



## Impact of fishing ban on socioeconomic status of Hilsa fishers in Bangladesh

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**Abstract.** Fishing ban is a useful regulatory measure for sustainable management and conservation of hilsa shad (*Tenualosailisha*) in Bangladesh. This study investigated the socioeconomic status of hilsa fishers, as well as their perceptions regarding the performance of fishing bans and coping strategies. Data were collected from 300 fishers residing in the three study areas by using semi-structured questionnaire to collect data related to the livelihood and socioeconomic variables of the fishers. Besides, fishers' perceptions regarding the performance of the ban as well as income generated from other activities during the fishing ban were also incorporated. Focus Group Discussions (FGD), Crosscheck Interviews (CI) with key informants' interview was also conducted to collect general information and to justify the collected information. The majority of the fishers feel the bans have resulted in positive socioeconomic impacts which enhance their income and livelihood status from fishing. However, its impact on loss of income and level of unemployment during ban forced some fishers to drive away the ban. In contrast, diversified alternative livelihood options have been adopted by fishers to cope with the ban that not only pull them out from dependency solely on hilsa fishing but also reduce the fishing pressure on the hilsa fishery as well as fish biodiversity. The study showed a positive correlation between fishing ban and resources' sustainability. In spite of the difficulties faced by fishers during ban, majority of the fishers support the ban for the long-term conservation of hilsa as it is their basic sustenance.

**Keywords:** Hilsa shad, Fishing ban, Socieconomics, Livelihoods

### Introduction

Seasonal fishing ban is a widely recognized conservation measure for the protection of a species through limiting fishing and protecting the species during their spawning season (Cohen *et al.* 2013, Chimba and Musuka 2014, Brilloet *et al.* 2019). Seasonal restrictions on different levels of fishing have been implemented as a popular tool around the world to conserve fish stocks and biodiversity from overexploitation (Suski and Cooke 2007, Sarkar *et al.* 2012, Kundu *et al.* 2019). During spawning, closure also positively affect population growth, as well as reduce annual fishing mortality by reducing fishing effort during and even after the closure (Clarke *et al.* 2015, Islam *et al.* 2021), thus it ensures the sustainability of fishing. Closed fishing season may have negative or positive impacts to the improvement of the livelihood of fishers (Chimba and Musuka 2014). The conservation measures sometimes cause serious socioeconomic disturbances (Finkbeiner *et al.* 2017, Brilloet *et al.* 2019, Islam *et al.* 2021). Besides, lack of community support is a major barrier in achieving the desired success for the management practices (Kincaid and Rose 2014, Islam *et al.* 2021). So, fishers' compliances with ban are necessary for conservation though it is strongly related to the cooperation between government and local fishers (Islam *et al.* 2021).

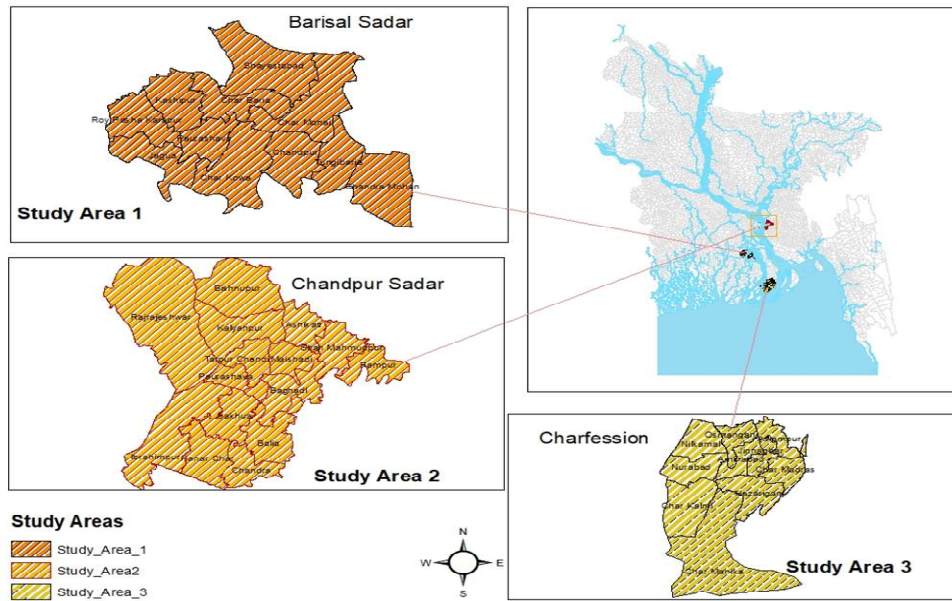
Hilsa (*Tenualosailisha*) is the biggest single-species fishery accounting for about 12% to the country's total fish production and 1% to the total GDP of the country (FRSS 2022). Not only it is a major source of food and animal protein but also 5 lac people directly and another 25 lac people indirectly depend on this single species for their livelihood (Islam *et al.* 2016b, DoF 2022). DoF has implemented different types of fishing bans/regulations following the Hilsa Fisheries Management Action Plan (HFMAP) to revive the dwindling catch of hilsa fishery since 2003. A seasonal ban on fishing in sanctuary areas for 2 to 3 months, another seasonal ban on any jatka (juvenile hilsa of <25 cm length) related activities for eight months have been imposed to restrict the exploitation of jatka. There is also a seasonal ban on brood hilsa fishing to protect gravid hilsa and allow them for uninterrupted spawning. The Government of Bangladesh declared the six areas of Meghna, Padma and Andharmanik River, their tributaries and the coastal rivers under the amended Protection and Conservation of Fish Rules 1985 (DoF 2022).

