or functions, with the purpose of incorporating or internalising environmental goods and services into markets or assessing compensation requirements for environmental losses.

Income elasticity: This is a measure of the extent to which willingness to pay is affected by changes in income.

Indirect utility function: $U(x,Q) = v(P,Q,y)$ This shows the demand (x) where we assume that if price (P) and income (y) remain constant, a person will be happier when the level of environmental quality (Q) has improved. As demand is dependent upon the price of the good consumers want to buy and the income level that consumers have, we assume that an improvement (whether in quantity or quality) of the good will make a consumer happier, given that price and income do not change.

Marginal (willingness to accept): The amount that individuals are willing to accept as compensation for a particular regulatory measure, as compared to a different level of regulation. This might be the difference between compensation payments for a 14 and a 21 day fishery closure.

Non-use value: Also known as 'existence value', this is an appreciation of the intangible value of an ecosystem service.

Net present value (NPV): The difference between the present value of benefits (the total discounted value of the benefits over time) and the present value of costs (the total discounted value of the costs over time). A positive NPV represents economic viability.

Option value: This refers to people's willingness to pay for preserving an environmental good or service for future use, even if they are unlikely to use it themselves.

Payment for ecosystem services (PES): A market-based mechanism that encourages conservation by providing incentives for actions that would improve or protect an environmental service. This incentive, whether monetary or otherwise, provides these incentives on the contract that a certain action will either begin (to encourage an ecological service) or cease (to prevent ecological harm).

Purchasing power parity (PPP): A macroeconomic metric used to compare economic productivity between two countries by comparing goods and services and putting the currencies at par based on their respective prices.

Stated preference methods: A range of methods used to inform environmental policy analysis, as they allow for measurement of willingness to pay (WTP) for environmental goods that do not exist in the market and measurement of non-use values that would otherwise not be included.

Transaction costs: Expenses incurred when buying or selling a good or service. In this context, these costs include the allocation, transport and distribution that are required for the incentive scheme to perform.

Use value: This refers to ecosystem services that are for human consumption or production through direct or indirect use.

Willingness to accept: The minimum amount of money that a consumer is willing to accept for ceasing a behaviour, or the minimum amount that a seller is willing to accept to sell a good or service.

Willingness to pay: The maximum amount an individual is willing to provide for a specific good or service.

Summary

While hilsa fish (*Tenualosa ilisha*) are integral to Myanmar's national and local economies, current reported metrics do not accurately account for the value of artisanal, small-scale hilsa fisheries, leading to chronic underinvestment. This has resulted in high levels of exploitation and illegal, unreported and unregulated fishing, culminating in a hilsa stock decline that threatens the livelihoods of more than 60,000 artisanal fishers in Myanmar, particularly in the Ayeyarwady Region.

This study uses valuation techniques and data to build a more accurate estimate of the value of Myanmar's artisanal hilsa fisheries by assessing both use and non-use value. Addressing this knowledge gap provides a more accurate picture of what level of investment is necessary for improvement, and what could be the return on that investment.

Using income reported by artisanal fishers in a socioeconomic survey, we estimated the direct income that is derived from hilsa outside of industrial fishing and secondary sales. Based on the total numbers of licensed and unlicensed artisanal fishers thought to derive income from hilsa, we estimated the total annual use value to be US$731.4 million.

However, this only represents a percentage of the value that is derived from hilsa, as this estimate is based solely on income. We also estimated the non-use value of hilsa, both for those who are involved in the hilsa value chain and those who derive value from the existence of hilsa fisheries without actually using them. This value was calculated through a benefit transfer from non-use values estimated through a contingent valuation survey that asked people in Bangladesh what they would be willing to pay for a hilsa restoration programme. Willingness-to-pay estimates were adjusted to account for inflation, deriving a non-use value for individuals of US$0.68 per annum. This willingness-to-pay estimate was applied to regional, subnational and national populations in Myanmar. For the Ayeyarwady Region's artisanal fisher population, aggregating use and non-use value took our total estimated annual value to US$731.7 million. We also estimated annual value across all coastal states and regions of Myanmar, since the coastal population is expected to derive non-use value from hilsa, even if they are not involved in the fishing process: this came to US$788.4 million. Finally, we extrapolated a national annual value of US$867 million, assuming that the cultural significance of catching and eating fish would negate a possible distance decay factor.

In order to estimate the monetary compensation that hilsa fishers would require to comply with fishing regulations designed to protect hilsa, we used willingness-to-accept data from a choice experiment in the Ayeyarwady Region. We estimated the amount of compensation that hilsa fishers would require for compliance with various hypothetical fishing regulations, including new seasonal closures, seasonal net mesh size restrictions and establishing new sanctuary spaces. Based on these amounts, between US$17.5 million and US$22.1 million would be required annually to compensate all licensed artisanal fishers in the Ayeyarwady Region.

We combined these figures with estimates of transaction and administration costs transferred from a food compensation scheme for hilsa fishers in Bangladesh, to estimate total costs of implementation. These came to between US$17.7 million and US$22.3 million per year if all licensed fishers in the Ayeyarwady Region were included.

We then estimated the benefits of an increase in hilsa production over a ten-year time period in terms of expected impact on economic value. We based this expected increase on the annual 5% increase in hilsa production reported in Bangladesh following the introduction of its compensation scheme. Our cost–benefit analysis indicated that implementation of an incentive scheme for hilsa fishers would produce a high net present value (between US$790.4 million and US$1.1 billion) and a benefit–cost ratio of between 5.7 and 9.3, meaning that an incentive scheme could generate benefits up to around nine times the cost of the scheme.

This study outlines the economic imperative to sustainably manage artisanal hilsa fisheries. While it is difficult to establish a direct connection between incentive-based fisheries management and fish production, management techniques grounded in rigorous social and ecological research provide our best chance of protecting hilsa. Investment in compensation to offset or reduce the economic losses incurred by artisanal fishers when new regulations are introduced could generate significant economic returns alongside social and ecological benefits.

1 Introduction

1.1 Myanmar's hilsa fisheries

The fisheries sector is pivotal to Myanmar's national economy and food security. Fish accounts for 50% of the animal protein in the Myanmar diet and average consumption lies around 30kg per person annually (Belton et al. 2019; FAO 2018). Further, fishery exports are valued at US$538 million and employ 3.2 million people (Belton et al. 2019). Nearly half of the population resides in coastal states and regions and small-scale artisanal fisheries produce an estimated 1.65 million tonnes of fish annually – a figure which could in reality be much higher due to an unreported 'hidden harvest' in delta areas (DoF 2019; Kelleher et al. 2012). Considering the value of artisanal fisheries is therefore critical to understanding the total value of the fisheries sector, particularly in terms of employment (FAO 2018; Gregory et al. 2016).

The hilsa shad (*Tenualosa ilisha*) has huge demand both nationally and internationally, with a high export value of US$32 million (DoF 2018). Hilsa are widely distributed throughout the Bay of Bengal and the majority of the total reported hilsa catch comes from inshore and offshore marine fisheries, in which both artisanal and industrial fishers operate (Hossain et al. 2019). Moving between marine and fresh water for feeding and reproduction, hilsa have been known to travel up to 1,200km inland to spawn, particularly in the period from July to September (Baran et al. 2015; Bladon et al. 2019). They can therefore be found along the coast, in estuaries and in the Ayeyarwady and Toe rivers, but populations diminish in the Central Dry Zone of Myanmar, north of Hinthada (Baran et al. 2015). Hilsa are also caught in brackish and fresh waters on their upstream and downstream migrations. They are therefore critical for the livelihoods of artisanal fishers, particularly in the Ayeyarwady Region, where hilsa can represent more than 75% of fishing household income (Hossain et al. 2019; Khaing et al. 2019; Baran et al. 2017).

Yet, while information is available on the value of hilsa to the national economy in terms of export revenues, the true economic value of Myanmar's hilsa fisheries, including the artisanal sector, has not been quantified. The lack of value placed on these artisanal fisheries has resulted in a chronic problem of underinvestment, leading to limited monitoring and poor management (Leadbitter 2017). Despite the regulations in place across inshore marine and freshwater fisheries, hilsa are overexploited in the Ayeyarwady Region, probably due to an increasing level of illegal, unreported and unregulated fishing (BOBLME 2015; Dewhurst-Richman et al. 2016). It is clear that urgent action must be taken to halt stock decline in the Ayeyarwady Region and management interventions must be underpinned by reliable, comprehensive and disaggregated monitoring, including direct sampling of artisanal hilsa catches and socioeconomic assessment of local communities (Soe et al. 2020; Merayo et al. 2020). Better data can not only provide a more accurate picture of what level of investment is necessary to strengthen management of hilsa and other fish stocks, but also allow the impacts of management interventions to be measured (Leadbitter 2017).

