A case study of illegal fishing causes during seasonal fishery closure in Kaptai Lake, Bangladesh

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ABSTRACT

Growing evidence shows that conservation strategies such as fishing bans may adversely affect the livelihoods of low-income communities, which often encourages community members to fish illegally. In this study, we determined the underlying factors that influenced fishermen to engage in illegal fishing during the closed season in the largest lake of Bangladesh, Kaptai Lake. Out of 231 fishermen interviewed, 46.8% were engaged in illegal fishing during the closed season. Engagement in illegal fishing was positively related to receipt of a financial loan and negatively related to receipt of a government subsidy and secondary occupation of the fishermen. Financial gain by selling the fish was the prime motive for illegal fishing. Surprisingly, fishermen received a 36% lower price for illegally-harvested fish during the closed season (mean price ± SD, BDT 95.8 ± 64.9), when compared to that during the open fishing season (BDT 151.5 ± 64.9). Mid-level actors secured 99 – 154% more profit during the closed season. This study shows that multiple factors are important for the engagement of fishermen in illegal fishing, and therefore, an integrated conservation policy considering all causative factors should be employed to achieve more effective conservation in the region's inland waters.

Keywords: Biodiversity conservation; fishing ban; illegal fishing; fisheries management; rural development; alternative livelihoods.

1 INTRODUCTION

Illegal harvesting (i.e. poaching) is a major concern for the sustainable management of natural resources, including fishes (Muth and Bowe Jr., 1998; Bell, Hampshire and Topalidou, 2007; Doherty *et al.*, 2021). Illegal harvesting poses a major challenge to policy makers and resource managers to make conservation efforts successful. Worldwide, losses from current illegal and unreported fishing are estimated to be between $10 billion and $36 billion (Agnew *et al.*, 2009; WorldBank, 2019). For capture fisheries, 7 – 17% of the global catch is produced through illegal, unreported and unregulated fishing (FAO, 2016). Therefore, illegal fishing reduces the success of fish stock management and threatens fish populations across the globe (Agnew *et al.*, 2009). However, minimisation of this problem requires an understanding of underlying factors that influence illegal harvesting of resources (Muth and Bowe Jr., 1998).

Fishing bans, permanent or temporary, are commonly used for fisheries management and biodiversity conservation in aquatic ecosystems (Shiffman and Hammerschlag, 2016; van Brakel *et al.*, 2018; Amali Infantina *et al.*, 2020). Implementation of fishing bans requires consideration of socioeconomic, cultural, political, and behavioural issues of dependent communities to be effective (Muth and Bowe Jr., 1998; Bell, Hampshire and Topalidou, 2007; van Brakel *et al.*, 2018). Illegal fishing in marine and coastal ecosystems has received widespread attention in recent times (Shiffman and Hammerschlag, 2016; Aceves-Bueno, Read and Cisneros-Mata, 2021) but remains less-explored for freshwater habitats (Free, Jensen and Mendsaikhan, 2015). However, freshwater fishes are being impacted by numerous factors including overfishing, water pollution, habitat destruction, flow modification and biological invasions (Dudgeon *et al.*, 2006; Suski and Cooke, 2007) and are considered one of the most susceptible groups of freshwater organisms to endangerment (Duncan and Lockwood, 2001; Arthington *et al.*, 2016). In Asia and Africa, inland water resources are intensively exploited and are most at risk (Welcomme *et al.*, 2010).

Bangladesh is a South Asian sub-tropical country with diverse fish and other aquatic fauna. The country is one of the top fish producing countries of the world, ranked third in inland capture and fifth in aquaculture production (FAO, 2018; Khan *et al.*, 2022). In Bangladesh, fishing bans are commonly used to manage fisheries exploitation and help conserve aquatic biota, especially fishes. Both permanent and temporary fishing bans have been employed in important habitats of the country (Mredul *et al.*, 2020; Shalehin, Naher and Galib, 2020). However, a large number of people in Bangladesh, including 1.32 million professional fishermen, almost exclusively living below the subsistence level, are solely dependent on fishing for their livelihoods (DoF, 2019). Concern about the welfare of these fishermen and other stakeholders is growing during temporary fishery closures (van Brakel *et al.*, 2018; Mredul *et al.*, 2020). Fishing bans, including seasonal fishery closure (the 'closed season') are often blamed for reduced income for fishing communities, which, in many instances, provokes fishermen to fish illegally, by violating the closure (Dey *et al.*, 2010; van Brakel *et al.*, 2018; Mredul *et al.*, 2020). It is often the case that fishermen receive subsidies during the closed season but ineffective distribution of these also encourages fishermen to become involved in illegal fishing (Mredul *et al.*, 2020; Rayhan *et al.*, 2021). In addition, financial loans at high interest rates from different sources also influence the decisions of financially poor fishermen over where, when and how to fish (Habib and Jan, 2021; Rayhan *et al.*, 2021).