Although Catch per Unit Effort (CPUE) data is lacking in Bangladesh to assess the exact recovery of hilsa stocks (Islam *et al.* 2018), nevertheless, according to fishers' perceptions and the global literature, a closed season has a positive role on stock revitalization (Islam *et al.* 2021). Though fishing bans have led to increase in hilsa production but it is not clear how these bans affect the fishers' livelihood (Nahiduzzaman *et al.* 2018). Fishers' perception regarding the impact of ban is very important as they are the first stakeholders of this tier and coping strategies taken by fishers. Although there are several studies on the livelihood of hilsa fishers and other aspects of hilsa fishery (Mohammed and Wahab 2013, Islam *et al.* 2016a, Porrasa *et al.* 2017, Rahman *et al.* 2017) but there is very little information on these attributes. For successful implementation and fine tuning of conservation measures, it is necessary to understand the socioeconomic status of hilsa fishers and their perceptions regarding fishing ban. The study was therefore conducted to evaluate the impact of fishing ban on socioeconomic status of hilsa fishers. The study will also help to make a future action plan for the sustainable management of hilsa fishery resources and improving the socioeconomic status of hilsa fishers.

### Materials and Methods

**Study area:** The study was conducted in three upazilas named Barishal Sadar, Chandpur Sadar, and Charfasson under the three major hilsa producing districts Barishal, Chandpur and Bhola respectively (Fig. 1). Three villages named Chorbukhainagar, Dingamanik and Habinagar were considered under Barishal Sadar of the Barishal district which is situated near the Arialkhan and Kirtonkhola Rivers. Three villages named Uttar Tilabari, Moddotilabari and Purbosiramdi were selected under Chandpur Sadar which is situated near the Meghna River. The Meghna River is one of the major breeding and nursery zones for hilsa, and the government declared 100 km of the lower Meghna estuary as a hilsa sanctuary in 2005 and impose fishing ban to protect jatka (juvenile) during March–April (Table I). Three villages named Charpatila, Charfakira and Khejorghasia were selected under Charfasson upazila. This area is located on the bank of

the river Meghna which was also declared as a hilsa sanctuary by the government in 2005 and since then fishing ban is imposed from March to April every year (Table I). The study area Chandpur Sadar and Charfession were chosen because these two study areas are situated in the sanctuary areas whereas Barishal Sadar is located in non-sanctuary areas.



**Fig. 1.** Map of Bangladesh showing the study areas (Map is generated by ArcGIS).

**Table I.** Different types of fishing bans imposed for Hilsa conservation\*

Fishing ban	Ban periods	Mode of action
Seasonal ban on jatka (Juvenile hilsa) catching started from 2003	November to June	Food assistance given to the fisher's family at the rate of 40kg/family/month (for 4 months) under vulnerable group feeding program (VGF)
Seasonal ban on brood hilsa (Gravid hilsa) fishing started from 2007	22 days (October to November) depending on the moon phase	Food assistance given to the fisher's family at the rate of 25 kg/family under VGF
Seasonal fishing ban in the six sanctuaries started from 2005	March to April for five sanctuaries and another one is from November to January	It covers the six sanctuaries established in the potential hilsa nursery and breeding areas and all types of fishing is banned

\*Source: adapted from Sarker *et al.* (2019)

**Data collection:** Data were collected from the fishers residing in the study areas by random sampling basis using semi-structured questionnaire from October 2020 to March 2021. A total of 300 fishers (100 from each site) were interviewed to collect data related

to the livelihood and socioeconomic variables of the fishers. Detailed interviews with the fishers focused on the issues such as level of education, experiences, family size, assets, income and secondary occupation. Besides, fishers' perceptions regarding the performance of the ban as well as income generated from other activities during the fishing ban were also incorporated. In the selected sites, Focus Group Discussions (FGD), Crosscheck Interviews (CI) with key informants was conducted to collect general information and to justify the collected information. A total of 12 FGDs consisting of 6 to 8 members from the three study areas were conducted.

**Data analysis:** Collected data were entered and tabulated on the basis of socioeconomic characteristics in Microsoft Excel and was analyzed in Statistical Package for Social Science (SPSS)(version 26). Statistical methods like Chi-Square test and other basic descriptive statistics like mean, standard deviation and ANOVA were used to analyze the data. Likert scale responses were used to assess the fishers' perception about ecological performance and socioeconomic impacts of fishing ban.

A logit regression model was applied using SPSS to identify the factors influencing fishers' perceptions and attitudes towards the effectiveness of fishing ban. The basic logit model (Gujarati and Porter, 2009) is described in the following formula:

$$\ln\left(\frac{P}{1-P}\right) = a + \sum_{i=1}^n \beta_i X_i$$

Where, P=the probability that an event (whether fishing ban is good or bad) occurs for an observed set of variables; a=the intercept (constant);  $\beta_i$ =the effect of  $i$ th explanatory variable on the probability of having a good or bad effect of fishing ban; and  $X_i$ = the explanatory variables ( $n=7$ ) namely monthly income, experience, Government assistance, ownership of fishing gear, fishing duration, savings and alternative sources of income during ban.