1.2 Aim and objectives

The Darwin Initiative-funded project Carrots and Sticks: Incentives to Conserve Hilsa Fish in Myanmar, also known as Darwin-Hilsa^{MM}, is seeking to address the threat of overfishing while protecting the livelihoods of small-scale fishing communities. Darwin-Hilsa^{MM} aims to design an economic incentive scheme, akin to Payment for Ecosystem Services (PES) in structure, that provides fishers with compensation for short-term economic losses incurred through compliance with new fishing regulations designed to maintain or increase hilsa populations. A similar scheme in Bangladesh has shown promising results in terms of both ecosystem and social resilience (Reid and Ali 2018).

It is crucial to understand who would be affected by implementation of this incentive scheme and how to balance participant needs with policy costs. This starts with understanding the context in which the scheme would be implemented and the level of investment required. The growing body of literature on implementation of PES schemes suggests that compliance rates hinge particularly on community input and acceptance (Barr and Mourato 2014). Equally important is determining an appropriate level of payment that can be sustained for as long as it is required (Engel et al. 2008). Payments must be sufficiently high to incentivise behaviour change, but not so high that they become inefficient or financially prohibitive in terms of the long-term funding of the scheme. PES schemes often face problems of permanence, where long-term environmental improvements are hindered due to a lack of funding (Engel et al. 2008). Similarly, some regulations may not impose enough of an economic cost on local fishers that they require an incentive. In these cases, payments are unlikely to be cost-effective. Thus, having a comprehensive understanding of the economic costs that local communities perceive to be associated with new regulations can ensure the effectiveness, efficiency and longevity of an incentive scheme.

The main objectives of this paper are to:

1. Estimate a lower bound economic value for small-scale, artisanal[1] hilsa fisheries in Myanmar, in terms of income earned from hilsa fisheries in the Ayeyarwady Region
2. Estimate a range of upper bound economic values for Myanmar's artisanal hilsa fisheries by incorporating the non-use value for hilsa at regional, subnational and national levels
3. Determine an optimal level of compensation for artisanal fishers to incentivise compliance with hilsa fishing regulations
4. Estimate the benefit–cost ratio and net present value of an incentive scheme for hilsa management in Myanmar

1.3 Structure of the report

This report is comprised of four sections. Following this section, Section 2 describes the methodology used to estimate the economic value of hilsa and the level of compensation required for hilsa fishers in the Ayeyarwady Region. Section 3 presents and discusses the results of the study, including a lower bound estimate of economic value, a range of upper bound estimates of economic value, an estimate of the level of compensation required by artisanal fishers and an analysis of the relative costs and benefits of investing in an incentive scheme. Finally, Section 4 presents conclusions and recommendations.

[1] We use the terms small-scale and artisanal interchangeably to describe fisheries and fishers operating mainly in fresh water and inshore marine areas of Myanmar, as opposed to industrial fishers who mainly operate offshore (see Silvester et al. 2020 for more detail).

2 Methods

Drawing on a combination of primary data collected by the Darwin-Hilsa^{MM} project and secondary data reported by the Myanmar government and collected from literature, this study uses environmental valuation to estimate lower and upper bounds for the economic value of Myanmar's artisanal hilsa fisheries. It then approximates the relative costs and benefits of implementing an incentive scheme for artisanal hilsa fishers in the Ayeyarwady Region.

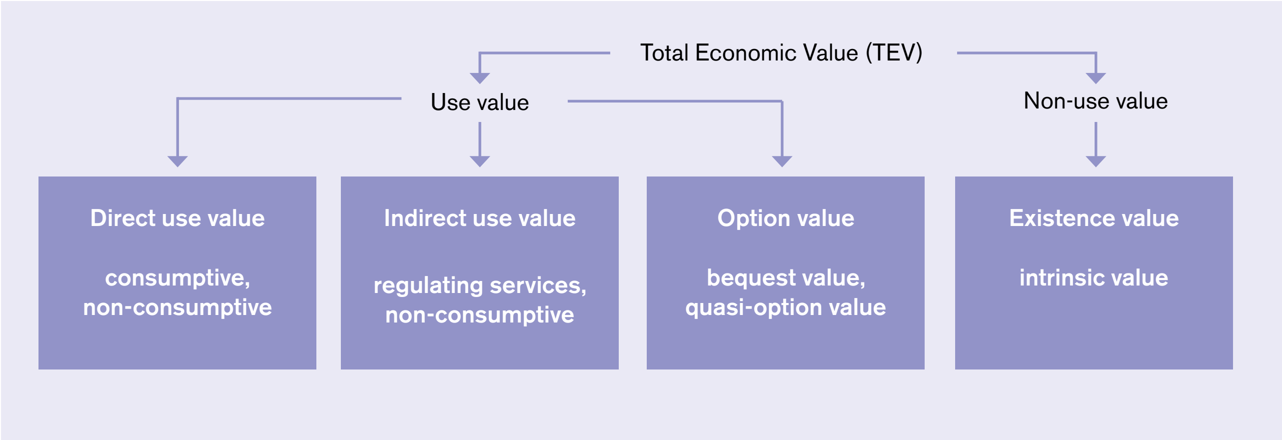
2.1 Environmental valuation

The purpose of environmental valuation[2] is to account for the values that go beyond a list of goods and services. An insufficient understanding of the different types of value attributed to an ecosystem can lead to policy that is inefficient in protecting all of the services it provides (Kenter 2016). Valuation studies should therefore attempt to account for that full scope by assessing the overall contribution to human wellbeing and the relative impact of changes or alternative actions (MA 2003). The total economic value framework encompasses use and non-use values of a particular ecosystem service (Pearce and Wardford 1993).

Use value and non-use value can be divided into categories based on the service provided (Figure 1). Use value refers to services that are for human consumption or production through direct use (eg fishing or tourism) or indirect use (eg regulating services such as nutrient cycling). Option value refers to people's willingness to pay for preserving an environmental good or service for future use, even if they are unlikely to use it themselves. This category includes bequest value (the value of preserving something for future generations) and quasi-option value (the value of choosing not to take an irreversible step if information about alternative outcomes will be available in future). Non-use value is an appreciation of the intangible value of an ecosystem service (Wainger et al. 2018). This type of value can be held by both those who use and those who do not use a good or service directly. A prominent example of non-use value is existence value, which refers to the benefit people derive simply from knowing that something exists. Cultural services (eg recreation or appreciation of nature) are valued by people even if they cannot necessarily be bought or sold in a market and might fit in any of the categories.

[2] Using the term environmental valuation, as opposed to economic valuation, simply specifies the type of goods and services that are evaluated: specifically, nature and its associated functions. For a more in-depth definition, see the Glossary.

Figure 1. The Total Economic Value Framework, adapted from MA (Millennium Ecosystem Assessment) (2003)



In this study, we estimated lower and upper bounds of economic value. For the lower bound estimate, we considered only (non-consumptive) direct use value by estimating income from artisanal hilsa fishing. For the upper bound estimates, we added non-use value, determined through a benefit transfer using data from a contingent valuation method (CVM)[3] study conducted in Bangladesh. This addition of value attempts to account for existence and other cultural values that Burmese residents hold, even if they do not necessarily depend on hilsa for income or food security. We calculated the upper bounds at regional, subnational and national levels to ensure clarity in value and to demonstrate how focusing solely on the areas where hilsa are prevalent may obscure a significant amount of their economic value.

2.1.1 Estimating the lower bound of hilsa value

We derived a lower bound of hilsa value from an estimate of average household income from hilsa fishing, multiplied by the total number of artisanal fishers thought to earn an income from hilsa fishing in the Ayeyarwady Region.[4] While there is no exact figure for the number of these fishers, in 2019 there were 63,000 artisanal fishers registered in the Ayeyarwady Region (DoF 2019). While not all target hilsa, most will catch hilsa at some stage. Silvester et al. (2020) estimated that there are likely to be the same number of people fishing without a licence. Thus, our lower bound assumes an estimated 126,000 fishers who derive an income from small-scale hilsa fishing.

While hilsa and hilsa products are caught, sold and distributed across Myanmar, this lower bound estimate only considers income from artisanal fishers in the Ayeyarwady Region. This lower bound estimate therefore excludes income from industrial (offshore) hilsa fishing and income from the sale of hilsa at secondary markets[5] across Myanmar. It also excludes the consumptive value of hilsa and any non-use value of hilsa for fishers.

We used primary income data reported by artisanal hilsa fisher households through a Darwin-HilsaMM socioeconomic survey carried out in early 2018 (Khaing et al. 2018). The survey collected quantitative data, including data on income, from 833 households in 46 villages across four townships in the Ayeyarwady Region. Only households whose primary source of income comes from fishing were selected for interview. The townships in this survey were chosen because of their representation of different hilsa fishing conditions across the region: artisanal hilsa fishing takes place in coastal saline, brackish and freshwater conditions. This study also provided a sample similar to national and regional demographics, which suggests this survey sample could be considered representative of the wider population. A majority of surveyed households were considered poor (45%) or very poor (28%), with the remaining percentage (29%) classified as better off or middle class (Khaing et al. 2018).

