



Socio-economic impacts of a poorly designed and managed hilsa shad fish sanctuary in Bangladesh and learning for sustainability

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Abstract

Biodiversity conservation and management of aquatic resources are crucial for improving dependent people's socio-economic conditions to partly achieve the sustainable development goals (SDGs). However, poor design and mismanagement of conservation program can result in negative outcomes. This study assesses the impacts of the Hizla-Mehendiganj hilsa sanctuary (where a complete fishing ban is imposed from March–April each year), Barishal, on fish catch and livelihoods of the dependent fishing communities adjacent to the sanctuary using a mixed-method approach. Results have shown negative impacts on both fish catch and socio-economic conditions of the dependent communities after the sanctuary establishment. Around 73% of fishers have reported that overall fish and hilsa catch in the sanctuary areas have reduced during the ban affecting their financial conditions, and consequently, their opportunity to take three meals a day has reduced. Households' mean fish consumption has decreased from 3.36 to 0.74 kg/week during the ban. Likewise, access to health care, family relationships, and children's education facilities have also been negatively affected during this period. The government's compensations, i.e., 40 kg rice/household/month hardly reach many of them. The compensations are very inadequate and affected due to mismanagement, and the fishers are unsatisfied with this. They were not involved in sanctuary design and management activities. Finally, this study provides some recommendations to involve the fishers in sanctuary management and improve their socio-economic conditions as well as to partly achieve some targets of Bangladesh SDGs.

Keywords Hilsa shad · Biodiversity conservation · Developing country · Fisheries management · SDGs · Bangladesh

1 Introduction

Fish sanctuaries are an important management tool to protect critical habitats and reduce fishing efforts on reproduction and spawning aggregations to preserve biodiversity and increase fish production (Islam et al., 2016a; Kincaid et al., 2014; Leleu et al., 2012). The objectives of a fish sanctuary include the sustainability of fish stocks and

biodiversity, food security for consumers, and habitat restoration (Kinacaid et al., 2014; Leleu et al., 2012). The effective and science-based fish sanctuary provides environmental/ecological, social, and economic benefits to resource-dependent people (Gleason et al., 2010; Spooner et al., 2021).

The sustainable development goals (SDGs) are a collection of seventeen interlinked goals designed to serve as a "shared blueprint for peace and prosperity for people and the planet, now and into the future." They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace, and justice. The United Nations (UN) describes the SDGs as seeking to "protect the planet, and improve the lives and prospects of everyone, everywhere" (UN, 2015). The SDGs 17 goals are No poverty (1), Zero hunger (2), Good health and well-being (3), Quality education (4), Gender equality (5), Clean water and sanitation (6), Affordable and clean energy (7), Decent work and economic growth (8), Industry, innovation, and infrastructure (9), Reduced inequalities (10), Sustainable cities and communities (11), Responsible consumption and production (12), Climate action (13), Life below water (14), Life on land (15), Peace, justice, and strong institutions (16), and Partnership for the goals (17). Some well-defined targets are set to partly achieve the SDGs goals such as 1 (No poverty), 2 (Zero hunger), 14 (Life below water), and 15 (Life on land) using effective and science-based fish sanctuary.

An effective fish sanctuary may contribute to SDG 1 (No poverty) by achieving the targets 1.1, 1.2, 1.4, and 1.b, respectively. It can achieve the above targets by eradicating poverty of the resource-dependent people by increasing fish production and thereby increasing income; reducing the proportion of women, men, and children of all ages living in poverty line through increasing income from fishery; ensuring equal access to the fishery resources and other basic services such as natural resource ownership, financial services including microfinance and appropriate new technologies for all men and women, particularly the vulnerable and poor; and providing sound policy frameworks based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions (UN, 2015). Besides, a fish sanctuary may contribute to SDG 2 (Zero hunger) by achieving target 2.3 by doubling the fish production and incomes of small-scale fishers, including secure and equal access to resources, knowledge, financial services, market, and opportunities for value addition (UN, 2015).

In addition, fish sanctuaries may contribute to achieve the targets 14.1, 14.2, 14.4, and 14.7 of SDG 14 (Life below water) by significantly reducing pollution of all kinds in the sanctuary area, in particular from land-based activities; by sustainably managing and protecting marine and coastal ecosystems including strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans; by effectively regulating harvesting and ending overfishing, illegal, unreported and unregulated fishing, and destructive fishing practices and implementing science-based management plans in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics; and by increasing the economic benefits from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture, and tourism (UN, 2015).

Moreover, fish sanctuaries may help to attain SDG 15 (Life on land) by reaching target 15.1 through the conservation, restoration, and sustainable use of inland freshwater ecosystems and their services; target 15.5 by taking urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity; and target 15.6 by promoting fair and equitable sharing of the benefits arising from the utilization of fisheries resources and promote appropriate access to resources (UN, 2015).

While fish sanctuaries are treated as an effective fisheries management tool and contribute to the SDGs, poorly designed fish sanctuaries can have opposite impacts especially negative impacts on the dependent communities economically, socially, politically, and culturally (Islam et al., 2016a; Jentoft et al., 2012; Mascia et al., 2010). For instance, closed areas frequently evict or marginalize subsistence fishermen, causing them financial hardship by limiting their income-generating options (Isaacs, 2011). Negative socio-economic impacts of marine conservation actions were found in three fishing communities in Indonesia (Eriksson et al., 2019). Due to negative socio-economic impacts, the lack of community support is found as a significant barrier to achieve desired success for implementation of the management action (Kinacaid et al., 2014). The community support lacking can be especially extreme while the advent of the sanctuary/other management action is accomplished without considering its possible effects on dependent communities. That's why the local context is vital to take into account in aquatic and marine conservation governance, and as a result, a combination of top-down and bottom-up governance tools may be more effective than a pure top-down strategy in some cases (Gaymer et al., 2014). It is, therefore, crucial to involve the fishing communities as stakeholders in the establishment of sanctuaries and other such kinds of fisheries conservation, to understand their circumstances and interests. In some countries, the government has provided incentives in the form of cash/rice and alternative income-generating activities on a limited scale to compensate fishers for fishing restrictions (Eriksson et al., 2019; Islam et al., 2016a; Von Essen et al., 2013). However, well-defined goals and objectives are prerequisites for any resource management plan (Gilliland & Laffoley, 2008; Katsanevakis et al., 2011; Stelzenmüller et al., 2013) which serve multiple purposes including delivering high-level planning strategies; clarifying expected outcomes and adopted measures; generating scenarios and evaluating identified options; and tracking implementation progress and, ultimately, the success of the adopted plan (Douvere & Ehler, 2011; Gilliland & Laffoley, 2008; Rogers et al., 2007). As such, the aim of this study is to assess the effectiveness of a coastal fish sanctuary in Bangladesh in order to portray its role in improving (or hindering) the socio-economic conditions of the dependent communities as well as partly fulfilling some targets of SDGs.