This study explored the underlying factors influencing illegal fishing during the closed season in Bangladesh's largest lake. Kaptai Lake is inhabited by at least 53 fish species, including 20 species of national conservation importance - eight endangered, six vulnerable and six near threatened species (Shalehin, Naher and Galib, 2020). We hypothesised that multiple factors associated with fishermen's livelihoods contributed to illegal fishing during the closed season, and that illegal fishing was primarily for commercial gain. Study outcomes may help to develop effective fisheries management and an improved biodiversity conservation policy, through better understating of underlying issues of illegal fishing.

2 MATERIALS AND METHODS

2.1 Study area

Kaptai Lake is located in the southeast of Bangladesh (Figure 1), comprises two basins, and has a total area of 68800 ha. It is a reservoir and was formed by damming the Karnaphuli River in 1962. Nationally, it is an important fishery resource (Khan *et al.*, 2022) and the most productive in southeast Bangladesh, with 10 152 metric tons of freshwater fishes landed in the year of 2017-18 (DoF, 2019). Through the 1950 Fish Act, fishing in Kaptai Lake has been prohibited between the beginning of April and mid-August since 1961, but this full closed season has not been widely implemented (Rayhan et al., 2021). Since 1992, a three-month fishery ban in the lake, from May to July, has been enforced by the government through Bangladesh Fisheries Development Corporation (BFDC), to safeguard fishes in the pre-spawning and spawning periods, immediately before and during the early part of the monsoon season. The lake authority (i.e. BFDC) launches patrolling operations from five different stations (Rangamati Sadar, Kaptai, Mahalchhari, Marishya and Langadu) to deter illegal fishing activities in the lake, usually on a daily basis, during the fishery closure period. However, given the size and remote location of the lake, and lakeside ridges that block line of sight across large areas of the lake, it is extremely difficult to police the whole lake consistently (Rayhan *et al.*, 2021). Therefore, poaching of fishes during this seasonal fishery closure is common in the lake (Shalehin, Naher and Galib, 2020).

2.2 Study approach

Data were collected in two stages. During the first stage, between January and April 2020, 260 fishermen were selected randomly, 130 from each of the north and south basins to avoid spatial bias in results (Figure 1) and interviewed using a questionnaire developed (based on relevant literature [Muth and Bowe Jr., 1998; Knapp, 2012; Islam *et al.*, 2017] and personal experiences) for the study. Respondents were selected at the fish landing centres of the lake when they brought their catch for selling. We approached four fishermen for interview (usually every third person) at each landing hour covering all landing schedules of the day. The questionnaire was designed to collect a wide range of demographic, socio-economic, cultural, political and behavioural information of the fishermen that potentially influenced fishing decisions of respondents (see Form S1 in the Supplementary information for questionnaire used for data collection). Although BFDC introduced licencing for fishermen and new fishermen are being brought under the licencing database every year, this is primarily for distribution of subsidies during the fishery closure period, not for controlling fishing activities in the lake. Therefore, fishermen engaged in fishing without a licence is very common and monitoring of fishing in the lake outside the fishery closure period seldom occurs except at the for seven fish sanctuaries in the lake.

In the second stage of study, data were collected between May and August 2020, comprising the closed season (May to July) and a further period of legal fishery operation (August). During this time fishermen were contacted weekly by mobile phone, to provide their fishing activity status (engaged in fishing or not). Because May–July is the closed season for fishing, data recorded during this stage enabled us to categorise respondents into two groups, (1) fishermen who were engaged in fishing during the closure (hereafter offenders), and (2) fishermen who were not engaged in fishing during the closure (hereafter law-abiding fishers). However, 19 fishermen could not be reached during this stage and therefore they were excluded from the analysis.