2.1.2 Estimating the upper bound of hilsa value

We calculated three alternative upper bound estimates of value by adding to our lower bound value an estimate of non-use value for the Ayeyarwady Region's artisanal fishers, the coastal population of Myanmar and for the Myanmar population as a whole. The non-use value

[3] Contingent valuation is a stated preference method where people are asked how much they are willing to pay for an improvement and/or how much compensation they would accept for the deterioration of a given ecosystem quality. For more detail, see Glossary.
[4] While hilsa are also caught in Rakhine and Mon States, Yangon and Bago Regions (Baran et al. 2017), the Ayeyarwady Region is the most important region for hilsa fishing in Myanmar and the focus of the Darwin-HilsaMM project.
[5] At secondary markets, wholesalers buy hilsa from local traders and sell on to national or export markets. For more detail on the hilsa supply chain, see Silvester et al. (2020).

was calculated based on a CVM study conducted in Bangladesh, by transferring the results to the Myanmar context using the benefit transfer method.

Conducting a primary study can be a costly and time-consuming process, and without sufficient time or budget, this can lead to inefficient or low quality studies (Johnston and Wainger 2015). In these circumstances, the benefit transfer method provides an efficient way of building reliable estimates by allowing for "the use of existing data or information in settings other than for what it was originally collected" (Rosenberger and Loomis 2003, p445). This process takes an estimation from a previous context and applies it to a similar environment. The original context, referred to as the 'study site', is used to derive estimates for the place we need information about, referred to as the 'policy site' (Rosenberger and Loomis 2003).

We used the benefit transfer method to adapt an estimate of non-use value for hilsa fisheries made for a comparable region of Bangladesh, using secondary data taken from a CVM study based on willingness to pay (WTP) (Mohammed et al. 2016). A total of 1,006 households within five districts in Bangladesh were asked how much they would be willing to pay for a programme designed to restore hilsa populations.

Prior to applying the benefit transfer method, we assessed the potential for comparability and consistency of data between the study site (Bangladesh) and the policy site (Myanmar) to ensure a reliable transfer (see Box 1). We modified the data collected through the CVM study, which had revealed how much respondents would be willing to pay for an improvement in a given ecosystem quality, and used these values to determine the indirect utility function[6] of the consumer for improvements to hilsa stocks.

Two methods of benefit transfer are available: a unit value transfer and a benefit function transfer. A unit value transfer uses a single value or set value from the study site, while a benefit function transfer relies on transferring the function that statistically relates willingness to pay to characteristics of the ecosystem and the people whose values were elicited, thus not

BOX 1. ENSURING RELIABILITY OF THE BENEFIT TRANSFER

Prior to applying the benefit transfer method, we established the context and framework to ensure that the data from the study site (Bangladesh) were similar enough to data from the policy site (Myanmar) to create a reliable transfer (Bateman et al. 2011). In both countries, hilsa are one of the most exported seafood products; in Bangladesh hilsa generate around US$630 million in annual export revenues (Dewhurst-Richman et al. 2016), while in Myanmar hilsa exports generate around US$32 million per year (DoF 2018). Fishing, and hilsa specifically, also provide a critical source of livelihoods in both countries. It is estimated that 2% of the total population of Bangladesh is directly or indirectly involved in the hilsa fishery (Bala et al. 2014). While no comparable statistics are available for Myanmar as a whole, at least 6% of the population is reportedly involved in the fisheries sector (DoF 2016). In the Ayeyarwady Region specifically, fishing contributes an average of 63% of household income in coastal and delta communities and almost all artisanal fishers catch hilsa (MMRD 2015; Khaing et al. 2018).

As the national fish of Bangladesh, hilsa also hold a cultural significance in the country and are often consumed at religious festivals. In Myanmar, hilsa does not have comparable associations with religion, but it is a highly valued food (particularly the roe) and forms the traditional basis of its national dish, Mohinga rice noodles.

Hilsa demonstrate similar migratory patterns in Bangladesh and Myanmar, migrating from the Bay of Bengal upriver for spawning. There are five major spawning grounds in Bangladesh, with the largest riverine nursery ground identified as the Meghna River (Bala et al. 2014). For their CVM study, Mohammed et al. (2016) sampled households in five districts of the Barisal Division, which has been identified as one of the districts containing major coastal rivers that are used as nursery grounds (Hossain et al. 2016).

Sharing a transboundary population of hilsa, both Myanmar and Bangladesh have experienced a decline in hilsa stocks. The CVM study in Bangladesh was not only designed to target the threat of overfishing from these same shared hilsa stocks, it also collected data from households with similar socioeconomic characteristics and livelihood challenges to those targeted in this study. This suggests that this study is viable for a valid transfer.

[6] The indirect utility function shows the demand where we assume that if price and income remain constant, a person will be happier when the level of environmental quality has improved. For an in-depth explanation, see Glossary.

including the original set values (Rolfe et al. 2015). We used the method of unit value transfer, which generally outperforms benefit function transfers when the study and policy site are highly similar (Rolfe et al. 2015). Problems can arise when errors are found either in the original primary study or in the transfer process, and therefore unit value transfers require careful implementation to ensure data quality. However, transfers from CVM studies generally produce fewer transfer errors than other valuation methods (Kaul et al. 2013).

To ensure validity of transfer (ie accuracy), we assessed WTP in the context of income data. Using site-specific measures of income in lieu of GDP per capita has been shown to increase transfer accuracy (Czajkowski and Ščasný 2010). Using income data from Mohammed et al. (2016), we identified what percentage of their income Bangladeshi respondents were willing to pay for hilsa restoration. We then transferred and attributed that percentage to the estimated average income of surveyed fishers in Myanmar, to estimate their WTP. Before the transfer was made, Myanmar income estimates were first adjusted to 2018 US$ values to ensure consistency between the upper and lower bound values in the Myanmar case. Then these values were adjusted with purchasing power parity (PPP) calculations for comparison (see Section 2.1.3).

It is important to address how changes in income may affect WTP estimates. The literature suggests that an increase in income does not necessarily imply an increase in WTP (Broberg 2014). Further, studies that focus on consumption by poorer communities suggest that consumers living in poverty will often opt for alternatives that improve social welfare over their own individual utility (van Kempen et al. 2009). This suggests that poorer respondents may provide a high WTP because of their dependence on the ecosystem service (ES), and that a slight increase in income may not necessarily mean a change in WTP, especially if dependence on that ES is inflexible. These concerns suggest it is worthwhile to consider 'income elasticity' when determining whether or not WTP values are likely to change. In WTP calculations, income elasticity is a measure of the extent to which WTP is affected by changes in income, which may allow a better understanding of the dependence that consumers have on ES (see Section 3.2.1).

Distance decay (the effect of respondents' WTP value decreasing as their distance from the major area of interest increases) can greatly impact the calculated total benefit in CVM studies (Glenk et al. 2019). This generally occurs when respondents are asked to address their WTP for use rather than non-use of ecosystem services. Indeed, Mohammed et al. (2016) found that distance from rivers did not diminish respondents' WTP for non-use of hilsa fisheries, but rather slightly increased it. This suggests that in the context of Bangladesh, distance decay did not factor into WTP for non-use of hilsa, probably because of ties to national and cultural identity, given that hilsa is the national fish of Bangladesh.

In the Myanmar context, we first estimated the WTP of fishers who rely on hilsa for their income, have access to rivers, live in fishing villages and sell their fish to village-level collectors (Khaing et al. 2018). It is unlikely that distance decay can come into effect at this level. As these WTP values account for non-use of hilsa, they can be applied beyond the scope of those that depend on hilsa fisheries for their income. As those who do not derive direct income from hilsa fishing may still derive some non-use value from hilsa fisheries, distance decay may come into play as the non-use value estimates are expanded. However, if we acknowledge that hilsa also play a part in the culture of Myanmar as they do in the culture of Bangladesh (see Box 1), and we assume that the same effects experienced in the Bangladesh case could therefore be observed, we are able to extrapolate to a national value without including a distance decay factor.

2.1.3 Purchasing power parity

We used the method of purchasing power parity (PPP) to standardise values in different currencies for comparison within this study. The method allows for a more reasonable comparison between countries by ensuring equal weight of value between currencies. Additionally, PPP represents the long-term value of the currency of a country, and so adjustments using PPP make national long-term value clearer than adjustments using regular exchange rates, which may undervalue investment (Ma et al. 2017). Empirical results from a 2012 rank test[7] suggest that PPP has shown long-term validity when used with East Asian countries, making them favourable for comparison (Chang and Su 2013).

[7] The study uses the Breitung rank test model, which tests for nonlinear cointegration for two or more time series, where sequences are compared. If there is cointegration between the two series, the sequences tend to converge, suggesting a relationship.