2 Fish conservation and management in Bangladesh

The Bangladesh government has taken some management actions toward the conservation of fish stocks (Rahman et al., 2018a, 2018b) in line of its policies, acts, rules, ordinances, strategies, and conventions. Some examples of conservation and management approaches include the establishment of fish sanctuaries, marine protected areas (Sarker et al., 2021), co-management (Islam et al., 2020), ecosystem approach to fisheries management (EAFM) (Islam et al., 2022), community-based management (Islam et al., 2020), integrated coastal zone management, payment for ecosystem services (Islam et al., 2016b), ecologically critical area, etc. The conservation actions include specific gear restrictions, bans on catching under-size fish species, fishing restrictions for specific times and areas, etc. These actions have different types of impacts on the local and dependent communities especially ecologically, socially, economically, and politically (Islam et al., 2016a; Jentoft et al., 2012; Mascia et al., 2010). However, the conservation program's social outcomes have received less attention, resulting in lower performance in terms of effectiveness and social equality (Islam, 2021). For example, Bangladesh's government has started payment for ecosystem services (PES) in the form of providing rice and alternative income-generating supports

on a limited scale (Islam et al., 2016b; Mozumder et al., 2018). In addition, the participation of local community stakeholders such as fishermen in developing a management plan for fish sanctuaries/marine protected areas/other actions is often ignored; however, it is very important for the effective and successful implementation of the conservation actions. In Bangladesh, a few studies have existed on the evaluations of the various impacts of the sanctuaries (a fisheries management approach) (Islam et al., 2016a, 2016b, 2018; Khan et al., 2018; Latif & Latif, 2018). For instance, a fish sanctuary in Kolavanga beel of Netrokona has positive ecological and economic impacts (Khan et al., 2018). Haldi Beel tank sanctuary also has positive impacts on fish production and the socio-economic condition of fishermen (Mahanta, 2022; Latif & Latif, 2018). To conserve Hilsa, the Bangladesh government has established six hilsa sanctuaries.

3 Different perspectives of hilsa shad fish

Hilsa shad (*Tenualosa ilisha*) is a biologically, economically, nutritionally, and culturally valuable fish species in the Bay of Bengal and Persian Gulf regions. It is an anadromous fish that migrates from sea to freshwater rivers and estuaries to spawn, but it also migrates in an amphidromous manner, that is, frequently transfers between freshwater and marine environments for feeding and swimming in accordance with tidal rhythms (Rahman et al., 2018a, 2018b). Hilsa is predominantly a plankton feeder, and it contributes to the trophic cycle by feeding at the lower trophic levels as the primary consumer. Nutritionally, it is a high-protein (18%) and high-lipid (19.5%) fish and rich in essential micronutrients, especially phosphorus, calcium, zinc, vitamins A and E, polyunsaturated fatty acids (PUFA), and Omega-3 fatty acids. Bangladesh has the lion's share (86%) of the fish, subsequently followed by India (8%), Myanmar (4%), and the remaining countries. It is the national fish and geographical indication (GI) product of Bangladesh. Hilsa, an iconic flagship species, is the single largest fishery in Bangladesh which contributes more than 1% to the national GDP (DoF, 2022). Besides, hilsa has cultural values as it is considered the prestigious fish in "Jamai Sasti" festival, even in "Durga Puja," the major religious event for Hindu communities in Bangladesh and India (DoF, 2022). Moreover, more than 2.5 million people are directly and indirectly involved in hilsa fishing for their livelihoods (DoF, 2022). Due to the huge importance of this single fish, the Bangladesh government has taken many initiatives for the conservation and management of hilsa. Among the initiatives, the Bangladesh government has established six hilsa sanctuaries to maintain sustainable production of this species. Now, the question is whether the hilsa sanctuaries are effective or not! Islam et al. (2016a) studied the effectiveness of five hilsa sanctuaries, and they reported that the fishers felt the increase in the hilsa production due to the establishment of hilsa sanctuaries, but the fishing ban has caused significant economic hardship due to the loss of income of the fishers during the ban. Overall, the studied five sanctuaries have positive ecological impacts but negative socio-economic impacts on the hilsa-dependent fishers (Islam et al., 2016a). Bangladesh government has established the 6th hilsa shad sanctuary in 2018 but no study has evaluated its effectiveness. For this, a rigorous study is needed to investigate the ecological and socio-economic impacts of the sanctuary and its management actions. Therefore, this study aimed to assess the impacts of the 6th hilsa shad sanctuary on hilsa production and the socio-economic condition of the dependent fishers for providing suggestions for better management and conservation of hilsa in order to partly achieve SDGs.

4 Methodology

4.1 Description of the study sites

This study was based on the Hizla-Mehendiganj hilsa sanctuary—the 6th hilsa sanctuary in Bangladesh which was established in 2018 and is the latest one (Fig. 1). The sanctuary is 82 kilometre (km) long covering an area of 318 km² in Hizla and Mehendiganj Upazila (sub-district) of Barishal district. Any type of fishing activity is prohibited in the sanctuary from March to April each year. Besides, 22 days fishing ban for conserving brood hilsa during its peak spawning season which is around the first full moon in the Bengali month of Ashwin (October–November) is also implemented here. Catching juvenile hilsa (*Jatka*) of < 25 centimetre (cm) is restricted throughout the year (DoF, 2020). Some specific gear restrictions such as the use of monofilament gill nets (e.g., *current jal*), bottom set bag nets (e.g., *behundi jal*), and any net with mesh size less than 6.5 cm are implemented throughout the year all over the country.

Figure 1 shows the location of the six hilsa sanctuaries in Bangladesh where the brown color indicates the location of the Hizla-Mehendiganj hilsa sanctuary. This sanctuary-dependent fishing communities are the inhabitants of Moddherchar, Char Bouduba, Char Lata, and Barajalia in Mehendiganj and Shreepur, Choygao, Nachokathi, Khagerchar, Char killa, Char Lakshmipur, and Kulargao in Hizla (Fig. 2). Most of the fishers are directly dependent on fishing inside the sanctuary for their livelihoods.