Fishermen belonging to the offender group were requested to disclose their motives for fishing during the period of fishery closure. We gave an idea of common motives, described by Muth and Bowe Jr. (1998) (Table S1), if asked for some examples by the respondent. If the fish caught by a particular fisher were sold, we collected information on selling points, people involved, pricing, and the marketing chain. Fishing gears used while fishing during the closed season were also recorded.

Weekly pricing data were collected over phone from 30 fishermen and 26 farias (mid-level participants in the marketing process who buy fish from fishermen at field sites (n = 8, four from each of the north and south basins of the lake) and send them to local or distant fish markets) over both data collection stages (Jan – August) to record the price of fishes at different levels of the supply chain. This allowed us to compare prices and determine gross profit margins between closed (May–July) and open (Jan–April and August) periods of the fishery. Price and profit analysis in this study was based on six major fish species of the lake (*Sperata aor*, *Corica soborna*, *Gudusia chapra*, *Labeo rohita*, *L. calbasu* and *L. bata*). Before every interview, respondents were informed that their participation was voluntary and that all data obtained would be kept confidential and anonymous, and would only be used for research purposes.

2.3 Data analysis

All statistical tests were performed in R (version 4.0.3; R Core Team, 2020) with an α level of significance of 0.05. Age, fishing experience, and education may be correlated, so a principal component analysis (PCA) defined the dimensions using the R package ‘psych’. Two PCA factors were identified for further analysis (Table S2) based on scree plots and a broken-stick model (Jackson, 1993). Age and experience were highly correlated on the same PCA axis (PC1, Table S2) and therefore only one (i.e. age) was considered for further analysis. A factor with a loading of >0.50 were considered to contribute to the meaning of a component due to small sample size (Budaev, 2010; Galib *et al.*, 2022). Collinearity between possible categorical variables (e.g. secondary occupation and financial loan) was checked by chi-square test and no significant relationships were detected (all $p > 0.05$).

Multiple logistic regression was used to determine factors that affected the likelihood of participants fishing in the lake during the closed season. A global model contained all potential variables (12 variables in total; age, education, BFDC licencing status, fishing ban knowledge, secondary income, land holding, other income generating member in household, financial loan, advanced finance from middlemen in supply chain, government subsidy, and past history of illegal fishing) and plausible models were defined with a ΔAIC of less than 2 (Burnham and Anderson, 2002) using the MuMIn package in R (Bartoń, 2019) (Table S3). A model averaging procedure was employed to generate the final model that included all important variables (Bartoń, 2019). However, each plausible model (with ΔAIC < 2) was tested and outcomes were similar to the final model considered (Table S4). Several factors, including training on alternative income generation, knowledge of fish law, membership of any political party were not considered for analysis as all respondents answered "no" to these questions.

To determine effects of fishery closure on price and profit levels, repeated measures pricing data were subjected to linear mixed-effects modelling (LMM) using the 'lme4' (Bates *et al.*, 2015) and 'lmerTest' (Kuznetsova, Brockhoff and Christensen, 2016) packages in R. During analysis, fishery condition (open or closed fishery season) was considered a fixed effect, whereas sampling month and fish species were considered random effects.

Data were explored before analysis to avoid common statistical problems (Zuur, Ieno and Elphick, 2010), especially when parametric tests were used. Where needed, data were subjected to log transformation to meet the assumptions for the test (McDonald, 2014).

3 RESULTS

3.1 Demographics

All participant fishers (n = 231) were male. Mean (± SD) age was 30.8 ± 8.6 and duration of fishing experience was 16.0 ± 7.6 years (Table 1). Mean duration of schooling was 1.8 ± 2.7 years. Further, no respondent had more than 10 years of schooling and 64.9% (n = 150) had no schooling (Table 1). Mean area of agricultural land owned by respondents was 0.002 ± 0.01 ha, and 96.1% (n = 222) of respondents owned no land (Table 1).

Fishing in the lake was the primary occupation, for earning income. However, 77.5% of respondents had a secondary income source, other than fishing in the lake (Table 1). 51.9% of the respondents' households had other income generating members (Table 1). Over half of respondents (58.4%, n = 135) had taken a financial loan from a local non-government organisation (NGO) at a simple interest rate above 20%. Over two thirds of respondents (67%, comprising 68% law-abiding and 66% offenders) received advance finance from the middlemen engaged in the supply chain at zero interest rate. Only 22 (9.5%) fishermen were members of a fishing cooperative society (Table 1). None of the fishermen had any training on agricultural cropping or other income generating activities. Most respondents from both study groups had not obtained licences from the BFDC (offender group: n = 102; law-abiding fishers: n = 81) (Table 1).