2.2 Estimating willingness to accept compensation

We used data from a choice experiment, conducted as part of the Darwin-Hilsa^{MM} project in Myanmar in 2019, to estimate willingness to accept (WTA) compensation for compliance with new or more stringent fishing management policies designed to protect hilsa populations (Glenk et al. 2020). The survey was disseminated to 381 respondents in the Ayeyarwady Region, who were selected to overlap with those households from whom income data had previously been collected through a socioeconomic survey (Khaing et al. 2018).

A choice experiment is another stated preference method[8] based on the idea that consumers have preferences between different goods or services depending on the attributes that the goods or services possess and the utility that the consumers derive from these attributes (Louviere et al. 2000). The experiment format consists of choice sets, where respondents are asked to choose between alternatives. The alternatives each contain different attributes at different levels and hence respondents' choice implies trade-offs in attributes across alternatives (Hoyos 2010). Choice experiments have been used previously to inform the design of incentive-based schemes and to understand preferences for management and compensation options (Hanley and Czajkowski 2019; Villanueva et al. 2017).

In this context, attributes in the choice experiment related to different hypothetical management changes that would protect hilsa populations, as well as different levels of monetary and in-kind compensation that they could receive. Management options included: (1) a closure that would last for seven days in one, two or three months in October, November and December; (2) sanctuary spaces for juvenile hilsa that would be placed every 9, 6 or 3 miles along the river; or (3) a requirement for an increase of fishing net mesh to 4.5 inches for three months out of the year[9] (see Glenk et al. 2020 for full methodological details of the choice experiment). We used the monetary compensation data from this study to estimate WTA values for our study. Participants in Glenk et al.'s experiment were offered the choice of six levels of compensation for these management options, ranging from US$30 to US$300. Scaling average individual WTP values up to the level of the Ayeyarwady Region's artisanal fisher population allowed us to estimate the total amount of money that would be required to provide fishers with an incentive to comply with each of these hypothetical management changes.

2.3 Cost-benefit analysis of a compensation scheme

Estimating the total costs and benefits of a programme allows the calculation of net present value (NPV) and benefit–cost ratio (BCR), which together provided an indication of overall value for money of an incentive scheme for artisanal fishers in Myanmar. NPV is a calculation of net benefit over the lifetime of a programme, and a positive NPV represents economic viability. BCR is used to understand the relative cost and benefit of the project, and a BCR greater than 1.0 reflects economic benefits outweighing the costs.

To estimate the cost of implementing a compensation scheme, we considered the total monetary compensation that would be required by fishers, as well as the potential transaction and administration costs of delivering the compensation.[10] To estimate the transaction and administration costs, we used those incurred by a food compensation scheme for hilsa fishers in Bangladesh (Haldar and Ali 2014). The scheme incurs costs relating to the selection of beneficiaries, transportation of the (food) compensation and staff wages required for allocation and distribution of compensation. The process for (and therefore cost of) distribution of compensation in Myanmar is expected to be quite similar to that in Bangladesh, where fishers use their ID cards to collect rice from local distribution points. Since access to bank accounts is not common among artisanal fishing communities in Myanmar, fishers would probably receive electronic transfers via a mobile app that would still require them to collect the cash from the office of a mobile financial services provider (eg Wave). It is probable that this cash would not be transported comparable distances to the food in Bangladesh, which can only be transported in its physical form, but there are likely to be additional costs associated with electronic transfers.

Rather than transfer these costs directly, we used the average cost incurred per household[11] compensated in Bangladesh in 2014 (updated to 2018 values)

[8] Stated preference methods are regularly used to inform environmental policy analysis, as these approaches allow for measurement of WTP for environmental goods that do not exist in the market and measurement of non-use values that would otherwise not be included (Hanley and Czajkowski 2019).
[9] In reality, any mesh size restriction should be permanent because it will require undersized nets to be destroyed.
[10] We assumed no additional cost to establishing the new regulations that would be compensated for, since it is unlikely that these would be accompanied by an increase in enforcement effort; the incentives would be used instead of additional top-down enforcement.
[11] Although this approach cannot account for the spread of fishers across administrative divisions, which may impact distribution spread, we used a per household cost rather than a total cost because the number of households compensated in 2014 in Bangladesh (226,852) was much higher than the number we are exploring in this study (63,000).

and multiplied this by the number of people currently licensed to fish in the Ayeyarwady Region.[12]

We added this cost to the total amount of compensation that would be required to compensate these fishers, based on WTA values (see Section 2.2). We ran the analysis for two hypothetical compensation scenarios: one which offered compensation for the three management measures described in Section 2.2 with the highest WTA values,[13] and one which offered compensation for the three management measures with the lowest WTA values.[14]

To estimate the benefit of the scheme, we considered the scheme's impact on our previously estimated lower bound of economic value (annual artisanal fishing income from hilsa in the Ayeyarwady Region) (see Section 2.1.1). Using the annual increase in hilsa production reported in Bangladesh following implementation of a similar scheme (Rahman et al. 2020), we estimated an increase in hilsa fishery production of 5% per year for the first ten years of implementation.[15]

It should be noted that direct causality between incentive-based management and increased hilsa production has been difficult to demonstrate. In reality, changes in productivity can also be influenced by other variables such as environmental change (Bladon et al. 2016). Furthermore, the fisheries regulations for which incentives were introduced in Bangladesh are not directly comparable to the hypothetical regulations under consideration in this study. Nonetheless, it is clear that incentive-based management has made a significant contribution to the hilsa stock recovery seen in Bangladesh (Dewhurst-Richman et al. 2016; Islam et al. 2016). Thus, for the purposes of this study we make the assumption that the increase in productivity was directly caused by incentive-based management and that the same impact would be expected in Myanmar. While a 5% increase in hilsa production would not necessarily lead to a concurrent 5% increase in hilsa income, without time series[16] data on hilsa fishing income in Bangladesh over this period, it is our best approximation of impact.

We also calculated benefit in terms of our upper bound estimate of value, incorporating both artisanal use value and also national non-use value (see Section 2.1.2). Although we would expect this non-use value to stay constant annually and not be affected by an increase in productivity, without an intervention like this it is possible that hilsa populations would collapse, reducing existence value to zero.

We calculated NPV and BCR over a ten-year time horizon, with annual costs and benefits both starting in the first year of implementation, and benefits (use value) increasing by 5% with each succeeding year, with a social discount rate of 7%. In the appraisal of projects seeking social benefits, a social discount rate reflects a society's relative valuation on today's wellbeing versus wellbeing in the future (Rambaud and Torrecillas 2005). The choice of an appropriate discount rate for cost–benefit analysis of public and environmental projects has long been a contentious issue. Setting it too high can mean socially desirable projects appear economically inefficient, and setting it too low risks making economically inefficient investments (Zhuang et al. 2007). Lower rates are often preferred for environmental projects, because they favour projects with benefits occurring in the more distant future (Thomas and Chindarkar 2019). For the purposes of this study, we used the interest rate charged to commercial banks and other financial institutions for the loans they take from the Central Bank of Myanmar (CBM 2020).

2.4 Limitations

These valuation techniques have limitations to what they can achieve. Values are often aggregated, transposed or expanded, and this use of generalisation can skew the magnitude at which the original values are relevant, leading to wide margins of error (Martínez and Bringas 2010).

In this paper, values are considered within a specific context and the most relevant and accurate estimates are used with the intention of transparency and accuracy. However, any change of context or population may lead to error and so these values are useful for characterising the order of magnitude of the value of hilsa fisheries in relation to compensation requirements to facilitate fishery conservation. These values can therefore be used to inform strategic decisions regarding investments in fisheries management and conservation but should be used with caution for economic appraisals of specific management options.

[12] Only licensed fishers would be eligible to participate in the incentive scheme. Our analysis therefore includes only the 63,000 people currently licensed to fish and does not account for unlicensed fishers potentially opting in in the future.
[13] The three measures with the highest WTA values are: 1) introduce a closed season for 21 days of fishing during peak fishing season; 2) increase fishing net mesh size requirements to 4.5 inches during peak fishing season; and 3) permanently close sanctuary areas to fishing every 3 miles along the river.
[14] The three measures with the lowest WTA values are: 1) introduce a closed season for 14 days of fishing during peak season; 2) increase fishing net mesh size requirements to 4.5 inches during peak fishing season; and 3) permanently close sanctuary areas to fishing every 9 miles along the river.
[15] After the first ten years of the incentive scheme for hilsa fishers in Bangladesh (2004/2005-2015/2016), there was a sharp rise in hilsa production from the annual 5% to 11%. This has been attributed to the introduction of other management interventions such as adaptive co-management, and so we did not consider changes beyond 2016.
[16] A time series is a series of data points indexed (or listed or graphed) in time order.

3

Results and discussion

Here we identify upper and lower bounds of the economic value of artisanal hilsa fisheries. We then estimate how much compensation would be required by artisanal fishers in the Ayeyarwady Region to incentivise compliance with hilsa fishing regulations, before approximating the relative costs and benefits of such a compensation scheme.