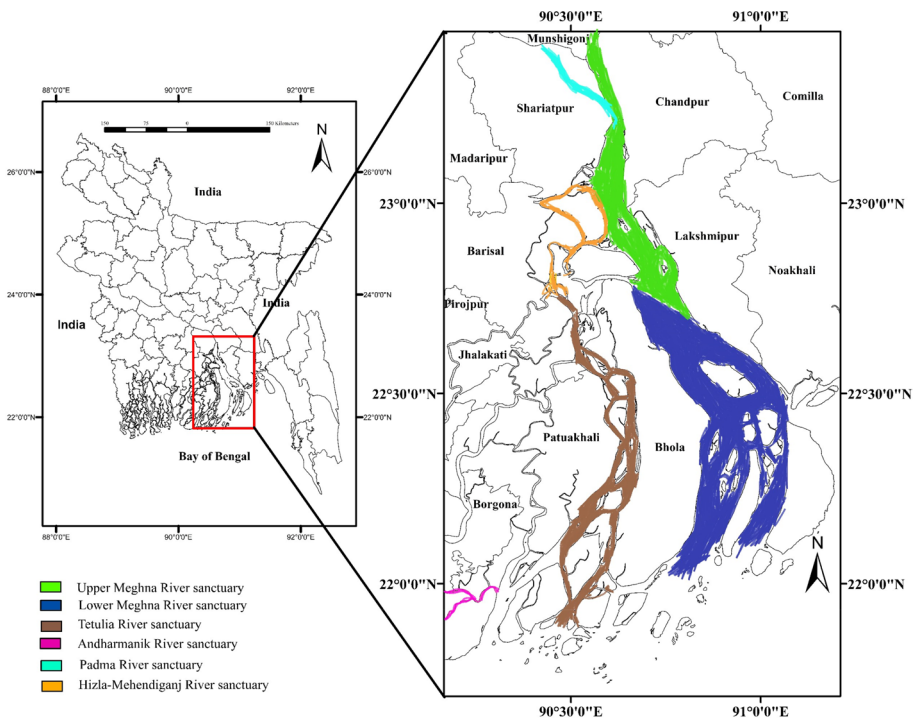


Fig. 1 Location of the six hilsa (*Tenualosa ilisha*) sanctuaries in Bangladesh (adapted from Islam et al., 2020)

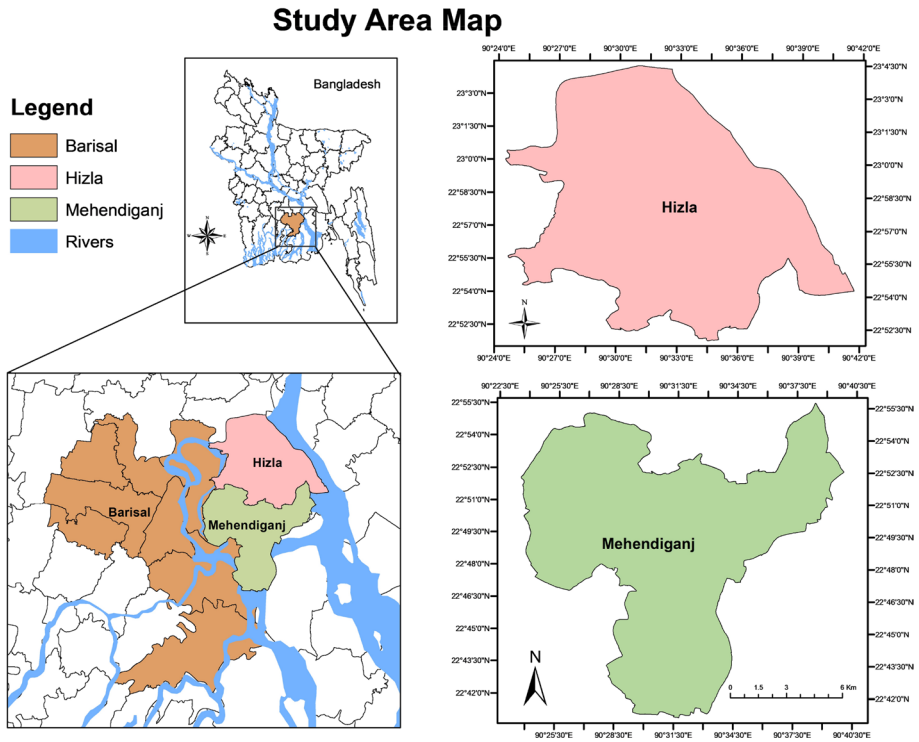


Fig. 2 Map of the study area, Barishal District, Bangladesh

Around 26,279 registered fishers live in Mehendiganj Upazila and 19,770 in Hizla Upazila (DoF, 2020).

4.2 Data collection

In this study, qualitative and quantitative data were collected using a mixed-method approach. Data collection tools are described below:

4.2.1 Household questionnaire survey

Household questionnaire surveys were conducted to collect data concerning the impact of the sanctuary on the dependent fishing communities such as changes in household food consumption, daily food intake frequency, health-care facilities, family relationship, children's education facilities, changes in income, formal and informal credits taking rate, etc., during and beyond fishing ban. In addition, involvement in the sanctuary establishment, satisfaction with the compensation scheme, alternative income-generating activities, etc., related data were also collected. A semi-structured questionnaire was developed earlier which was modified after the scoping study. For the household survey, the sample size was calculated following the formula of Yamane (1973):

$$n = \frac{N}{1 + N(e)^2}$$

where n = sample size, N = population size = 476, and e = marginal error = 0.05. A total of 217 household questionnaire surveys were conducted in this study, and respondents were selected for the household survey based on the random sampling technique. In this study, only household heads were interviewed, and each session lasted for about 45 min.

4.2.2 Key informant interviews (KIIs)

A total of six key informant interviews (KIIs) were conducted in the Hizla and Mehendiganj Upazila (three in each Upazila). In this study, experts for KIIs were chosen within and outside the communities (e.g., members of the fishers' cooperative society, Upazila fisheries officers, etc.) who had adequate knowledge about the fishing communities. Moreover, representatives of different governmental and non-governmental organizations (GOs and NGOs) (e.g., local union Parishad Member, NGO officials, etc.) who are involved with the communities were also interviewed. A checklist containing the socio-economic impacts of the Hizla-Mehendiganj hilsa sanctuary on the dependent fishing communities was designed before the KIIs. Each session continued for 40–45 min.

4.2.3 Focus group discussions (FGDs)

To triangulate the data collected from the household questionnaire surveys, two focus group discussions (FGDs) were conducted in this study. Both the FGDs lasted for around 2 h. As some participants might feel uncomfortable talking in front of certain people (e.g., community leaders or any political person), so each FGD consisted of 8–10 homogenous participants (local fishers who fish in the river) (Powell & Single, 1996). Alike KIIs, a checklist was also designed before conducting the FGDs. A breakout session was conducted to encourage all respondents to involve in the discussion session. In the FGD session, all participants' involvement was confirmed in the discussion.