## Results

**Socioeconomic profile of the hilsa fishers:** The study revealed that 36% of the fishers were illiterate, 56.7% were able to sign and received primary level education, 7.3% completed secondary level education and above (Table II). The average family size of the fishers was 5.74 ( $\pm 1.84$ ). Almost 99% fishers had access to sanitary latrine (ring slab) among them 95.3% had semi-pakka (tin wall with tin roof), 4.4% had pakka and 0.3% (1 respondent out of 300) had latrine which was made of brick wall with tin shed (Table II). For fishers' household, 99% of the roof and 91.3% of the wall were made of tin. The rest 6.3%, 1% and 0.3% of the wall of the fishers' house were made of wood, bricks and palm leaves, respectively. Only 1% fishers were floating, lived on boat. Almost 52% of fishers have been fishing for above 20 years and on average fishers have 23.59 ( $\pm 10.32$ ) years of fishing experiences.

Most fishers (92.3%) had their own fishing boat and gear, among them 84% had motorized and 16% had non-motorized boat (Table II). Above seventy percent (73.3%) of fishers used Chandijal (set gill net) for hilsa fishing and 6.9% of fishers solely used Current

*jal*(gill nets). Almost 70% of fishers involved in fishing for above 8 months per year (Table II). During the peak season, the average CPUE (kg/gear/day) of 36% of fishers was 10-20 while 34% had 21-30 and 5% had above 30. Most fishers (75%) had access to debt to Non-Government Organization (NGO), arotder or mahajan (local money lenders/commissioning agents), and bank. The majority of fishers (66.2%) took loan for boat construction and making net, rest of them (34.8%) took loan for other purposes (Table II).

**Table II. Socioeconomic characteristics of the hilsa fishers**

Socioeconomic variables	Category	Percent (%)	Mean ( $\pm$ SD)
Educational status	No education	36.0	
	Primary education	56.7	
	Secondary education and above	7.3	
Family size			5.74 ( $\pm$ 1.84)
Housing status			
Wall materials	Corrugated tin	91.3	
	Wood	6.3	
	Palm leaves	1.0	
	Cement –bricks	0.3	
	Others	1.0	
Roof materials	Corrugated tin	99.0	
	Others	1.0	
Access to sanitary toilet	Yes	99.0	
Status of toilet	Pakka	4.4	
	Tin roof surrounded by tin wall	95.3	
	Others (tin roof surrounded by brick wall)	0.3	
Fishing experiences (yr)			23.59( $\pm$ 10.32)
Access to credit	Yes	75.0	
Source of credit	Bank	1.0	
	NGO	30.3	
	Arotder/money lender	19.3	
	Both (arotder and NGO)	24.3	
Purpose of loan	Fishing	66.2	
Ownership of boat	Yes	92.3	
Type of boat	Mechanized	84.0	
Type of fishing gear	<i>Chandijal/ilishjal</i>	73.3	
	Miscellaneous	19.9	
	<i>Current jal</i>	6.9	
Fishing months per year	above 8 months	70.0	
Average fish catch (kg) per day per gear	below 10	25	
	10 to 20	36.0	
	above 20-30	34.0	
	above 30	5.0	

The monthly income of majority of fishers (68%) ranged from BDT 10,001-20,000, while 23.7% of fishers had the income ranging from BDT 5,000-10,000 and 8.3% of fishers earned between BDT 20,001 and 30,000 (Fig.2). The average monthly (SD) income of fishers was BDT 16,199 $\pm$ 4237. The mean values of household income are not significantly different for the three study areas (ANOVA,  $p > 0.05$ ). The fishers faced different shocks and stresses during ban and non-ban period (Table III). The re-payment of installment of loan was a great problem, reported by 70% of fishers. Loss of income during ban, lack or limited opportunities to alternative source of income, increasing number of fishers, natural disaster and loss of fishing gear were identified by 82%, 70%, 63%, 56% and 71% of fishers respectively.

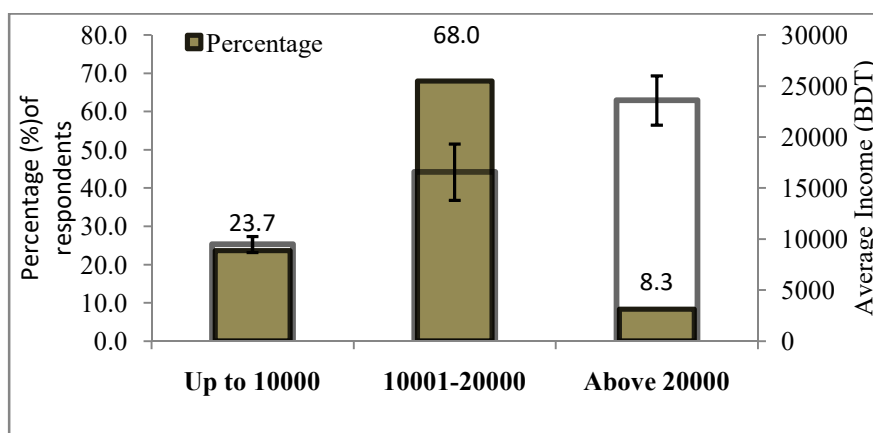
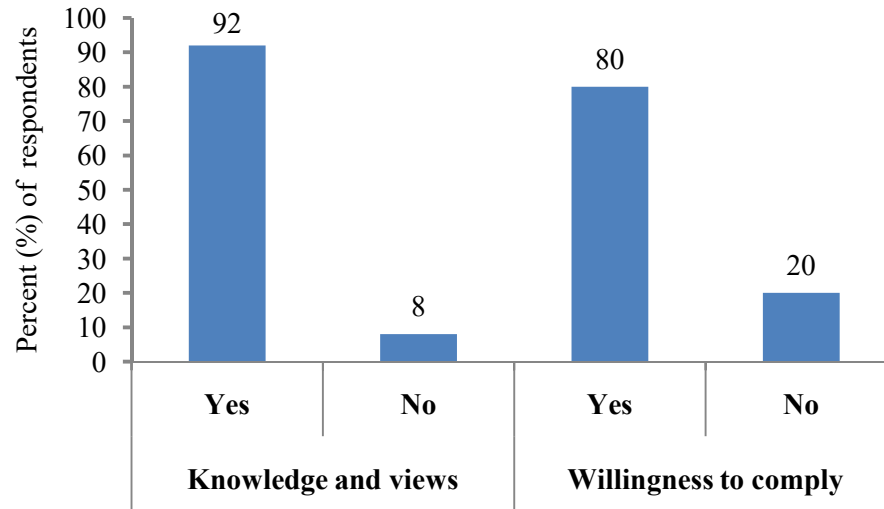