3.1 The lower bound estimate of value

Our lower bound estimate of value is based on the total non-consumptive use value of the Ayeyarwady Region's artisanal hilsa fishery, which we equated to the total income from artisanal hilsa fishing in the region. On the basis of information collected by Khaing et al. (2018), full-time fishers can make anywhere between MMK2,100,000 and MMK3,650,000[17] annually from hilsa fishing alone, depending on: whether fishers adhere to the closed seasons;[18] and the market price of the hilsa, which is usually determined by weight and therefore varies seasonally. An average estimate from this study places the mean hilsa fishing income at MMK250,000 per month. Based on the assumption that fishers do adhere to the three-month closed season,[19] this equates to MMK2,250,000 annually.

Using this average annual household income from hilsa fishing and assuming an estimated 126,000 fishers derive an income from artisanal hilsa fishing,[20] we calculated the total estimated use value of hilsa fisheries in US$ using 2018 exchange rates (World Bank 2019a) (see Table 1).

[17] Myanmar Kyat (MMK) exchange rate in 2018 = US$1/MMK 1,429.808
[18] Under the Freshwater Fisheries Law established in 1991, there is an official closed season for all freshwater and inshore marine fishing in the months of May, June, and July.
[19] Survey participants generally said that they do cease fishing activities during the closed season, but it is possible that the result was influenced by participants not wishing to disclose sensitive behaviour, since anecdotal reports indicate that many people do fish during the closed season (Khaing et al. 2018). Our estimate of income is therefore a conservative one.
[20] As noted in the methodology section, we based our estimate of total number of artisanal fishers on the number registered in the Ayeyarwady Region (63,000 in 2019 according to DoF 2019) and the estimate provided by Silvester et al. (2020) of fishers operating without a licence (which he concluded was likely to be the same figure).

Table 1. Estimated total annual income from artisanal hilsa fishing

ARTISANAL FISHERS	ESTIMATED ANNUAL INCOME FROM HILSA FISHING PER HOUSEHOLD (MMK)	ADJUSTED ESTIMATED ANNUAL INCOME FROM HILSA FISHING PER HOUSEHOLD (US$)	ESTIMATED TOTAL ANNUAL INCOME FROM HILSA FISHING (MMK)	ESTIMATED TOTAL ANNUAL INCOME FROM HILSA FISHING, ADJUSTED FOR PPP (US$)
126,000	2,250,000	5,805	2,250,000 x 126,000 fishers = 283.5 billion	5,805 x 126,000 fishers = 731.4 million

3.2 The upper bound estimates of value

Our upper bound estimates of hilsa value are comprised of our estimate of non-consumptive use value (see Section 3.1) added to an estimate of non-use value determined through the benefit transfer method. We estimated non-use value at three scales: for artisanal fishers in the Ayeyarwady Region, for the wider coastal population of Myanmar (including Ayeyarwady Region) and for the national population of Myanmar.

3.2.1 Value derived from hilsa by artisanal fishers in the Ayeyarwady Region

As noted in the methodology section, the benefit transfer used data from a survey of households in a region of Bangladesh where hilsa are found, in which respondents were asked how much they would be willing to pay for a hypothetical habitat restoration programme (Mohammed et al. 2016). Both median and mean figures were available, representing lower and higher estimates of non-use value (see Table 2). As this is intended to be an upper bound estimate, we used the mean figure from the Bangladesh study, as this sets a maximum limit.

Average monthly household income of survey respondents in Bangladesh was estimated at BDT12,191 (Bangladeshi Taka),[21] from a mix of livelihoods, and we multiplied this by twelve to obtain an annual estimate which, when converted and adjusted for inflation, came to US$1,967 (Table 2). This figure was slightly lower than that of fishers in the Myanmar survey, which showed an annual income of US$2,640 (Khaing et al. 2018). This difference is not surprising, given that Mohammed et al. (2016) surveyed people with a range of different types of livelihood, whereas Khaing et al. (2018) surveyed only people who fish, including some people of a higher 'social class' who had significantly higher levels of income than others.

The income elasticity of WTP for the Bangladesh study was calculated at 0.133, indicating inelastic demand for hilsa, which suggests that lower income groups are willing to pay more for hilsa restoration than those who have a higher income. This is probably because of their dependence on fishing as their primary source of income, whereas higher income groups have alternative income generation opportunities. Indeed, fishers are one of the most vulnerable communities in Bangladesh, and per capita annual income of hilsa fishers on the Padma River is 70% lower than the average per capita income of the population of Bangladesh as a whole (Sunny et al. 2019). Khaing et al. (2018) found that households in Myanmar that were identified to be in the 'lower' social classes had lower income and tended

Table 2. Estimated annual WTP value per household in Bangladesh

	ANNUAL WTP VALUE (2016) (BDT)	ANNUAL WTP (2018) (ACCOUNTING FOR INFLATION) (BDT)	ANNUAL WTP VALUE (2018) (US$)	ANNUAL WTP VALUE (2018), ADJUSTED FOR PPP (US$)
Mean WTP value	63.71	71.50	0.86	2.33
Annual income	146,290	164,178	1,967	5,355

[21] Exchange rate in 2018 =US$1/BDT 83.466

Table 3. Calculation of total annual value derived from hilsa by artisanal fishers in the Ayeyarwady Region

ANNUAL USE VALUE DERIVED BY ARTISANAL FISHERS FROM HILSA FISHING (US$)	ANNUAL NON-USE VALUE DERIVED BY ARTISANAL FISHERS (US$)	TOTAL ANNUAL (USE AND NON-USE) VALUE DERIVED BY ARTISANAL FISHERS (US$)	TOTAL ANNUAL VALUE DERIVED BY ARTISANAL FISHERS, ADJUSTED FOR PPP (US$)
1573.64 x 126,000 fishers = 198.3 million	0.68 x 126,000 fishers = 85,680	198,278,370 + 85,680 = 198.4 million	731.7 million

to be more dependent on fishing as a primary source of income. We can therefore assume that income from hilsa is similarly inelastic in Myanmar as it is in Bangladesh, meaning that the variation in income level between the two studies is less important.

Adjusted estimates for Bangladeshi survey respondents show a PPP income of US$5,355 and an adjusted mean WTP value of US$2.33, accounting for 0.04% of annual income (an unadjusted WTP value of US$0.86). If we consider the estimated annual income from hilsa fishing in Myanmar, adjusted for PPP (which is US$5,805), these values reveal a much lower income disparity between the two regions than unadjusted income comparisons show, suggesting that values from the Bangladesh study are comparable to estimates derived from a primary study carried out in Myanmar. Assuming that Burmese fishers are willing to attribute 0.04% of their unadjusted income as their WTP, we estimated a WTP value of US$0.68 and transferred this to the Myanmar case. Multiplied by the total number of fishers in the Ayeyarwady Region (126,000) this came to a total of US$85,680.

We combined this value with the lower bound estimate from Section 3.1 to estimate a total annual unadjusted (use and non-use) value of US$198,364,320 derived by artisanal fishers in the Ayeyarwady Region (see Table 3). When adjusted for PPP, this value comes to US$731.69 million.

3.2.2 Value derived from hilsa by the wider coastal population

The non-use value derived by artisanal fishers in the Ayeyarwady Region is probably an underestimate of the total non-use value, as even those who do not participate in hilsa fishing gain non-use value from the hilsa. Particularly in coastal areas, where catching and consuming fish has particular cultural significance, people are likely to value the existence of artisanal hilsa fisheries (see Box 1). Myanmar's coastline can be divided into three major coastal regions: the Rakhine coastline, the Deltaic coastline and the Tanintharyi coastline (FAO 2016). This encompasses six states: Rakhine, Ayeyarwady, Yangon, Bago, Mon and Tanintharyi.

Given that we have used a non-consumptive use value and have not taken into account offshore fisheries and secondary markets, we can assume that this value will remain the same when assessing the total (use and non-use) value of artisanal hilsa fisheries to the wider coastal population. The total population of the coastal states and regions (including Ayeyarwady Region) is 22,566,105 (see Appendix A). Using the same method employed above – ie a WTP value of US$0.68 – we estimated the non-use value derived by the total coastal population to be US$15.3 million. The total estimated value of hilsa fisheries, including non-use value, derived by the entire coastal population, is therefore US$213.7 million (Table 4). This value goes up to US$788.3 million when adjusted for PPP (Table 4).