4.3 Data analysis

The quantitative data were coded using SPSS version 20.0. Descriptive statistics such as mean, frequency, standard errors, percentage, Pearson's chi-square test, etc., were used for the quantitative data analysis. The content analysis technique was used for the qualitative data analysis. Based on the grounded theory approach, qualitative data were categorized into different themes and groups. The analysis consisted of three steps: preparing and organizing the data for analysis, reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in tables or as part of a discussion (Strauss & Corbin, 1998). Data were presented in tabular and graphical formats.

5 Results and discussion

5.1 Socio-economic conditions of the fishing communities

This study has found that 88% of respondents are full-time fishers, whereas, the rest of them are part-time fishers (Table 1). All of the household heads are male dominated (who have the decision-making power in the household) in the surveyed communities. The household head's mean age is 36.82 years. Most of the fishers are involved in fishing over the decades. The mean experience of fishing is approximately 19 ± 11 years in the study sites. The study has found that more than half of the respondents are illiterate (57%). The mean years of education is 1.88 ± 2.64 years. This study has shown that only 71% of fishers had fisher's identity (ID) card, which is provided by the Department of Fisheries, Government of the People's Republic of Bangladesh. This study has found that fishers use different types of fishing gear to catch fish. Around 78% of fishers use monofilament gill nets particularly *current jal*, and 66% of fishers use other types of gill nets such as *Sutar jal* along with seine nets and fixed purse nets. Almost all of the fishers use mechanized and non-mechanized boats to catch fish either using own or shared boats. This study has estimated that fisher households' mean monthly income including fishing and other activities is USD (United States dollar) 140.90 ± 59.53 , and the overall mean monthly expenditure is USD 128.21 ± 56.63 .

Pearson's correlation matrix demonstrated that there are significant relationships among different categorical responses of the fishery-dependent communities. For example, this study found a moderate positive correlation between household's mean monthly income from fishing and household's mean monthly expenditure (p value=0.658) as well as age of the household head and years of fishing experiences (p value=0.544) (Table 2). There has also a significant correlation between number of household's total members and household's mean monthly income from fishing as well as household's mean monthly expenditure.

5.2 Impact of the sanctuary on fish catch

In this study, 73% of fishers perceived that overall fish catch including hilsa was comparatively high in the water bodies adjacent to the Hizla-Mehendiganj sanctuary before the establishment of the sanctuary (Table 3). Based on local fishers' perception, this study found that the catch of big-size hilsa (more than 1.2 kg) and medium-size hilsa (0.5–1.2 kg) was high before the establishment of the sanctuary. However, around 55% of fishers reported that the catch of juvenile hilsa (< 25 cm) (locally known as *Jatka*) is high after the establishment of the sanctuary. Recent records of yearly riverine capture-based fish production in the Barishal district showed that in the 2016–2017 fiscal year, fish production was 41,326 metric tons (MT) (DoF, 2017), whereas, in the 2018–2019 fiscal year, it was 40,503 MT (DoF, 2019) which partially supports fishers perceptions on decreasing fish catch after the sanctuary implementation. The FGD participants also reported that overall fish catch including hilsa has reduced to some extent after the establishment of the sanctuary.

The above-mentioned case is not the same for all the hilsa sanctuaries around the country. Islam et al. (2016a) reported that hilsa catches have increased due to the establishment of 5 hilsa sanctuaries as most fishers (75%) agreed. In another study, about 17% of fishers

Table 1 Household basic information of the fishery-dependent communities of the Hizla and Mehendiganj Upazila, Bangladesh ($n=217$)

Criteria	Percentage (%)	Mean \pm SD
Type of fisher	88	–
	12	–
Gender of fisher	100	–
	0	–
Age (years)	0.5	36.82 \pm 12.41
	28	–
	34	–
	19	–
	11	–
	7.5	–
Experience in fishing (years)	–	18.89 \pm 10.58
Education	57	–
	0	–
	32	–
	10	–
Number of household's family members	27.7	5.66 \pm 1.92
	57.3	–
	12.3	–
	2.7	–
Households' fishery-related resources (boat)	53	–
	46	–
	77	–
	16	–

Table 1 (continued)

Criteria	Percentage (%)	Mean \pm SD
Households' fishery-related resources (net)		
Monofilament gill net	78	–
Seine net	3	
Bottom set bag net (<i>Behundi jal</i>)	1	
Rectangular-shaped gill net (<i>Bata jal</i>)	1	
Gill net (<i>Sutar jal</i>)	66	
<i>Poa jal</i> (gill net to catch Pama croaker)	11	
<i>Chewa jal</i> (gill net to catch Chewa fish)	17	
<i>Bei jal</i> (gill net)	10	
Households' mean monthly expenditure (USD) over the year		128.21 \pm 56.63
Households' mean monthly income (USD) from fishing excluding ban		124.25 \pm 56.38
Households' total mean monthly income (USD) including fishing and other activities excluding the ban		140.90 \pm 59.53
Households' mean monthly income (USD) from fishing during the ban		0
Households' total mean monthly income (USD) from other activities excluding fishing during the ban		16.65 \pm 30.46

* 1 USD = 87.62 BDT (Bangladesh Taka) (date: May 30, 2022)

Table 2 Pearson's correlation among different categories of the fishery-dependent communities of the Hizla and Mehendiganj Upazila, Bangladesh

Variables	Age of household head (year)	Fishing involvement (year)	Education (year)	Household members (No.)	Household's mean monthly expenditure (USD)	Household's mean monthly income from fishing (USD)
Age of household head (year)	1	0.544**	-0.204**	0.149*	0.101	0.056
Fishing involvement (year)	0.544**	1	-0.137*	0.083	0.070	0.067
Education (year)	-0.204**	-0.137*	1	0.009	-0.044	0.082
Household members (No.)	0.149*	0.083	0.009	1	0.342**	0.227**
Household's mean monthly expenditure (USD)	0.101	0.070	-0.044	0.342**	1	0.658**
Household's mean monthly income from fishing (USD)	0.056	0.067	0.082	0.227**	0.658**	1

**Correlation is significant at the 0.01 level (two-tailed)

*Correlation is significant at the 0.05 level (two-tailed)

Table 3 Fisher's perceptions on the fish catch before and after the sanctuary establishment in the Hizla-Mehendiganj hilsa sanctuary, Bangladesh

		Fishers' perceptions on the amount of fish catch (% of response)				
		Very high	High	No change	Low	Very low
Fish catch	Before sanctuary	1.9	73	7	17.8	0
	After sanctuary	0.5	18	9	67	6
Hilsa catch	Before sanctuary	4	70	4	22	0
	After sanctuary	1	23	4	66	7
> 1.2-kg size hilsa catch	Before sanctuary	7	68	9	15	1
	After sanctuary	1	16	8	43	33
0.5–1.2-kg size hilsa catch	Before sanctuary	2	57	24	17	0
	After sanctuary	1	21	25	47	6
Juvenile hilsa catch	Before sanctuary	5	49	9	35	3
	After sanctuary	8	55	5	30	3

Some data are provided as [bold] due to highlighting the higher percentage

were neutral about whether hilsa catches increased or not in the sanctuaries, whereas, the remaining 8% of fishers disagreed. In the Meghna River, the majority of fishers indicated a positive trend of catch after the establishment of the hilsa sanctuary (Islam et al., 2018). In the current study, a prevalent response from the responding fishermen was “*too many fishers chasing too little fish*,” indicating that the rising number of fishers is leading to overfishing. This overfishing happens particularly through the use of illegal fishing equipment (Islam et al., 2018) which is highly supported by the present study.