Fig. 2. Average monthly income( $\pm$ SD) of the fishers within the range.

Table III. Constraints faced by the fishers (multiple responses)

Major constraints	Frequency	Percentage (%)
Burden of debt to informal sources and microcredit institute	210	70
Loss of income during ban	246	82
Lack of alternative sources of income	210	70
Lack or limited alternative skill for other work	190	63
Increased number of fishers	190	63
Natural disaster/river bank erosion	167	56
Loss or damage of fishing gear	212	71

**Fishers' awareness and compliances with ban:** Almost all the respondents were found to be aware of the importance of fishing ban and 92% of fishers had full knowledge of the importance of fishing ban and viewed it as good measures to conserve the hilsa fishery as well as other fisheries resources. Most of fishers (80%) expressed their willingness to comply with the fishing ban and 20% of surveyed fishers did not agree to comply with the ban (Fig.3).



**Fig. 3.** Fishers' knowledge about the importance of fishing ban and willingness to comply with ban

**Fishers' perceptions towards catch performance of fishing ban:** Most fishers (85.3%) agreed that hilsa catches had increased due to implementation of fishing ban (Table IV), while 13% of fishers responded in a neutral way and the remaining (1.7%) disagreed regarding whether fishing ban had led to increased hilsa catch ( $\chi^2=202.34$ ,  $p=0.000$ ). The results of the Chi-square test suggest that the distribution of fishers' beliefs could not be explained by chance, yet perceptions remained diverse among fishers. Over three-fourth (76.3%) of the fishers agreed that the size of hilsa had improved while 11.7% were found to be neutral in their opinion and 12% disagreed ( $\chi^2=172.76$ ,  $p=0.000$ ).

In response to question if the abundance of other species especially catfish have increased or not, 83% of fishers agreed, 15% of fishers responded in a neutral way and 1.7% disagreed ( $\chi^2=169.62$ ,  $p=0.000$ ). The majority of fishers (79%) agreed that fishing ban is an important tool to conserve hilsa and other fishery resources, only 3.7% strongly disagreed, 3.3% disagreed and the remaining (14.0%) responded in a neutral way ( $\chi^2=208.16$ ,  $p=0.000$ ) (Table IV).

**Perceptions of fishers towards socioeconomic impacts of fishing ban:** Fishers' perception regarding increase in monthly income compared to before and after the implementation period of ban, 72.4% of fishers felt their average monthly income has increased while 11.6% disagreed and the remaining 16.0% responded in a neutral way ( $\chi^2=144.76$ ,  $p=0.000$ ) (Table V). In response to question regarding the negative impact of fishing ban on income and food consumption, 76% of fishers expressed that the fishing ban was a temporary threat to their income ( $\chi^2=172.73$ ,  $p=0.000$ ). About 66.3% of fishers indicated that the ban negatively impacted their food consumption while 20.6%

disagreed and the remaining (13.0%) were irresolute in their opinion ( $\chi^2 = 92.90$ ,  $p = 0.000$ ) (Table V).

**Table IV. Fishers' perceptions toward ecological performance of fishing ban**

Likert-scale item	Response (%)						P-value
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree	Chi-square	
Hilsa catches have been increased due to ban	0.0%	1.7%	13.0%	56.3%	29.0%	202.34	.000
Hilsa size have been increased	5.3%	6.7%	11.7%	42.0%	34.3%	172.76	.000
Diversity of other fish species have been improved	0.0%	1.7%	15.0%	52.0%	31.0%	169.62	.000
Fishing ban is an important tool for hilsa fishery and other fishery management	3.7%	3.3%	14.0%	34.7%	44.3%	208.16	.000

**Table V. Fishers' perceptions towards socioeconomic impacts of fishing ban**

Likert-scale item	Response (%)						P-value
	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Chi-square	
Average monthly income has increased	6.3%	5.3%	16.0%	39.7%	32.7%	144.76	.000
Income negatively impacted during ban	5.3%	4.3%	14.3%	40.3%	35.7%	172.73	.000
Food consumption negatively affected during ban	9.3%	11.3%	13.0%	37.3%	29.0%	92.90	.000

As their perceptions regarding the socioeconomic and ecological outcomes are divided in terms of loss of income issues, it was important to investigate the factors that influence fishers' attitudes towards the fishing ban to know whether they will be supportive of conservation measures or not. The results from the logit regression model showed that monthly income of fishers, government support, income during ban and fishing experiences were significant factors in explaining the positive and negative impacts of fishing ban on their income and conservation of fishery resources (Table VI). The fishers with monthly income above BDT 10,000 and fishers who received Vulnerable Group Feeding (VGF) considered fishing ban as a good initiative taken by the government ( $p < 0.05$ ). Fishers who were involved in other alternative sources of income to earn, they considered that the fishing ban has a positive role on their income and conservation of fishery resources. Fishing experiences above 20 years had an influence on fishers' perceptions regarding the positive role of fishing ban in hilsa conservation.