Table 4. Calculation of total annual value derived from hilsa by the coastal population of Myanmar

ANNUAL USE VALUE DERIVED BY ARTISANAL FISHERS IN THE AYEYARWADY REGION (US$)	ANNUAL NON-USE VALUE DERIVED BY COASTAL POPULATION (US$)	TOTAL ANNUAL VALUE DERIVED BY COASTAL POPULATION (US$)	TOTAL ANNUAL VALUE DERIVED BY COASTAL POPULATION, ADJUSTED FOR PPP (US$)
198.3 million	0.68 x 23,974,506 = 16.3 million	198,278,370 + 16,302,664 = 214.6 million	791.6 million

Table 5. Calculation of total annual value derived from hilsa by the national population of Myanmar

ANNUAL USE VALUE DERIVED BY ARTISANAL FISHERS IN THE AYEYARWADY REGION (US$)	ANNUAL NON-USE VALUE DERIVED BY NATIONAL POPULATION (US$)	TOTAL ANNUAL VALUE DERIVED BY NATIONAL POPULATION (US$)	TOTAL ANNUAL VALUE DERIVED BY NATIONAL POPULATION ADJUSTED FOR PPP (US$)
198.3 million	0.68 x 53,708,395 = 36.52 million	198,278,370 + 53,708,395 = 234.8 million	867 million

3.2.3 Value derived from hilsa by the wider national population

Assuming that distance decay does not factor into non-use value estimates (see Section 2.1.2), we used the population of Myanmar, which was 53,708,395 in 2018 (World Bank 2019b), to calculate a figure of US$234.8 million for the total use and non-use value of hilsa fisheries for the entire Myanmar population, which increased to US$867 million when adjusted for PPP. This upper bound is a conservative estimate of the total economic value of hilsa fisheries to the nation and illustrates the true scale at which changes to artisanal hilsa fisheries could operate.

3.3 Willingness to accept compensation

As noted in the methodology, we estimated the monetary investment that would be required to compensate hilsa fishers for compliance with new regulations by using the results of a choice experiment conducted in Myanmar in 2019 to estimate willingness to accept (WTA) compensation for compliance with new or more stringent fishing management policies designed to protect hilsa populations (Glenk et al. 2020).

Glenk et al. (2020) identified four management options to produce statistically significant WTA values: (1) a closure that would last for seven days in two months, amounting to a total of 14 days; (2) a closure that would last for seven days in three months, amounting to a total of 21 days; (3) an increase of fishing net mesh to 4.5 inches for three months out of the year; and (4) sanctuary spaces for juvenile hilsa that would be placed every 3 miles along the river. The significant WTA values indicated that the economic losses imposed by these management options were perceived to be high enough to require compensation, with the change in fishing net mesh size requiring the most compensation and the 14 day closed season and sanctuary spaces requiring the least (Table 6).

All but one of the management options in Table 6 required cash compensation amounting to less than one month of estimated average income from hilsa fishing. For example, while the choice experiment indicated that fishers would be willing to accept US$73 in compensation for a 21-day fishing ban, survey data indicate that fishers in Myanmar have the potential to earn US$79 per month from hilsa during peak fishing season,[22] and so if fishing were closed for three weeks of this season, fishers could potentially lose US$236 (Khaing et al. 2018). The discrepancy between these two values could partially be due to limited opportunity for alternative income generation, creating a willingness to accept even low amounts of compensation over none at all (Grutters et al. 2008). It could also be due to the hypothetical timing of the 21-day fishing ban in the choice experiment, during the period from October to December, since the main festival in October (*Thadingyut*) is likely to reduce compensation requirements.

An increase in minimum net mesh size for three months of the year had the highest WTA value and was the only management option for which choice experiment participants required more compensation, on average, than estimated income earned from hilsa in one month. This is probably because the proposed change would be in place for the longest period of time and during peak fishing season, when hilsa catch and income are at their highest. If the entire artisanal fisher population of the Ayeyarwady Region were to be compensated for this management option, we estimate that this compensation would total just over US$30 million annually. If the same number of people were compensated for new hilsa sanctuaries spaced every three miles along the river, or for an additional closed season of 14 days over two months, each measure would total just over US$5 million annually.

[22] Defined by Khaing et al. (2019) as the period from September to January.

Table 6. Mean marginal[23] willingness to accept (WTA) per household per year and total annual compensation required for the Ayeyarwady Region's artisanal fisher population for four survey attributes (management options) presented to respondents through a choice experiment

Survey attribute	Annual WTA value per household (MMK)*	Annual WTA value per household (US$)	Total Annual Compensation (MMK)**	Total Annual Compensation (USD)**	Total annual compensation as % of national total economic value
Additional closed season of 7 days per month for 2 months (14 days total)	56,920	40	6.8 billion	5 million	2%
Additional closed season of 7 days per month for 3 months (21 days in total)	104,060	73	12.5 billion	9 million	4%
An increase in fishing net mesh size to 4.5 inches for 3 months of the year	340,700	238	50 billion	30 million	13%
Establishment of sanctuary areas spaced every three miles	57,030	40	6.8 billion	5 million	2%

* As modelled by Glenk et al. (2020). Survey attributes that did not produce statistically significant coefficients are not presented here, as they could not effectively be translated into WTA values.
** Estimates based on an estimated population of 126,000 fishers in the Ayeyarwady Region (Silvester et al. 2020).

Management options that were not found to be statistically significant by Glenk et al. (2020) cannot be effectively translated into WTA values, with the exception of sanctuary spaces every nine miles along the river, which revealed a negative estimate indicating that no compensation would be necessary for this particular management measure. This observation was supported by reports from some respondents of pre-existing self-imposed sanctuary spaces, enforced at the community level. It is therefore important to note that as long as sanctuaries are placed at appropriate intervals along the river they can be used in combination with any of the other management options with no additional cost in compensation.

3.4 The net benefits of investing in an incentive scheme

By approximating the total costs and benefits of an incentive scheme for artisanal fishers in Myanmar, we calculated the net present value (NPV) (ie net benefit) and benefit–cost ratio (BCR) of such a scheme over a ten-year period.

We supplemented our estimate of the total amount of compensation required (Section 3.3) with transaction and administration costs incurred by a food compensation scheme in Bangladesh in 2014. These came to BDT33.33 million or an average of BDT146 per household compensated (Haldar & Ali 2014). Updated to 2018 values, this comes to an average of US$2.23 per household. Compensating all 63,000 licensed artisanal fishers in the Ayeyarwady Region of Myanmar

[23] The marginal WTA is the amount that individuals are willing to accept as compensation for a particular regulatory measure, as compared to a different level of regulation.

would therefore incur an annual total of US$140,602 in transaction and administration costs.

If compensation were provided for the three hypothetical management options that were perceived to require the lowest compensation amounts (incentive scenario one in Table 7),[24] individual fishers would require an annual total of US$278. Together with transaction and administration costs, this would scale up to a regional total of US$17.7 million per year. If compensation were provided for the three hypothetical management options that were perceived to require the highest compensation amounts (incentive scenario two in Table 7),[25] individual fishers would require an annual total of US$351 according to the results in Section 3.3. If all licensed artisanal fishers in the Ayeyarwady Region were compensated, this would scale up to an annual total of US$22.3 million, including transaction and administration costs.

Table 7 demonstrates a significant return on investment in an incentive scheme across a range of compensation levels, whether benefits are considered in terms of impacts on our lower bound estimate of value (income derived from hilsa by artisanal fishers in the Ayeyarwady Region) or impacts on our upper bound estimate of value (artisanal fisher income combined with the non-use value derived from artisanal hilsa fisheries by the wider national population). We estimate that, over ten years, investing between US$132.7 million and US$167.2 million could yield a total discounted benefit of between US$957.6 million and US$1.2 billion. Under incentive scenario one (the lowest compensation amount) and considering benefits in terms of use and national non-use value, the NPV of a compensation scheme is US$1.1 billion and the BCR is 9.3, indicating that the benefits outweigh costs by more than nine times. At the lower end of the scale, when the greatest compensation amounts are provided (incentive scenario two) and benefits are considered in terms of`regional artisanal use value alone, the NPV is US$790.4 million and the BCR is 5.7, which is still well above the 1.0 measure for programme viability.

These results show that investment in a compensation scheme would be economically viable, regardless of the compensation amounts that are likely to be required. It should also be noted that although this cost–benefit analysis was conducted using a social discount rate of 7%, net benefits remain positive even with much higher discounting.[26]

Table 7. Comparison of two incentive scenarios over a ten-year time horizon

	TOTAL DISCOUNTED COST (USD)	TOTAL DISCOUNTED BENEFIT (USD)	NPV	BCR
Incentive scenario one				
Lower bound value	132.7 million	957.6 million	824.9 million	7.2
Upper bound value	132.7 million	1.2 billion	1.1 billion	9.3
Incentive scenario two				
Lower bound value	167.2 million	957.6 million	790.4 million	5.7
Upper bound value	167.2 million	1.2 billion	1.1 billion	7.4

[24] Introduce a closed season for 14 days of fishing during peak fishing season, increase fishing net mesh size requirements to 4.5 inches during peak fishing season, and permanently close sanctuary areas to fishing every 9 miles along the river.
[25] Introduce a closed season for 21 days of fishing during peak fishing season, increase fishing net mesh size requirements to 4.5 inches during peak fishing season, and permanently close sanctuary areas to fishing every 3 miles along the river.
[26] For example, under incentive scenario two and considering benefits in terms of use value alone, a discount rate of 35% gives a NPV of US$348.93 million and a BCR of 5.28.