3.2 Fishing behaviour during the seasonal fishery closure

Nearly half of respondents (46.8%, n =108) were engaged in fishing the lake during the closed season (Table 1). Overall, 98.3% (n = 227) of respondents, including all members of the law-abiding fishers and 96.3% of the offender group, were aware of the seasonal fishing ban in the lake and its duration (Table 1). More than half of respondents (54.1%, n = 125) had fished Kaptai Lake during the closed season in the past. In 2020, 56.7% of respondents had received a subsidy (20 kg rice per month per fishing household) from the government to help support them during the closed season (Table 1). All fishing nets used in during the closed season (small-meshed gillnets and seine nets, 35% and 65% respectively) were non-selective in nature.

3.3 Factors affecting fishing during the seasonal fishery closure

Fishing during the closed season was strongly affected by financial loan, government subsidy, and secondary income (Table 2). Fishing during the closed season was positively affected by responders being in receipt of a financial loan and negatively by receipt of a government subsidy and secondary income (Table 2). All fishermen who received a subsidy from the government but engaged in fishing during the fishery closure (17.6%, Table 1) mentioned that the subsidy was not adequate to fulfil their needs (100% offenders and 77% law-abiding fishermen), or was distributed later than it should have been (58% offenders and 31% law-abiding fishermen). No effects of ban knowledge and fishing society membership were found (Table 2).

3.4 Post-harvest distribution of fish during fishery closure

All respondents reported that they consumed a small portion of fish harvested (~1% of the total catch) as a part of their daily consumption (Figure 2). However, they also mentioned that the prime motive for fishing during the closure period was to earn money by selling, not for household consumption and they did not return any catch into the lake.

Fish harvested during the closed season were either sold to local consumers within the study area or consumers in two of the largest cities in the country, Chattogram [= Chittagong] and Dhaka (Figure 2). Fishermen engaged in illegal fishing received significantly lower prices (mean ± SD: BDT 95.8 ± 64.9; BDT is the Bangladeshi Taka, ~80 BDT = 1 USD) during the closed season than the open season (BDT 151.1 ± 87.3). Unlike fishermen, mid-level actors involved in fish distribution during the fishery closure earned 99–154% more profit (LMM: F = 50.5 – 130.6, $p \leq 0.001$; Figures 2 & 3). Interestingly, two thirds of members of the offender group (66%) received finance from mid-level actors during the fishery closure period with a condition of selling their harvested fish to them (Table 1).

4 | DISCUSSION

This study indicates that engagement in illegal fishing during a well-documented and publicised closed season was very common in the study area. This practice is also common in coastal or marine habitats of Bangladesh (van Brakel *et al.*, 2018; Mredul *et al.*, 2020) and all over the world (FAO, 2001; Bell, Hampshire and Topalidou, 2007; Agnew *et al.*, 2009). Despite knowing about the fishery closure in the lake and regular patrolling by government officials, a high proportion of fishermen continued fishing, which indicates that factors were more important to these fishermen than the potential risk of being caught and fined. A high level of illegal fishing potentially undermines the efficacy of measures designed to manage the fishery sustainably and to support wider biodiversity (FAO, 2001; Agnew *et al.*, 2009; Arlinghaus *et al.*, 2015).

4.1 Demographics

All respondents surveyed were male, which was expected in Bangladesh. In Bangladesh, fishing is considered a risky job that often requires going out at night (Parvez *et al.*, 2017). Therefore, despite increasing participation of women in other fisheries-based professions (e.g. fish processing and selling) (FAO, 2018), fishing activities were predominated by males. The result is comparable to findings of others that showed fishers were all or almost exclusively male in Bangladesh (Islam *et al.*, 2013; Galib *et al.*, 2016), a pattern that also tends to be reflected globally (Harper *et al.*, 2020; Albright and Lucas, 2021).

Education is considered important in fishery management, including for the conservation of resources (Albright and Lucas, 2021), but respondents surveyed in this study had a low level of education. Poor education of fishermen in Bangladesh is primarily due to early engagement in income generating activities to assist their families economically (Rahman *et al.*, 2020).