In this study, large-size hilsa decreased but small-size hilsa (juvenile) increased after the establishment of the sanctuary which is contradictory to other hilsa sanctuaries and other fish sanctuaries. This might be occurred because of the increasing use of small mesh size fishing gear and decreasing large- and medium-size hilsa. In addition, this study has found that fisher number has increased in the Hizla-Mehendiganj hilsa sanctuary to some extent after the sanctuary establishment which might also affect the overall fish catch. Since more people are being engaged in fishing activities, intensified fishing efforts and increased competition for fishing ultimately exacerbated the overall fish production. Some fishers also said that the depth of the mouth of the sanctuary has decreased to less than 10 m preventing large hilsa to enter into the sanctuary.

5.3 Impact of the sanctuary on the fishery-dependent households

This study has found adverse impacts on the socio-economic conditions of the fishery-dependent communities of the Hizla and Mehendiganj Upazila. They are described below:

5.3.1 Impacts on daily basic needs

Results have shown that 2 months fishing ban in the sanctuary negatively affected the basic daily needs of the fishers. The opportunity to take three meals a day has changed to two meals a day or lesser during the fishing ban comparing other periods. About 55% of fishers

Table 4 Fishers' perception (in percentage) on the changes in daily basic needs during and outside the fishing ban period in the Hizla-Mehendiganj hilsa sanctuary, Bangladesh

Household daily basic needs		Fishers' perceptions (in percentage)				
		Very good	Good	Moderate	Bad	Very bad
Opportunity to take three meals a day	Outside ban period	1	55	37	7	0
	During ban period	0	4	27	47	22
Households' health-care facility	Outside ban period	0	46	47	6	1
	During ban period	0	2	20	58	20
Children's education	Outside ban period	0	41	50	8	1
	During ban period	0	4	25	51	21
Opportunity for supplementary work	Outside ban period	0	11	30	37	22
	During ban period	0	8	22	28	42
Households' family relationship	Outside ban period	1	66	32	1	1
	During ban period	0	21	33	40	6

Some data are provided as bold due to highlighting the higher percentages

reported that the opportunity to take three meals a day is good outside the ban period, whereas 69% of fishers reported that this opportunity is reduced during the ban (Table 4). This study has shown that 78% of respondents' health-care facilities is bad and/or very bad (i.e., they cannot get health-care facilities due to lack of money) during the ban, whereas, only 7% of fishers reported that their health-care facilities are bad and/or very bad when there is no fishing ban. This indicates that the sanctuary particularly the fishing ban negatively indirectly affected the local fishing communities' health-care facilities. The scenario is almost similar in the case of children's education in the fishery-dependent communities of the study areas. According to FGDs, local fishers' opportunities for supplementary work become scarce during the ban as many fishers become jobless, whereas, the condition is fair enough when there is no fishing ban over the year.

Islam et al. (2018) reported, like the current study, that, in most cases, fisher households' daily food intake from three meals a day has been reduced to two meals or lesser meals a day during the fishing ban due to their very low income. Generally, fish sanctuaries have imposed adverse socio-economic impacts on the fisher's livelihood. According to Islam et al. (2016a), 65% of fishers reported that they failed to manage or ensure their households three meals a day because of financial hardships which strongly supports the findings of the present study. Eriksson et al. (2019) also reported that the income of fishers had drastically reduced during the fishing ban which had negatively affected their daily basic needs.

5.3.2 Changes in fish consumption

Fish consumption is relatively high in the fishing communities of Bangladesh. In fishing communities, fish is their main source of protein. Generally, fisher households target to sell high-value species and consume less-valued species caught by them. This study has found that the mean weekly fish consumption of a household is 3.36 kg with a maximum value of 14 kg/week when there is no ban on fishing (Table 5). However, during the fishing ban, their fish consumption has decreased drastically to 0.74 kg/week. During the ban, some fisher households are unable to eat any fish as they could not afford to buy fish from the market. As a result, in some cases, this leads to illegal fishing during the ban. Comparing

Table 5 Changes in household fish consumption (kg/week) during and outside the ban period in the Hizla-Mehendiganj hilsa sanctuary, Bangladesh ($n = 151$)

Changes in households' fish consumption	Range (kg/week)	Mean \pm SD (kg/week)
During ban period	0–8	0.74 \pm 1.22
Months excluding the ban period	0.5–14	3.36 \pm 2.27

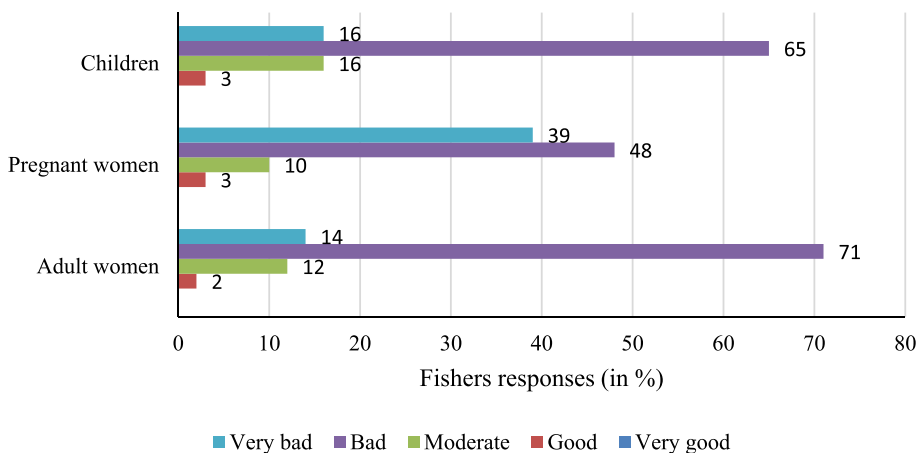
with the poor and marginalized fisher households (majority in number), the richer fishers (fewer in number) were able to buy fish from the market to meet their daily protein needs during the ban. One of the FGD participants in Mehendiganj says,

Two months of fishing bans in the sanctuary is good for rich and powerful people but bad for the poor.