**Table VI. Factors influencing fishers' perceptions and attitudes towards ban (Logit model)**

Variables	Coff	SE	df	Odds Ratio	z	P>z
Govt. assistance (1 = Yes, 0 = No)	1.009	0.378	1	2.742	2.667	0.008
Monthly income ((0 = lower than 10,000; 1 = else)	1.952	0.383	1	7.040	5.095	0.000
Fishing gear (1 = Yes, 0 = No)	-0.909	0.589	1	0.403	-1.542	0.123
Fishing experience greater than 20 (1 = Yes, 0 = No)	1.498	0.376	1	4.471	3.982	0.000
Income during Ban (1 = Yes, 0 = No)	1.475	0.388	1	4.373	3.805	0.000
Fishing hour per day	-0.225	0.168	1	0.799	-1.338	0.181
Monthly saving (1 = Yes, 0 = No)	0.621	0.623	1	1.861	0.997	0.319
Main occupation (1 =fishing, 2 = non-fishing)	-0.890	0.646	1	0.411	-1.377	0.168

(Coff = Coefficient, SE = Standard error) (Number of observations =300, Chi-square =221.437, -2 Log likelihood =194.451, Pseudo R Square = 0.696).

**Perceptions regarding the duration of ban and management approach:** Most fishers (83.7%) expressed their willingness to get involved in management approach ( $\chi^2 = 136.01$ ,  $df = 1$ ,  $p = 0.000$ ). In response to a question regarding the duration of fishing ban, 88.7% of fishers expressed that fishing ban in the sanctuaries for a period of 2-3 months was a long duration while 11.3% of fishers expressed their positive attitudes ( $\chi^2 = 418.46$ ,  $df = 1$ ,  $p = 0.000$ ); in case of jatka fishing ban and gravid hilsa fishing ban above 90% of fishers responded positively (Table VII).

**Table VII. Fishers' attitudes about duration of fishing ban and management approaches**

Variables	No	Yes	Chi-square	P-value	df
Duration of jatka (8 months) fishing ban is all right	6.7%	93.3%	225.33	.000	1
Duration of all out (2-months) fishing ban is all right	88.7%	11.3%	418.46	.000	1
Duration of Gravid (22 days) hilsa fishing ban is all right	7.0%	93.0%	221.88	.000	1
Willingness to participate in management approaches	16.3%	83.7%	136.01	.000	1
Willingness to involve to other alternative income generating activities	20.7%	79.3%	103.25	.000	1

**Coping strategies taken by hilsa fishers:** To cope with the ban period, the majority of fishers (66%) were found to be involved in diversified alternative income generating activities (Fig.4). Only 3.7% of fishers were involved in illegal fishing and 21% of fishers' household also drew their savings to maintain daily expenditures, 2% of fishers moved to other districts to seek alternative livelihood options (Figure 4). One-fourth (26%) of fishers' household reduced their meal frequency and took low expensive food items to adjust loss of income or reduced income during ban (Fig.4). Some negative coping strategies were also reported by 32.7% of fishers-who borrowed money from local moneylenders or elites with high interest and took microcredit from NGOs ranging from BDT 5,000 to 60,000 (Fig. 4). To compensate the loss of income during fishing ban, the government has provided rice incentives to the affected fishers' households and 60% of fishers received food incentives in the form of rice under VGF program (Fig.4).

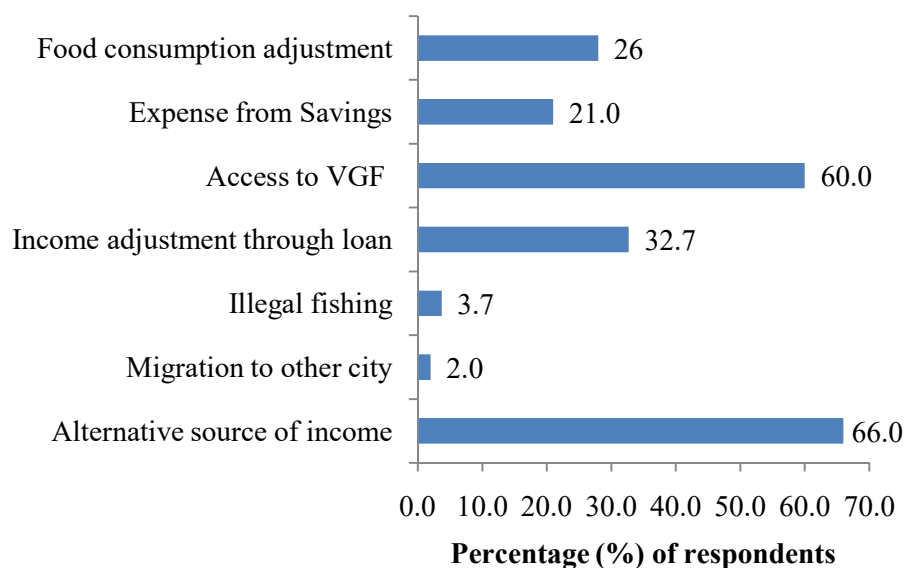


Fig. 4. Coping strategies adapted by fishers during the fishing ban.