4

Conclusions and recommendations

We estimate that the economic value of Myanmar's artisanal hilsa fisheries could be as high as US$867 million per year. This estimate includes values previously undocumented in national metrics: our lower bound estimate of value, based on the total income derived from hilsa by artisanal fishers in the Ayeyarwady Region (US$731.7 million), as well as estimates of non-use value derived from hilsa by the national population. It should be noted that even our upper bound estimate of economic value is conservative, since it assumes that artisanal fishers comply with the current closed season and does not include income derived from hilsa by fishers outside of the Ayeyarwady Region.[27]

The importance of hilsa to artisanal fishers, in terms of income generated, highlights the scale of socioeconomic return that could be generated through increased investment in sustainable management of artisanal hilsa fisheries. But our calculations also indicate the wider value that coastal populations and the nation as a whole place on the existence of hilsa stocks, and therefore the critical importance of protecting them.

Our research indicates that artisanal fishers in the Ayeyarwady Region would be willing to participate in an incentive scheme for hilsa fisheries management and that some management options were less acceptable than others, requiring higher levels of compensation. WTA values indicated that individual fishers would require a minimum of around US$278 per year in cash compensation for the three hypothetical management options that were perceived to require the highest compensation amounts (ie introduce a closed season for 14 days, increase fishing net mesh size requirements and permanently close sanctuary areas to fishing every nine miles along the river); and a maximum of US$351 for the three hypothetical management options that were perceived to require the highest compensation amounts (ie introduce a closed season for 21 days, increase fishing net mesh size requirements and permanently close sanctuary areas to fishing every three miles along the river).

Our approximation and analysis of the costs and benefits of these hypothetical incentive schemes demonstrate that, despite their cost (between US$17.7 million and US$22.3 million per year if all licensed fishers in the Ayeyarwady Region were included), they would be an economically rewarding investment. Depending on how the benefit–cost ratio was calculated, benefits outweighed costs by between five and nine times and the net present value of the schemes ranged from US$790.4 million up to US$1.1 billion. Furthermore, a previous study has demonstrated how the costs could be funded through fiscal reform (Silvester et al. 2020). By increasing the efficiency of revenue collection from the hilsa value chain and adapting current tools to better target actors nearer the top of the hilsa value chain, the government of Myanmar could triple current revenues available for fisheries management, generating more than enough

[27] There is also artisanal hilsa fishing in Rakhine and Mon States and Yangon and Bago Regions (Baran et al. 2017).,

additional funds to cover the annual total costs of incentive-based management.

It is important to note that the management measures proposed in Glenk et al. (2020)'s choice experiment were hypothetical, and are not necessarily the management measures that should be implemented in practice.[28] Careful location-specific assessments will be required to refine appropriate compensation amounts once specific regulations have been identified for implementation. We also acknowledge that the implementation of the proposed management measures will not necessarily guarantee a comparable increase in hilsa populations to that reported in Bangladesh. However, it is clear that current management measures do not adequately protect hilsa and a new approach is required (Bladon et al. 2019). Incentive-based fisheries management has great potential both to halt the overexploitation of hilsa in Myanmar and reduce vulnerability of artisanal fishers by compensating them for short-term economic losses incurred through compliance with new regulations (Bladon et al. 2016; Dewhurst-Richman et al. 2016). The results from this study demonstrate that, in the context of the value that is derived from these fisheries, incentives to support fishing regulations grounded in rigorous ecological and biological understanding of hilsa would be a worthwhile and cost-effective investment.

[28] Two studies have since been published that provide policy recommendations based on new understanding of the spawning seasonality and migratory routes of hilsa in the Ayeyarwady Region (Bladon et al. 2019; Merayo et al. 2020).

Appendix A Population figures for the coastal states and regions of Myanmar, according to the 2014 census data

Table 1. Population figures from each of the six coastal states and regions in Myanmar, according to the 2014 census data (DoP 2018)

STATE/REGION	POPULATION
Rakhine	2,098,807
Ayeyarwady	6,184,829
Yangon	7,360,703
Bago	4,867,373
Mon	2,054,393
Tanintharyi	1,408,401
Total	23,974,506

References

Bala, BK, Arshad, FM, Alias, EF, Sidique, SF, Noh, KM, Rowshon, MK, Islam, QMM and Islam, MM (2014) Sustainable exploitation of hilsa fish (*Tenualosa ilisha*) population in Bangladesh: Modeling and policy implications. *Ecological Modelling* 283 19–30.

Baran, E, Ko Ko, W, Za Wah, Z, Estepa, N, Samadee, S, Tezzo, X, Myat Nwe, K and Maningo, E (2015) Distribution, migration and breeding of hilsa (*Tenualosa ilisha*) in the Ayeyarwady system in Myanmar. BOBLME, Thailand and FAO.

Baran, E, Nwe, KM, Swe, T, Hanshein, S, Keomonyneath, P, Sokvisal, R, Lunn, Z and Gätke, P (2017) Consultations of fishers on fishery resources and livelihoods in the Ayeyarwady Basin. Ayeyarwady State of the Basin Assessment (SOBA) Report 4.3. National Water Resources Committee (NWRC), Myanmar.

Barr, RF and Mourato, S (2014) Investigating fishers' preferences for the design of marine Payments for Environmental Services schemes. *Ecological Economics* 108 91–103.

Bateman, IJ, Brower, R, Ferrini, S, Schaafsma, M, Barton, DN, Dubgaard, A, Hasler, B, Hime, S, Liekens, I and Navrud, S (2011) Making benefit transfers work: Deriving and testing principles for value transfers for similar and dissimilar sites using a case study of the non-market benefits of water quality improvements across Europe. *Environmental and Resource Economics* 50(3) 365-387.

Belton, B, Marschke, M and Vandergeest, P (2019) Fisheries development, labour and working conditions on Myanmar's marine resource frontier. *Journal of Rural Studies* 69 204–213.

Bladon, A, Myint, KT, Ei, T, Khine, M, Aye, PT, Thwe, TL, Leemans, K, Soe, KM, Akester, M, Merayo, E and Mohammed, EY (2019) Spawning seasonality of hilsa (*Tenualosa ilisha*) in Myanmar's Ayeyarwady Delta. IIED, London.

Bladon, A, Syed, MA, Hassan, SMT, Raihan, AT, Uddin, MN, Ali, ML, Ali, S, Hussein, MB, Mohammed, EY, Porras, I and Steele, P (2016) Finding evidence for the impact of hilsa fishery management in Bangladesh. IIED, London.

BOBLME (2015) Stock assessment of hilsa shad (*Tenualosa ilisha*) in Myanmar. BOBLME, Yangon.

Broberg, T (2014) Relative income and the WTP for public goods. CERE, Sweden.

CBM (2020) Interest rates. Central Bank of Myanmar, Republic of the Union of Myanmar.

Chang, T, and Su, C (2013) Revisiting purchasing power parity of East Asian countries using the rank test for nonlinear cointegration, *Applied Economics* 45(19) 2847–2852.

Czajkowski, M and Ščasný, M (2010) Study on benefit transfer in an international setting. How to improve welfare estimates in the case of the countries' income heterogeneity? *Ecological Economics* 69(12) 2409–2416.

Dewhurst-Richman, N, Mohammed, EY, Ali, ML, Hassan, K, Wahab, MA, Ahmed, ZF, Islam, MM, Bladon, A, Haldar, GC, Ahmed, CS, Majumder, MK, Hossain, MM, Rahman, A and Hussein, B (2016) Balancing carrots and sticks: incentives for sustainable hilsa fishery management in Bangladesh. IIED, London.

DoF (2016) Fisheries Statistics 2016. Department of Fisheries, Ministry of Agriculture, Livestock and Irrigation, Republic of the Union of Myanmar, Naypyidaw.

DoF (2018) Fishery statistics 2018. Department of Fisheries, Ministry of Agriculture, Livestock and Irrigation, Republic of the Union of Myanmar, Naypyidaw.

DoF (2019) Unpublished fishery statistics 2019. Department of Fisheries, Ministry of Agriculture, Livestock and Irrigation, Republic of the Union of Myanmar, Naypyidaw.

DoP (2018) 2014 Census Data. Department of Population, Republic of the Union of Myanmar, Naypyidaw.

Engel, S, Pagiola, S and Wunder, S (2008) Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics* 65(4) 663–674.

FAO (2016) Formulation and operationalization of a National Action Plan for Poverty Alleviation and Rural Development through Agriculture (NAPA). Coastal Resources Management, Yangon.

FAO (2018) FAO Yearbook. Fishery and Aquaculture Statistics 2016. FAO, Rome.