The findings of this study are aligned with the findings of some other studies that also reported that hilsa fishery-dependent households' fish consumption rates were reduced severely and their livelihood patterns changed dramatically as their income from fishing ceased during the ban (Arin, 2018; Islam et al., 2016a).

5.3.3 Impacts on women and children

The conservation actions have a profound impact on the women and children of the fishery-dependent communities. In this study, around 71%, 48%, and 65% of the respondents reported that the fishing ban has been considered bad for adult women, pregnant women, and children of the dependent households, respectively (Fig. 3). Even, 16%, 39%, and 14% of the respondents reported that the ban has very bad impacts on the above-mentioned three groups. From KIIs, this study has found that female members of the fisher households have suffered the most in terms of food consumption and health-care facilities during

**Fig. 3** Fishers' perception (in percentage) on the impacts of fishing bans on adult women, pregnant women, and children during the fishing ban

the ban period. In addition, children and pregnant women of the fisher households suffer severely from protein deficiency during the ban as fishers cannot buy protein-rich foods. The findings of this study are in line with the findings of Islam et al. (2016b). Some fisher households often take their kids out of school to save money, particularly during the ban season and place them in income-generating activities to support their family expenses (Islam et al., 2016a, 2018).

5.3.4 Impacts on fishers' finance

The household's mean monthly income from fishing is USD 124.21 outside the ban period which covers 89% (mean value) of the household income over the year. However, fishers have no income from fishing during the ban as they do not go fishing in the rivers at that time. Some fishers who have alternative income-generating activities have earned some money to support their families (see Sect. 5.3.5 for more details). However, the opportunity for alternative job activities is very scarce for them to bear the family expenses.

Because of no income from fishing during the ban, fishers are often taken formal and informal credits from the local Mohajon (money lenders) or Aratdar (depot holder). This study has found that the percentage of informal and formal credits taken by the fishers has increased to some extent during the ban comparing non-ban periods to maintain daily expenses (Fig. 4). One of the FGD participants reported that a considerable number of fishers do not have any supplementary income-generating activities; therefore, they are bound to take loans from formal and informal sources and pay them back while they can earn money from fishing.

This study has found that the majority of the hilsa fishers are living from hand to mouth. They were compelled to borrow money from relatives, neighbors, or non-governmental organizations (NGOs) at an extremely high-interest rate during the ban because their income source was likely to be cut off in that period. The amount of the loan varied between USD 22.83 and 570.86. For the majority of them, they had to sell their boats and nets to pay back the debt, and they gradually became impoverished (Arin, 2018). One of the FGD participants reported that marine conservation activities were important, but their income had reduced as a result of implementing marine conservation. According to Eriksson et al. (2019), around 49% of respondents stated in their study that their economic gain had deteriorated since marine conservation activities began in their area. The most frequently urged response from the fishers was a loss of income as a direct result of the fishing

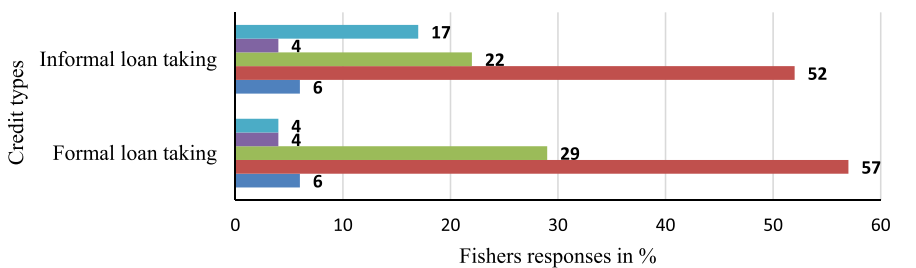


Fig. 4 Fishers' perception (in percentage) of changes in credits during the fishing ban

ban (Islam et al., 2018). Islam et al. (2016a) reported that fish sanctuaries had a detrimental impact on their fishing income. During the ban, fishers borrowed money through micro-credit groups, money lenders, and other middlemen in the fish value chain. Many fishing households have a widespread practice of taking microcredit from one NGO and repaying it to another NGO, resulting in them always remaining in debt to microcredit institutions. This situation indicated that the livelihoods of hilsa fishers are not sustainable (Islam et al., 2018).

As fishers rely on middlemen for capital, middlemen frequently encourage fishers to engage in illicit fishing with destructive gear to satisfy their avarice (Branch et al., 2002). Another study found that fishers continue to fish during the prohibited season to pay back their weekly loan installments to microcredit institutions (Rahman et al., 2011). These findings are consistent with the condition of "poverty traps" (Barbier, 2010; Barrett & Swallow, 2006; Haidar et al., 2018; Stoop et al., 2016) in which impoverished fishers are unable to mobilize the resources necessary to overcome either shocks or low-income situations, and as a result, they participate in activities that may further entrench their poverty (Cinner, 2009; van Brakel et al., 2018).

5.3.5 Impacts on alternative income-generating activities

There have very less alternative livelihood opportunities among the fishers of the sanctuary area. Fishing is the main livelihood activity of 88% of households (Table 1). Fishers' alternative livelihood activities are daily laboring, agriculture laboring, agriculture, cattle rearing, small business, driving, carpentry, etc., during the ban as well as during non-ban seasons. This study found that only 12% of fishers have alternative income-generating activities. The findings of the present study coincided with the findings of some other studies (Eriksson et al., 2019; Islam et al., 2016a, 2018). According to the study by Eriksson et al. (2019), in the Indonesian fishing communities, 37% of fishers reported that they had easy access to alternate sources of income, while 46% of the fishers reported that they had no access to such sources. The most significant barrier is a lack of access to financial assistance for the establishment of new businesses, such as street kitchens or local shops (Eriksson et al., 2019).

Moreover, some studies indicated that fishers typically lack formal schooling, and their abilities are not easily transferable to other occupations. As a result, fishers are ill-equipped to find alternate employment during seasonal closures (Felt, 1990; Islam, 2011; Islam et al., 2018). According to many respondents, fishing is the only job they learned from their forefathers, so they are unable to supplement their income by working in another occupation. As a result, they have no fishing, so no income during the ban (Islam et al., 2018; Mozumder et al., 2018).