4.2 Fishing behaviour and factors affecting illegal fishing

Fishing during the closed season was more likely for respondents who had received a financial loan. Fishing communities in Bangladesh usually rely on NGOs or individual money lenders for financial loans, whose interest is much higher than from government organisations (e.g. government banks, usually 9% interest rate; cf. >20% for NGO) (Islam *et al.*, 2017; Rahman *et al.*, 2020). Moreover, these NGOs demand weekly instalments of repayment in most cases that require fishermen to earn and repay the money regularly. Similarly, in the study area, all respondents had received loans from NGOs at the higher rate. Financial loans at high interest rates can make fishermen vulnerable to financial exploitation (Rahman *et al.*, 2020). At Kaptai Lake, illegal fishing would likely be the primary means of earning money during the closed season for respondents who have taken loans from various sources at high interest rates.

Illegal fishing during the closed season was less likely for those respondents in receipt of government subsidies at Kaptai Lake. In Bangladesh, the government often allocates subsidies (i.e. money and / or essential goods such as rice, flour, oil) to fishermen during the closed season to economically assist fishing households. Unfortunately, distribution of these subsidies often does not reach the bona fide fishermen and results in their engagement in illegal fishing (Mredul *et al.*, 2020). This might have been the case in our study, where over 80% of fishermen in the offender group stated they did not receive any subsidies. Interestingly, despite receiving a subsidy, a considerable proportion (about one fifth) of the offender group fished illegally during the closed season. However, the government closed-season subsidy often arrives late, or the amount provided is inadequate, which stimulates fishermen to fish illegally (Dey *et al.*, 2010; Islam *et al.*, 2017; Mredul *et al.*, 2020), as in the study area.

Our model output showed that fishing during the closed season was less likely for respondents with a secondary source of income. People who have income sources other than fishing would likely face less difficulties to maintain their livelihood during the closed season. Income of fishing households may be reduced by 50% during the seasonal fishery closure, and therefore, alternative or secondary income generating activities are considered vital for the vulnerable community of fishermen in Bangladesh (Dey *et al.*, 2010; Rahman *et al.*, 2020). However, secondary sources of income during the closed season were generally regarded by respondents as insufficient to cover livelihood costs. No respondent received training on any income generating ventures, which may be a barrier to creating alternative livelihood opportunities in the study area and reflects the overall scenario of poor fishermen in South Asia where they have few alternative livelihood options (Panigrahi and Pattnaik, 2020; Rahman *et al.*, 2020).

Illegal fishing impacts may have serious consequences on the Kaptai Lake fish biodiversity, especially the threatened fishes of the lake (mainly siluriforms, osteoglossiforms, synbranchiforms), as all the fishing nets used during the fishery closure period were non-selective and no catch was returned to the lake. Fishing nets like gillnets and seine nets are capable of catching fishes of almost all sizes (Galib *et al.*, 2009) widely recognised for having serious negative impacts on the threatened species as well as total fish community in a habitat (Mancini *et al.*, 2012; Free, Jensen and Mendsaikhan, 2015). Rayhan *et al.* (2021) report how the percentage contribution of large-bodied native cyprinids to catches in Kaptai Lake has declined dramatically in recent decades. Wild fish production in Kaptai Lake is now dominated by three small-bodied clupeids *Corica soborna*, *Gudusia chapra* and *Gonialosa manmina* (Shalehin, Naher and Galib, 2020). The shift from 80% of fishery production comprising large cyprinids in 1966 (Ahmed *et al.*, 2005) to the situation now, where small-bodied clupeids comprise 90% of fishery production is consistent with an overfishing scenario. Nevertheless, damming of the river and resultant habitat modification associated with migration blockage and habitat modification (Lucas and Baras, 2001), as well as pollution and siltation (Shalehin, Naher and Galib, 2020; Rayhan *et al.*, 2021), are likely contributory factors to the observed decline in large cyprinids and nationally endangered siluriforms such as *Pangasius pangasius*.

4.3 Fate of harvested fish

Most illegally harvested fish were sold for commercial gain by the fishermen to mid-level actors in the supply chain, this being one of the major motives for poaching worldwide (Muth and Bowe Jr., 1998). Fishermen who fished during the closed season received significantly lower prices for their catch from mid-level actors in the supply chain. This may be due to: (1) fishermen were exploited by the mid-level actors knowing that the harvest was illegal, or (2) they had no choice but to sell their harvest to cope with issues encountered (e.g. maintaining livelihoods and repaying high-interest based loans under situations when income became restricted).