### Discussion

**Socioeconomic profile of hilsa fishers:** Since 2003, DoF has been implementing different types of seasonal bans to ensure the sustainable growth of hilsa fishery as well as to improve the socioeconomic status of fishers. The socioeconomic variables like level of education, fishers' assets, sanitary and housing condition, income and other variables were studied to get the reflection of the living conditions of the fishers. Family size is an important socioeconomic indicator because it affects the income and socio-economic wellbeing of the households. The average family size of the fishers' household was 5.74 which are higher than the national average (4.11 persons) of Bangladesh (BBS, 2020). One third of surveyed fishers (36%) were illiterate and 56.7% of fishers were able to sign and completed primary level of education. Ali et al. (2015) and Mondal et al. (2013) reported, 82% of fishers of Lakshmipur Sadar Upazila (sub-district) and 76% of fishers of Ramgati Upazila under Lakshmipur District were illiterate respectively which is not similar with the present study. The present study found that almost all fishers of the surveyed areas used sanitary latrine (ring slab) and 95% of them had semi-pakka (tin roof surrounded by tin wall), 4% had pakka (wall and roof of latrine were made of brick and concrete respectively) and very few latrine's wall and roof were made of brick and tin. Faruque and Ahsan (2014) who found 92% of fisher's toilets of Godagari and Charghat Upazilas under Rajshahi District were *katcha* while 7% were semi-pacca and remaining 1% had no sanitary facilities. Ali et al. (2015) documented that 17% of fisher's toilets of Lakshmipur Sadar Upazila were *kacha*, 60% were semi-pacca, 17% had no toilet and 6% of the toilets were *pakka*. Roy et al. (2016) reported that 78.25% of fishers of

different Upazilas under four districts namely Chandpur, Lakshmipur, Bhola and Patuakhali had *kacha* (open) latrine (made of bamboo with leaf and inadequate drainage system) where 21.75% used semi-*pakka* (ring-slab with tin roof) latrine.

For fishers' household, 99% of roof and 91.3% of wall were made of tin whereas according to national survey, 89.41% of roof and 55.73% of wall of the rural households are made of tin/brick/wood (BBS, 2020). Roy *et al.* (2016) reported that 62.25% of hilsa fishers had *kacha* house (tin shed with bamboo wall) while 20.63% had tin shed with tin surroundings house and only 17.12% had thatched (straw components) houses. Another study also found that 92.6% of the roof and 94.7% of the walls of the fishers' house are made of tin (Islam *et al.*, 2018) which is similar to the present findings. According to fishers' opinion, in previous years, about 80% of house had thatched or tin shed surrounded by bamboo wall but now housing condition of the hilsa fishers is improving as their income from fishing has been increased. In comparison to national average and other reports, this study indicates that the housing condition and sanitary status of the fishers' households reflected considerable improvement.

The monthly income of the majority of fishers ranged from BDT 10,001-20,000 whereas 23.7% of fishers had the monthly income in the range of BDT 5,000-10,000 and 8.3% earned above BDT 20,000 in a month. The average monthly income of fishers was BDT 16,199 whereas the national average income per rural household per month is BDT 13,353 (BBS, 2020). Rana *et al.* (2018) found that 44% of fishers' annual income ranged from BDT 21,000 to 41,000 and 31% had between BDT 41,000 and 60,000. Islam *et al.* (2018) stated that 53.2% of fishers had the monthly income between BDT 5,000 and 10,000 while 23.4% earned between BDT 10,000 and 20,000 and 11% of fishers' monthly income was above BDT 20,000. Ali *et al.* (2015) stated that fishers having annual income ranged between BDT 30,000 and 150,000. It revealed that the ranged from BDT 31,000-60,000 categories had the highest proportion (40%) while 13% had BDT 61,000-90,000 and above BDT 150,000 category had the lowest proportion (7%). This study suggests that the monthly income of fishers was higher in comparison to the national survey and other reports. Although there is no baseline data on the average monthly income of fishers before the imposition of fishing ban nonetheless there are some indications based on fishers' opinion and other survey reports indicating that monthly income of fishers has increased during the intervention period of ban. As the hilsa catch and hilsa sizes have increased due to implementing various fishing bans which enabled fishers to earn more from fishing outside the ban period. In recent years, the news was covered up in the newspapers and other popular media as 'bumper' production of hilsa in Bangladesh waters and restoration of hilsa in rivers and water bodies where hilsa was heavily depleted (Islam *et al.* 2018).

Fishing equipment is the primary means of earning and it is good indication that the present study shows over 90% of fishers have their own fishing boats and gears among them 83.2% have motorized vessel. Fishers having no fishing gear work in others' boat on share or payment basis. Sarker *et al.* (2016) found that 85% of fishers used mechanized boat. Rana *et al.* (2018) reported that only 33% had their own boats and nets, and majority of hilsa fishers (67%) worked with other fishers which are not consistent with the findings

of present study. This indicates that now they are experienced with huge hilsa catch so their income has increased which enabled them to make their own fishing boat and gear.

***Attitudes and perceptions of fishers towards the fishing ban:*** This study found that almost all the fishers were aware and had knowledge about the importance of fishing ban because the Department of Fisheries (DoF) carries out comprehensive awareness building programs, motivational meetings with fishers and other stakeholders before embarking on the fishing ban each year since 2003. The majority of fishers (80%) expressed their willingness to comply with the fishing ban and viewed it as a good measure to conserve their much-treasured fishery resources on which their livelihood is dependent. Islam et al. (2021) stated that most fishers (79%) showed their willingness to comply with the ban which is very similar to the present findings. Chimba and Musuka (2014) stated that the majority of fishers were aware and had full knowledge of the importance of closed fishing season and viewed it as a good measure to conserve fish. This is the most effective ban as it is supported by 94% of fishers and 96% of fish traders (Kunda and Barman 2015).