5.3.6 Impacts on the compensation scheme

According to the Department of Fisheries, Government of the People's Republic of Bangladesh, registered fishers (i.e., fisher ID card holders) who are dependent on the water bodies adjacent to the sanctuary area are being provided with 40 kg of rice per month as compensation during the 2 months of fishing ban (DoF, 2019). However, 62% of fishers have reported that they do not get any compensation during the ban period. Among the fishers who got the compensation, all accused that they did not get the full compensation package, i.e., 40-kg rice per month. They got only 10–30 kg of rice per

month. The finding of the present study highly supports the findings of other studies such as Arin (2018), Islam et al. (2016a), and Islam et al. (2018). Arin (2018) found that only 37.5% of fishers received a government-issued VGF card, while 62.5% lacked one. The VGF cardholders received 10–15 kg of rice three times a year which is insufficient for the fishers' households (Arin, 2018). This study has found that for all who got some rice, their fisher ID cards are taken by the local government representative (Chairman of Union Parishad) and are not given back for a year. A few of the fishers also claimed that there is mismanagement of the distribution of compensation during the ban among the registered fishers by the local government representatives. They raised the issue of nepotism by the local government representatives. Islam et al. (2018) also reported that the process of enlisting legitimate fishers is unjust because of nepotism and corruption.

In this study, around 29% of the respondents reported that they do not have a "jele card" (fishermen's identity card), which is required to get government incentives during the ban. One of the FGD participants reported that a 2-month supply of 40 kg of rice per month is insufficient for fisher households. Fishers further reported that they did not get any cash incentives to meet other family expenses such as education and medical costs.

Around 54% of fishers reported that they are very unsatisfied with the compensation scheme (Fig. 5). Besides, they do not get their compensation on time. One of the key informants also raised the same issue for the compensation scheme. According to the government's rules, compensation should be provided before and during the enforcement of the fishing ban (DoF, 2019). This study has found that most of the fishers (80%) are unhappy and do not support the 65 days marine fishing ban because of the failed compensation scheme, less availability of hilsa and other fish, corruption among law enforcers, etc.

According to the study of Islam et al. (2016a), one fisherman who received government compensation reported that during the 15 days fishing ban for the conservation of hilsa spawning (the government increased the duration of the fishing ban to 22 days later), his lost income from fishing was USD 10 against the monthly incentive of USD 7. Certainly, this incentive by the government is insufficient to compensate fishers' financial losses. Their loss is even higher during the jatka ban period (Islam et al., 2016a). Given that hilsa fishers are typically poor (Islam et al., 2016b; Minar et al., 2012; Mozumder et al., 2018), sanctuaries could make them worse off if the government does not provide suitable alternative livelihoods and compensations for them.

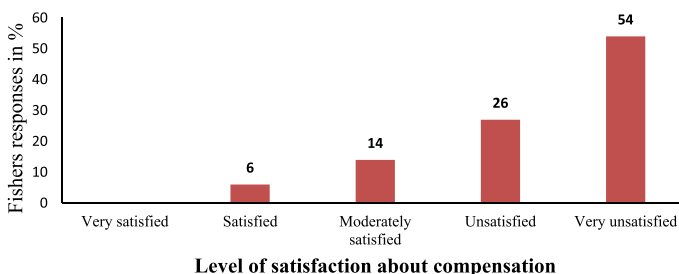


Fig. 5 Percent (%) response of satisfaction among the fishers regarding the compensation scheme

5.4 Involvement of fishers in sanctuary management

In this study, around 99% of respondents of Hizla and Mehendiganj Upazila stated that they are not involved in the hilsa fish conservation management process. The government did not consult or inform the fishers before the establishment of the sanctuary. Moreover, FGD participants reported that they do not get any kind of announcement before the start of the fishing ban each year. As a result, this leads them to fish during the ban, and some of the fishers get caught by the implementing administration for illegal fishing. This study found a communication gap between local fishers and government fisheries institutions which indicates the poor management of the Hizla-Mehendiganj hilsa fishery sanctuary.

5.5 Toward ecological and socio-economic sustainability of the sanctuary management

Based on fishers' perceptions, this study found that overall fish production including big- and medium-size hilsa catch has decreased in the study sites after the establishment of Hizla-Mehendiganj hilsa sanctuary which has created negative socio-economic impacts on the dependent communities. Fishers' households' daily basic needs, health-care facilities, children's education, family relationships, fish consumption, and financial conditions are adversely affected during the fishing ban. Moreover, there are very limited alternative income-generating activities during the fishing ban which may further reinforce fishers' poverty. The economic incentives provided by the government to the fishers are very insufficient to compensate for their losses from fishing during the ban.

By exacerbating negative socio-economic impacts on the dependent fishing communities, the Hizla-Mehendiganj hilsa sanctuary fails to contribute to the SDGs targets 1.1, 1.2, 1.4, and 1.b. Likewise, the findings of this study have failed to fulfill SDGs targets 2.3, 14.2, 14.4, and 14.7 as the sanctuary fails to increase the fish production and economic benefits of the fishers.

From the above discussion, it is undoubted that the science-based and inclusive conservation strategy is very important for ensuring the social and economic sustainability of the dependent communities. A fundamental tenet of the most conservation planning process is that stated goals and objectives should serve as a foundation for more site-specific conservation planning and early in the process, those precise goals and objectives should be set (Dahl-Tacconi, 2005; Pomeroy et al., 2004). In any planning process, roles and responsibilities need to be made clear so that everyone works within the same framework and toward the same goals. Numerous studies have indicated that the involvement of stakeholders is critical to the successful implementation of conservation programs (Guénette & Alder, 2007; Helvey, 2004; Stump & Kriwoken, 2006). During the whole deliberation process, all resource users (whether they use the resource or not), interest groups, and general citizens must be included. Stakeholders and decision-makers have prioritized minimizing socio-economic consequences in the formulation of conservation programs. This study has recommended some important issues that can help improve the setting, implementation, or management of the existing conservation actions and fulfill the SDGs. These are—

5.5.1 Suggestions toward ecological sustainability

5.5.1.1 Monitoring the conservation actions by the government Most of the fishers reported that overall fish catch has decreased to some extent, and small-size (juvenile) hilsa catch has increased after the implementation of the Hizla-Mehendiganj hilsa sanctuary. This might be happened because of habitat shifting, changing migration routes, past overfishing, etc. Thus, the government needs to identify why fish catch/production has decreased and regularly monitor it. Academicians and scientists can also conduct research on these issues. Based on the identified results, the government should take proper management strategies to revise the current management process.

5.5.1.2 Inclusive and participatory conservation management strategy According to household surveys and FGDs, this study found that fishers were not involved in the sanctuary establishment and fishing ban implementation process. Most of the fishers have also claimed that they are not aware of the fishing ban starting and end time as well as they are not involved in the sanctuary management. However, the involvement of resource users in policymaking is a key ingredient of good governance for successful management and better conservation of aquatic resources (Coffey, 2005). It can change fisher's perceptions (Cripps & Aabel, 2002; Jones, 2002) and play a significant role in successful fisheries management of diverse interests (Gelcich et al., 2008; Jones, 2002). Therefore, conservation policies should be introduced in consultation with the stakeholders and local communities. Islam et al. (2016a) claimed (cited in van Brakel et al., 2018) "A co-management approach involving fishers and government is the possible best management option for operating sanctuaries in a sustainable way." Therefore, the above suggestions will bring ecological sustainability and contribute to the SDGs targets 14.1, 14.2, 14.4 as well as 15.1, 15.5, and 15.6.