One potential limitation in our study deserves consideration. As we collected data of illegal fishing over the telephone it was not possible for us to confirm if any of the respondents hid his involvement in illegal fishing. However, as the participation was voluntary and data were promised to be used anonymously, we believe that data obtained are likely to be reliable.

4.4 Conclusions

Fuller consideration and integration of underlying issues of fisheries and conservation management plans is urged, because these have the potential to affect the success of those management measures, including at Kaptai Lake. Although such statements, and the needs of vulnerable stakeholders, are frequently emphasized in global reviews (Cooke *et al.*, 2016), studies such as ours show that conservation actions, which appear laudable as policies, may have little practical or ethical application at the local level. The issue of “closed seasons”, which remain open in practice at Kaptai Lake, is parallel to the concept of “paper parks” which purport to provide protected area conservation but offer little protection in reality (Pieraccini, Coppa and De Lucia, 2017). Greater efforts are needed locally and globally to ensure that fisheries and aquatic biodiversity protection policies achieve their intended outcomes in practice.

Evidently fishermen in the study area fished during the closed season due to the increased pressure from loan providers, lack of alternative occupation to support livelihood adequately, and insufficient or no subsidy support from the government. Therefore, an integrated management policy considering all such factors is needed to enable the closed season to function. We suggest that regular financial or special loans at low interest rates should be sanctioned for fishermen in the study areas. We recommend timely distribution of subsidies in appropriate amounts to as many Kaptai fishermen as possible. The size of the household should be considered during the distribution of such support. Alternative livelihood options for vulnerable fishermen should be explored and supported by the lake regulating authority (i.e. BFDC and associated government organisations). Training on alternative livelihood options may be effective in this regard, as reported for the mud crab fishery in Southwest Bangladesh (Rahman *et al.*, 2020). This might prove effective given that none of the respondents were trained in any alternative livelihood options. Increased patrolling for illegal fishing and associated activities (e.g. visiting fish markets for selling of illegally harvested fish) may be necessary, but this is unlikely to be suitable as a long-term solution, without concurrent measures such as those described above. Currently, a small number of fishermen had membership of a fisheries cooperative society, which should be expanded and brought into close cooperation with lake regulatory or associated organisations. This would be helpful for organising fishermen for initiatives related to biodiversity conservation in the lake involving the community, a common conservation initiative worldwide with a view to improving both the biodiversity and livelihood performances (Knapp, 2012; van Brakel *et al.*, 2018).

Ultimately, both community- and incentive-based conservation programmes may not be successful until underlying economic issues are resolved. Fishing communities are among the poorest communities in Bangladesh and much of southern Asia (Willmann, 2004; Rahman *et al.*, 2020). Therefore, to enhance the success of long-term management that employs permanent or temporary fishery closure in developing regions, the affected communities should be lifted out of poverty through development of alternative livelihoods.

Ethical statement

The lake is one of the most attractive tourist destinations in Bangladesh and open to the public, so no special permission was needed to conduct this study. The study design and questionnaire / data collection form used in this study was approved by the Office of the Dean of the corresponding author's institution (Ref. 77/22/FisFac).

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Table 1: Descriptive summary showing major demographic, economic and knowledge of the respondent fishermen of Kaptai Lake, Bangladesh. Those fishing during the closed season on Kaptai Lake in 2020 were classed as ‘offenders’ and those not fishing were the ‘law-abiding fishers’.