The fishers opined that, hilsa catch is increasing in spite of increasing number of new fishers to hilsa fishery as it is an open access fishery and their perception is well supported by catch statistics reports of DoF. Due to implementation of management measures with incentives, hilsa production increased from 199,032 MT in 2002-2003 (starting of the on-going management program) to 496,417 MT in 2016-2017; 550,428 MT in 2019-2020 and 565,183 MT in 2020-2021 (DoF 2022, FRSS 2022). Islam et al. (2016a) also stated that the majority of fishers felt an apparent recent increase in hilsa catch due to the establishment of sanctuaries. Fishers' perceptions regarding the ecological returns of the ban was found to be positive as most fishers agreed that hilsa catch and size had been increased due to implementation of fishing ban.

Most fishers acknowledged that the large sizes of hilsa netted more frequently might be due to creation of favorable environment in rivers through imposition of various measures. The gradual shifting from smaller size groups to the larger size groups indicating better fisheries status (Rahman et al., 2020) and hilsa size in all sanctuaries has increased (Rahman et al. 2015, Rahman et al. 2017, Sunny et al. 2017). Over 80% of fishers viewed that the abundance of other fish species especially catfish have also increased along with hilsa which is well supported by Rahman et al. (2020) who reported, the abundance of river catfish like Pungus (*Pangasius pangasius*), Ayr (*Sperata aor*), Rita (*Rita rita*) and Baghair (*Bagarius bagarius*) have increased due to implementation of hilsa management measures. Other study found that the availability of juveniles of brackish water and freshwater fish species has also increased along with jatka in the hilsa sanctuaries and adjacent areas (Rahman et al. 2015, Rahman et al. 2017) which indicates the positive impact of management measures on fish biodiversity (Sunny et al., 2017). It is suggested that effective enforcement measures in critical sites and during the breeding period could significantly contribute to increasing hilsa production and maintaining biodiversity (Halder 2004). Most fishers felt that fishing ban in the hilsa sanctuaries increased the abundance and biodiversity of other fish in the sanctuaries (Islam et al. 2016a).

In spite of these positive outputs, some negative impacts also were claimed by fishers, fishing ban has resulted in reduced income and nutritional intake. Loss of income during the ban period was the direct negative effect of ban as reported by the fishers; fishing ban ceases their main source of income. The loss of income or unemployment problem they face during ban forced some fishers to create unfavorable opinion towards the ban which is well emphasized in this survey. Nahiduzzaman *et al.* (2018) also reported that similar negative impacts on the dependent livelihoods during two-month fishing ban in the sanctuaries. Chimba and Musuka (2014) reported that 58% of fishers were negatively impacted and another 55% of respondents indicated that complete stoppage of fishing ceased the opportunity to have a regular income. The present study showed that hilsa fishers' household had fish 5-6 days per week during fishing season. The less expensive fish caught along with their target species hilsa during fishing season and this less expensive fish are mainly consumed by fishers' households. During ban season, fish consumption was reduced from 5-6 days to 1-2 days per week. During closed fishing season, food security was threatened, as fish provides one of the cheapest sources of animal protein to the poor (WFC 2005). Fishing bans have negative impact on livelihood and food consumption of the fishers; children and pregnant/lactating women suffer most from lack of nutrition, as the source of protein is taken away during the ban period (Islam *et al.* 2016a, 2016b).

Though, the majority of fishers showed their positive views on the conservation initiatives but their perception towards the socioeconomic and ecological outcomes are divided in terms of loss of income issues. A number of factors, particularly socioeconomic characteristics were found to influence their perceptions and attitudes regarding the performance of fishing ban. The logit regression analysis revealed the socioeconomic variables such as average monthly income of fishers, government assistances, experiences of fishing and income during ban were significant factors in explaining the positive impacts of fishing ban on their income and conservation of fishery resources. Fishing experiences is an important factor in explaining the fishers' perceptions regarding the positive role of fishing ban in hilsa conservation and fishers with long experiences supported the ban as a good measure for the conservation of hilsa fishery resources. The response to a question on duration of the fishing ban varied. In case of brood hilsa fishing ban and jatka fishing ban fishers think that the duration is all right. But most fishers feel that the duration of fishing ban in sanctuaries for 2-3 months is too much long duration.

Among the three bans (jatka fishing ban, fishing ban in sanctuaries and brood hilsa fishing ban) the majority of fishers feel that jatka fishing ban had no impact on their regular income because they could catch other fish. They felt that brood hilsa fishing ban has little impact on their income as the duration is much shorter and they consider it as a short break for repairing and coloring their boat/trawler and also for making and mending net. Kunda and Barman (2015) and Nahiduzzaman *et al.* (2018) also found similar results. Besides these, the catches of most fishers are high reaching up to 35 to 50 kg just after opening the ban and before imposing the ban as this is the peak season for hilsa catch. So, they can generate higher income from hilsa fishing outside the ban. Almost half of the fishers think that the seasonal ban results in an increase in catch during post-ban periods.

(Islam *et al.* 2021). However, the all-out fishing ban in the sanctuaries exerts serious negative impact on the livelihoods of fishers as all kinds of fishing are banned. This study revealed that most fishers expressed their willingness to involve themselves in management approach and their involvement in management approach will be more helpful in making the conservation efforts successful through increasing more compliance with ban and reducing the tendency of violating the rules. Thus, the conservation success is highly dependent on delegating responsibilities to communities (Pita *et al.* 2010, Islam *et al.* 2016a). To reduce enforcement costs of the government, fishers' participation in management approaches is highly expected (Islam *et al.* 2016a).