5.5.1.3 Science-based policymaking It is not clear where the Hizla-Mehendiganj fish sanctuary was established based on scientific evidence and study. According to the fishers, this place is not a suitable to establish a sanctuary as the depth of the water in many places of the sanctuary particularly in the mouth is too shallow to migrate the larger- and medium-sized hilsa fish. Also, there should have study on how the fishers can be made aware and how they can own the conservation program rather than forcing them. How they would be able to support their livelihoods during the fishing ban period should also need to be studied. The discussion in Sect. 5.3 also depicts that the science-based and inclusive conservation strategy is very important for ensuring the sustainability of both aquatic habitats, fish, and the dependent communities.

5.5.2 Suggestions toward socio-economic sustainability

5.5.2.1 Proper allocation and distribution of compensation scheme during the ban The fishing ban has created serious socio-economic impacts on the dependent fishing communities. For this reason, the government has taken some initiatives to provide compensation for the affected fishers (e.g., 40-kg rice/registered fisher/month). However, there are critics of the allocation and distribution of compensation schemes. In addition, the total amount of compensation that is distributed among the fishers is very inadequate in terms of the total affected fishers which needs to be increased. Fishers' awareness should also be increased to get a fisher ID card to register themselves in the government database. The distribution of

the compensation process should also need to be fair and transparent. In addition, the compensation scheme should be enough to maintain the household's basic needs. Considering the number of fisher's family members, the amount of incentives needs to be adjusted or when allocating rice/grain, the size of the households needs to be taken into consideration. Moreover, ensuring a sufficient, easy, equitable, and transparent compensation scheme is important for the sustainable management of conservation actions because economic incentives and compensation packages are highly effective in implementing regulatory measures (Mohammed & Wahab, 2013).

5.5.2.2 Inclusion of protein sources in the compensation scheme Providing only rice is not enough to fulfill the basic nutritional requirements of a household. Children and women particularly pregnant women suffer severe protein deficiency over a significant period during the fishing ban. The compensation scheme should include the protein source and other nutritious food (e.g., fish) to meet their protein needs during the ban as they cannot catch fish to consume during that period.

5.5.2.3 Financial support for fishers' households All the fishers emphasized that they need to pay for other expenses during the fishing ban such as groceries and education for their children, for which no assistance is available. They would appreciate assistance or direct support in those areas if it is possible. Government should think to provide financial support to the affected fishers during the fishing ban. Policymakers can also think to add other daily basic goods to the compensation package such as oil, pulse, salts, etc., which is also important for the fishers' households.

5.5.2.4 Opportunity for alternative income-generating activities (AIGAs) Most of the fishers in this study are solely dependent on fishing as they do not have any opportunity for AIGAs. As a result, fishers who do not have any alternate income source except fishing suffered the most during the ban. The government and non-government organizations working in those areas should facilitate the fishers (for both male and female household members) by providing need-based and viable different alternative livelihood options such as small-scale businesses, cow fattening, goat rearing, poultry rearing (duck/chicken), van/rickshaw pulling, sewing machine operation, net making, cage culture, plant nurseries, home gardening, handicrafts, etc. However, more emphasis should be given on supporting transformative livelihood income-generating activities. If they get an alternate income source to support their families, they might be less affected during the ban. One study has reported that fishers who are engaged in AIGAs could play a significant role in obeying fishing restrictions and protecting and conserving fisheries resources, particularly hilsa (Mozumder et al., 2018).

5.5.2.5 Increasing awareness regarding conservation actions The fishers of the studied areas have limited knowledge about the conservation actions implemented in their area. The 2 months long sanctuary fishing ban, 22 days of brood hilsa ban, and other gear (e.g., monofilament gill net, fixed trap, etc.) restrictions, 8 months jatka (juvenile hilsa) fishing ban, mesh size restriction, etc., throughout the year are sometimes unknown to the fishers, or their concepts regarding various fishing restrictions are not clear. They usually do not get any kind of communication or announcement before the start of the ban. So, proper awareness campaigns should be arranged to inform the local fishers about different types of conservation actions and their importance. The Department of Fisheries, Government of

the People's Republic of Bangladesh together with the NGOs and private sector can play an important role in this awareness-building action.

5.5.2.6 Proper information flow between the government and the fishers An important issue found in this study was the communication gap between the fishers and the government fisheries institutions. Fishers need to be communicated to make them aware of the fishing ban and its importance for successful and effective conservation activities.

5.5.2.7 Establishment of fisher's cooperatives Since there have no fishers' cooperatives in the study areas, so law enforcement or local authority cannot contact the local fishers. The cooperative can be used to create awareness against illegal fishing and obeying fisheries regulations. The fishers will also be more aware of their rights through the cooperatives. Fishers who are members of such an organization are more likely to see the establishment of sanctuaries positively. This attitude is connected to the fact that members of social organizations may be outspoken and/or participate in management (Islam et al., 2016a).

5.5.2.8 Increasing women's involvement in sanctuary management Women need to be involved in the sanctuary management process. Development organizations and also government institutions should consider women's empowerment to minimize the conservation impacts on dependent households.

The above suggestions will bring economic and social sustainability and help to fulfill SDGs 1, 2, 14, and 15.

6 Conclusions

The establishment of the conservation program is an important attempt to improve the fish biodiversity of aquatic/ marine habitats. At the same time, there is a need for considering the socio-economic issues of the fishing-dependent communities in those areas. Based on this study, it is understood that poorly designed and managed conservation program has many negative consequences. The negative impacts will be worsening if proper actions are not taken at the right time. The government should take measures for resolving the existing problems in the studied sanctuary area. In-depth research is required to find out the exact reason for decreasing fish production in the studied area after the establishment of the sanctuary. As the fishers claimed that the Hizla-Mehendiganj area is not a suitable place for establishing a hilsa sanctuary, this needs to be validated with scientific study. At the same time, special attention needs to pay to the fisheries-dependent communities to improve their socio-economic status. Science-based and effective sanctuary management needs to be established in the studied area to contribute to SDGs. Further studies are required to avoid the negative impacts of other conservation programs on the dependent communities.

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and MIK contributed to manuscript writing—original draft; MNY, MIK, MMI, AB, and MABH contributed to manuscript writing—review and editing; MMI worked in supervision; and MMI worked in funding.

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Data availability Data will be made available on reasonable request.

Declarations

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