Factors	**Mean ± SD (range) or percentage (%)**		
	Law-abiding fishers (*n* = 123)	**Offender group (*n* = 108)**	**Total (*n* = 231)**
Age (year)	28.8 ± 6.6 (18 – 55)	33.0 ± 9.9 (13 – 60)	30.8 ± 8.6 (13 – 60)
<20	3	9	12
20–29	72	32	104
30–39	40	34	74
40–49	7	29	36
50–59	1	3	4
≥60	0	1	1
Fishing experience (year)	13.4 ± 6.1 (5 – 30)	18.9 ± 8.1 (3 – 40)	16 ± 7.6 (3 – 40)
Schooling (year)	2.0 ± 2.7 (0 – 10)	1.4 ± 2.6 (0 – 10)	1.8 ± 2.7 (0 – 10)
No schooling	57.7 (71)	73.1 (79)	64.9 (n=150)
Primary schooling	31.6 (39)	17.6 (19)	25.1 (n=58)
Secondary schooling	18.6 (23)	9.3 (10)	10 (n=23)
Owned agricultural land (ha)	0.001 ± 0.01 (0–0.04)	0.002 ± 0.02 (0–0.2)	0.002 ± 0.01 (0 – 0.2)
Landless	94.3 (116)	98.2(106)	96.1 (222)
Secondary income (%)			
Yes	60	92.7	77.5
No	40	7.3	22.5
Other income generating member in household (%)			
Yes	55.3	48.1	51.9
No	44.7	51.9	48.1
Taken formal financial loan (%)			
Yes	45.6	73.1	58.4
No	54.4	26.9	41.6
Loan sources			
NGO	100	100	100
Others	0	0	0
Received advance finance from the middlemen in the supply chain (%)			
Yes	68	66	67
No	32	34	33
Membership of fishing cooperative society (%)			
Yes	6.5	13	9.5
No	93.5	87	90.5
Received government subsidy during fishing ban (%)			
Yes	91.1	17.6	56.7
No	8.9	82.4	43.3
Past history of fishing during ban (%)			
Yes	47.2	62	54.1
No	52.8	38	45.9
Aware of fishing ban in the lake (%)			
Yes	100	96.3	98.3
No	0	3.7	1.7
BFDC licencing			

Yes	34.1	5.6	20.8
No	65.9	94.4	79.2

Table 2: Factors affecting illegal fishing in Kaptai Lake, Bangladesh during the fishery closure period in 2020 (May-July), obtained through multiple logistic regression.

Factors	**Estimate**	***z* value**	***p* value**
Ban knowledge	–20.37	–0.014	0.989
Fishing society membership	0.86	0.903	0.366
Financial loan	0.47	3.661	**<0.001**
Government subsidy	–5.36	–7.842	**<0.001**
Secondary income	–3.49	–4.997	**<0.001**

Table 3: Pricing of fishes (in Bangladesh Taka, BDT) at various levels of fish distribution from Kaptai Lake, Bangladesh in 2020 along with linear mixed-effect modelling (LMM) results.

Actors	**Price (per kg; Mean ± SD)**		**Trends (%)**	**LMM outputs**		
	During banned period (May–Jul)	**Outside banned period**		**Estimate**	***F***	***p***
Fishermen	95.8 ± 64.9	150.5 ± 87.0	↓ 36	–0.21	35.4	**0.001**
Faria (local)	168.8 ± 83.8	179.2 ± 100.4	↓ 6	–0.02	0.9	0.390
Faria (national)	209.2 ± 102.9	207.3 ± 121.3	↑ 1	0.02	1.0	0.360

~80 BDT = 1USD$; *farias* are mid-level actors in the distribution channel of fishes. ↓, lowering of price during the fishing banned period than outside banned period;