Glenk, K, Johnston, RJ, Meyerhoff, J and Sagebiel, J (2019) Spatial Dimensions of Stated Preference Valuation in Environmental and Resource Economics: Methods, Trends and Challenges. *Environmental and Resource Economics* 75(2) 215–242.

Glenk, K, Novo, P, Khaing, WW, Lwin, WW, Burcham, L, Mohammed, EY, Soe, KM, Akester, M, Bladon, A and Merayo, E (2020) Informing incentive-based management of hilsa fish in Myanmar: Results of a choice experiment. IIED, London.

Gregory, R, Mackay, K, Andrew, N, Nyein, Y, A Naing Oo, A and Hermes, R (2016) Securing Myanmar's Inshore Fisheries. International Center for Living Aquatic Resources Management (ICLARM), Yangon, Myanmar.

Grutters, JPC, Kessels, AGH, Dirksen, CD, van Helvoort-Postulart, D, Anteunis, LJC and Joore, MA (2008) Willingness to Accept versus Willingness to Pay in a Discrete Choice Experiment. *Value in Health* 11(7), 1110–1119.

Haldar, GC and Ali, L (2014) The cost of compensation: Transaction and administration costs of hilsa fish management in Bangladesh. IIED, London.

Hanley, N and Czajkowski, M (2019) The Role of Stated Preference Valuation Methods in Understanding Choices and Informing Policy. *Review of Environmental Economics and Policy* 13(2) 248–266.

Hossain, MS, Sharifuzzaman, SM, Chowdhury, SR and Sarker, S (2016) Habitats across the life cycle of hilsa shad (*Tenualosa ilisha*) in aquatic ecosystem of Bangladesh. *Fisheries Management and Ecology* 23(6) 450–462.

Hossain, MAR, Das, I, Genevier, L, Hazra, S, Rahman, M, Barange, M and Fernandes, JA (2019) Biology and fisheries of Hilsa shad in Bay of Bengal. *Science of the Total Environment* 651 1720–1734.

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

Islam, MM, Islam, N, Sunny, AR, Jentoft, S, Ullah, MH and Sharifuzzaman, SM (2016) Fishers' perceptions of the performance of hilsa shad (Tenualosa ilisha) sanctuaries in Bangladesh. *Ocean & Coastal Management* 130 309–316.

Johnston, RJ and Wainger, LA (2015) Benefit Transfer for Ecosystem Service Valuation: An Introduction to Theory and Methods. In: Johnston, RJ, Rolfe, J, Rosenberger, RS and Brouwer, R (eds.) *Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners*. Springer, Dordrecht 237–274.

Kaul, S, Boyle, KJ, Kuminoff, NV, Parmeter, CF and Pope, JC (2013) What can we learn from benefit transfer errors? Evidence from 20 years of research on convergent validity. *Journal of Environmental Economics and Management* 66(1) 90-104.

Kelleher, K, Westlund, L, Hoshino, E, Mills, D, Willmann, R, de Graaf, G and Brummett, R (2012) Hidden harvest: the global contribution of capture fisheries. Worldbank and WorldFish.

Kenter, JO (2016) Editorial: Shared, plural and cultural values. *Ecosystem Services* 21(B) 175–183.

Khaing, WW, Akester, M, Merayo Garcia, E, Bladon, A and Mohammed, EY (2018) Socioeconomic characteristics of hilsa fishers in the Ayeyarwady Delta, Myanmar: Opportunities and challenges. IIED, London.

Leadbitter, D (2017) Myanmar fisheries – situation report. Fish Matter, Myanmar.

Louviere, JJ, Hensher, DA and Swait, JD (2000) Stated Choice Methods: Analysis and Applications. Cambridge University Press, Cambridge.

MA (Millennium Ecosystem Assessment) (2003) Concepts of Ecosystem Value and Valuation Approaches. In *Ecosystems and Human Well-being: A Framework for Assessment*. MA and Island Press, Washington D.C. 127–147.

Ma,W, Li, H and Park, SY (2017) Empirical conditional quantile test for purchasing power parity: Evidence from East Asian countries. *International Review of Economics & Finance* 49(C) 211–222.

Martínez, A and Bringas, C (2010) Valoración ambiental: aportaciones, alcances y limitaciones. (Environmental assessment: contributions, scope and limitations.) *Problemas del Desarrollo (Development Problems*) 41(160) 209–221.

Merayo, E, Myint, KT, Ei, T, Khine, M, Aye, PT, Thwe, TL, Leemans, K, Soe, KM, Akester, M, Bladon, A and Mohammed, EY (2020) Migratory patterns of hilsa shad in the Myanmar Ayeyarwady delta: Lessons for fisheries management. IED, London.

MMRD (2015) Livelihood assessment of Hilsa fisher families in the Ayeyarwady Delta. Myanmar Marketing Research and Development, Yangon.

Mohammed, EY, Ali, L, Ali, S, Hussein, B, Wahab, MA and Sage, N (2016) Hilsa's non-consumptive value in Bangladesh: Estimating the non-consumptive value of the hilsa fishery in Bangladesh using the contingent valuation method. IIED, London.

Rahman, MJ, Wahab, MA, Nahiduzzaman, M, Haque, ABMM and Cohen, P (2020) Hilsa fishery management in Bangladesh. *IOP Conference Series: Earth and Environmental Science* 414 1–10.

Rambaud, SC and Torrecillas, MJM (2005) Some considerations on the social discount rate. *Environmental Science & Policy* 8(4) 343–355.

Pearce, DW and Warford, JJ (1993) World without end: Economics, environment and sustainable development. Oxford University Press, New York.

Reid, H and Ali, L (2018) Ecosystem-based approaches to adaptation: strengthening the evidence and informing policy. Research results from the Incentive-based Hilsa Conservation Programme, Bangladesh. IIED, London.

Rolfe, J, Windle, J and Johnston, RJ (2015) Applying Benefit Transfer with Limited Data: Unit Value Transfers in Practice. In: Johnston RJ, Rolfe J, Rosenberger R, and Brouwer, R (eds.) *Benefit transfer of environmental and resource values: A guide for researchers and practitioners*. Springer, Dordrecht 141–162.

Rosenberger, RS and Loomis, JB (2003) Benefit Transfer. In: Champ, PA, Boyle, KJ and Brown, TC (eds.) A primer on nonmarket valuation. Springer, New York 445–482.

Silvester, P, Bladon, A, Akester, M, Soe, KM and Mohammed, EY (2020) Financing incentive-based hilsa fisheries management in Myanmar through fiscal reform. IIED, London.

Soe, KM, Baran, E, Grantham, R, Tezzo, X and Johnstone, G (2020) Myanmar inland fisheries and aquaculture: a decade in review. ACIAR, Canberra and WorldFish, Yangon.

Sunny, AR, Ahamed, GS, Mithun, MH, Islam, MA, Das, B, Rahman, A, Rahman, MT, Hasan, MN and Chowdhury, MA (2019) Livelihood status of the hilsa (*Tenualosa ilisha*) fishers: The case of coastal fishing community of the Padma River, Bangladesh. *Journal of Coastal Zone Management* 22(2)(469) 1–8.

Thomas, V and Chindarkar, N (2019) Economic evaluation of sustainable development. Palgrave Macmillan, Singapore.

van Kempen, L, Muradian, R, Sandóval, C and Castañeda, J (2009) Too poor to be green consumers? A field experiment on revealed preferences for firewood in rural Guatemala. *Ecological Economics* 68(7) 2160–2167.

Villanueva, AJ, Glenk, K and Rodríguez-Entrena, M (2017) Protest Responses and Willingness to Accept: Ecosystem Services Providers' Preferences towards Incentive-Based Schemes. *Journal of Agricultural Economics* 68(3) 801–821.

Wainger, LA, Helcoski, R, Farge, KW, Espinola, BA and Green, GT (2018) Evidence of a Shared Value for Nature. *Ecological Economics* 154 107–116.

World Bank (2019a) Official exchange rate – Myanmar. World Bank Group, Washington, DC.

World Bank (2019b) Population, total – Myanmar. World Bank Group, Washington, DC.

Zhuang, J, Liang, Z, Lin, T and De Guzman, F (2007) Theory and practice in the choice of social discount rate for cost–benefit analysis: a survey (No. 94). ERD working paper series.

Current national statistics do not capture the true value of Myanmar's hilsa fisheries. As a result, investment in the sustainable and inclusive management of its artisanal hilsa fisheries is limited. This study estimates the economic value of artisanal hilsa fisheries in Myanmar, using artisanal income data to estimate use value and a benefit transfer to estimate non-use value. Over ten years, implementing an incentive scheme that compensates artisanal fishers for compliance with new fishing regulations could yield a net benefit of between US$790 million and US$1.1 billion, with benefits outweighing costs by up to nine times. These benefits include an annual 5% increase in the income of artisanal fishers and maintenance of the existence value placed on hilsa by the wider population. Although this is a rough approximation of benefits compared with costs, it clearly demonstrates that an incentive scheme would be an economically beneficial management option.

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