**Coping strategies:** In the present study, fishers have already involved in several alternative livelihood strategies to cope with the ban. The alternative options included casual labor, boatman, net making or mending, migration to other city for rickshaw pulling or daily labor, running seasonal business and grocery shop, driving of motorized and non-motorized vehicles, cattle rearing and agricultural work. Some fishers draw their savings to adjust the income during ban as the recent bumper catch of hilsa has enabled the fishers to make some savings to cope with the ban period (Nahiduzzaman *et al.* 2018). This study shows that very few percent of fishers are involved in illegal fishing as they have no other options to earn. This is a good indication that they are aware of importance of ban and show their compliances with ban. Violations of 'fishing ban' and other management practices are partly due to the absence of adequate alternative livelihoods (Cimba and Musaka 2014). Different types of strategies are adapted by fishers to cope with the ban, such as involving in illegal fishing, selling off family properties, doing seasonal migration, taking out loans, reducing daily intake of food, and compelling other family members to engage in work (Ali *et al.* 2015, Nahiduzzaman *et al.* 2018, Rana *et al.* 2018, Sunny *et al.* 2019).

To compensate for the loss of earnings and food security, the government provides incentives in the form of rice under VGF program and alternative income generating activities AIGA to the affected fishers' households. Each fisher's household receives VGF at the rate of 40 kg of rice per month for four months during jatka fishing ban and 25 kg for 22 days during gravid hilsa fishing ban so that they can comply with the ban. The study found that 60% of hilsa fishers are getting this food incentives and the percentage is increasing over the year. Besides this food support, fishers also were provided AIGA inputs with little amount of money to run small business. ECOFISH-Bangladesh project distributed on-farm inputs such as vegetable seeds, goats, chicken and fingerling of fish to the fishers to improve their income as well as livelihood status and these AIGAs were proved to be successful in terms of better production rate, more balanced diet and increased net profit (Nahiduzzaman *et al.* 2018). Different AIGA inputs were provided to the fishers under Jatka Conservation Program project of DoF to enable them to improve their livelihoods (Roy *et al.* 2015).

This study reveals some negative approaches that are adopted by the fishers to adjust the loss of income or reduced income during the ban such as taking out loan from microcredit organizations (NGOs) and borrowing money from local moneylenders.

Besides these, some fishers' households reduce their meal frequency and take low expensive food items to cope with the situation. Similar adaptation approaches of the fishers have also been documented by Ali *et al.* (2015), Sarker *et al.* (2016), Faruque and Ahsan (2014) and Islam *et al.*, 2018 and Islam *et al.* (2021). The majority of fishers are interested to involve themselves in other alternative income generating activities but the access is very limited due to seasonality of the works, less skill to other alternative works and remoteness of the area from the main town. Fishing skills, in combination with low levels of education, remoteness of the fishing villages and temporary employment during ban are the factors that make it difficult for the fishers to obtain alternative employment during seasonal closures (Islam *et al.* 2018, Islam *et al.* 2021). The study showed that most fishers took loan from informal and formal sources to invest mainly for fishing purposes, as institutional credit facilities were very limited for the fishers' community, they had to take loan in advance (locally called dadon) from NGOs and local moneylenders. So they were bound to re-pay the loan by selling their catch to them (arotder/ or mohajon) in their fixed price and commission rate and also restricted from selling their catch to open market (Rana *et al.* 2018).

In the present study, one of the major constraints that were identified by the fishers is re-payment of installment of the loan/advance round the year (during ban and non-ban season). Other studies also identified that inadequate credit facilities and burden of loan/advance were the main constraints in the fishing communities (Roy *et al.* 2016, Rana *et al.* 2018), indebtedness to local money lenders and microcredit institution was one of the major constraints reported by 76% of fishers, so they faced such type of problems round the year and cannot come out from the vicious cycle of indebtedness (Islam *et al.*, 2018). So if there were no option of imposing ban on fishing, nevertheless they could have faced such type of problem which ultimately keeps them in financial crisis although their income from fishing is sufficient. In contrast, fishing bans create an opportunity for fishers to pull them out from dependency solely on fishing through involving themselves into diversified livelihood options to earn as well as reduces the fishing pressure on the hilsa and other fishery resources in the sanctuary and non-sanctuary areas. Though income earned from these alternative activities are not enough to sustain their families during ban but it could be potential alternative sources of income over time to compensate loss of income. Such diversification of the income source has the potential to cope with this ban as well as to reduce poverty and build social resilience among the fishers (Nahiduzzaman *et al.* 2018).

The living condition based on the variables like housing, sanitary status and income of the fishers has been found to achieve considerable improvement during the implementation period of fishing ban. Fishers perceived these bans have resulted in positive impact in terms of increased hilsa catch and size which ultimately increased their income. However, the ban especially 2-3 months fishing ban in the sanctuaries has led to income loss or reduced income that has posed serious repercussion on their livelihoods.

Different types of livelihood strategies have already been adapted by fishers to cope with the hardship occurred during ban. Though the income was not enough to sustain their family, it could be potential sources of income to compensate loss of income during

ban period. The government also offered incentive based hilsa fisheries management approaches to compensate the loss of earnings of the fishers. However, in spite of the difficulties they have faced during ban, the majority of fishers considered the bans as good measures for the long-term conservation of hilsa fishery and other fisheries resources.

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