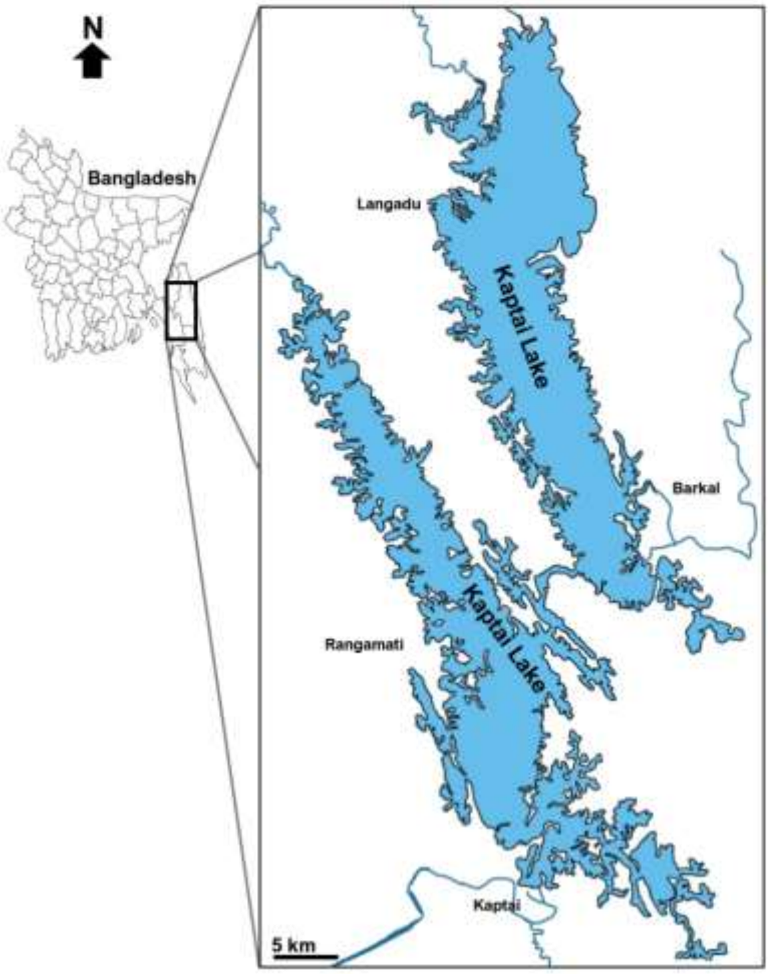

Figure 1: Map of the study area, Kaptai Lake in Bangladesh.

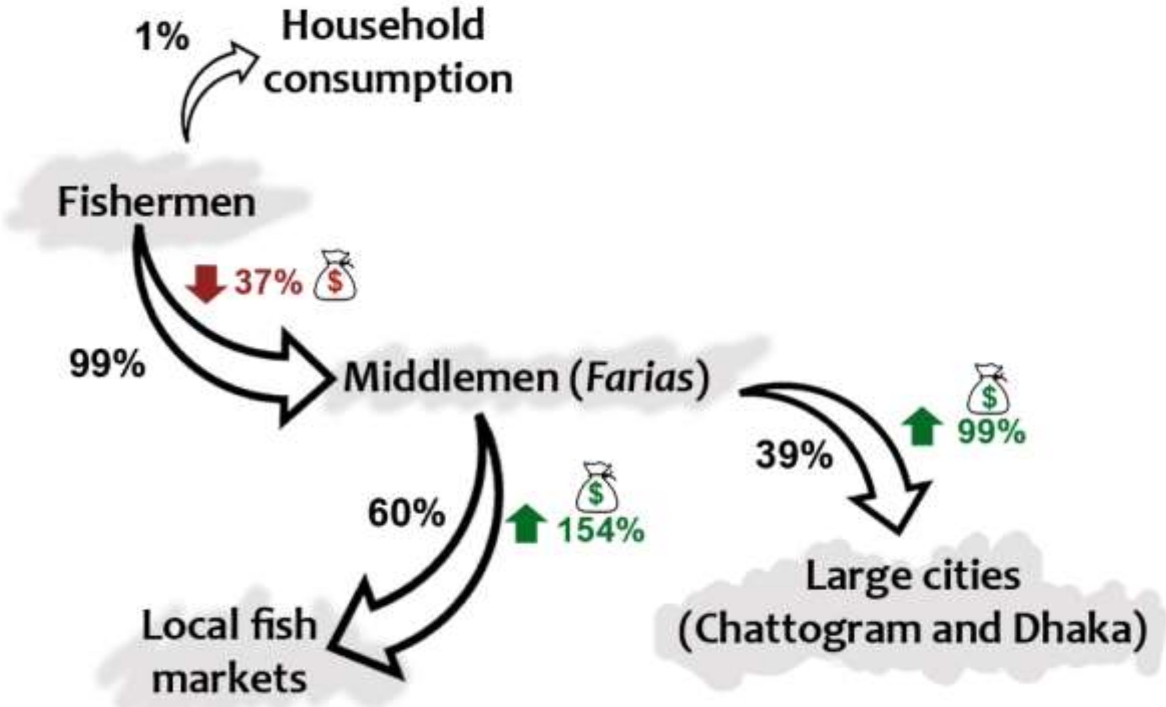

Figure 2: Marketing channels showing distribution of fishes harvested during the ban period in 2020 in Kaptai Lake, Bangladesh. Coloured straight arrows indicate trends of gross profit compared to non-ban period. Figure (as %) on the left of the curved arrow shows the approximate proportion of the total amount of initial harvested. Chattogram was formerly known as Chittagong.

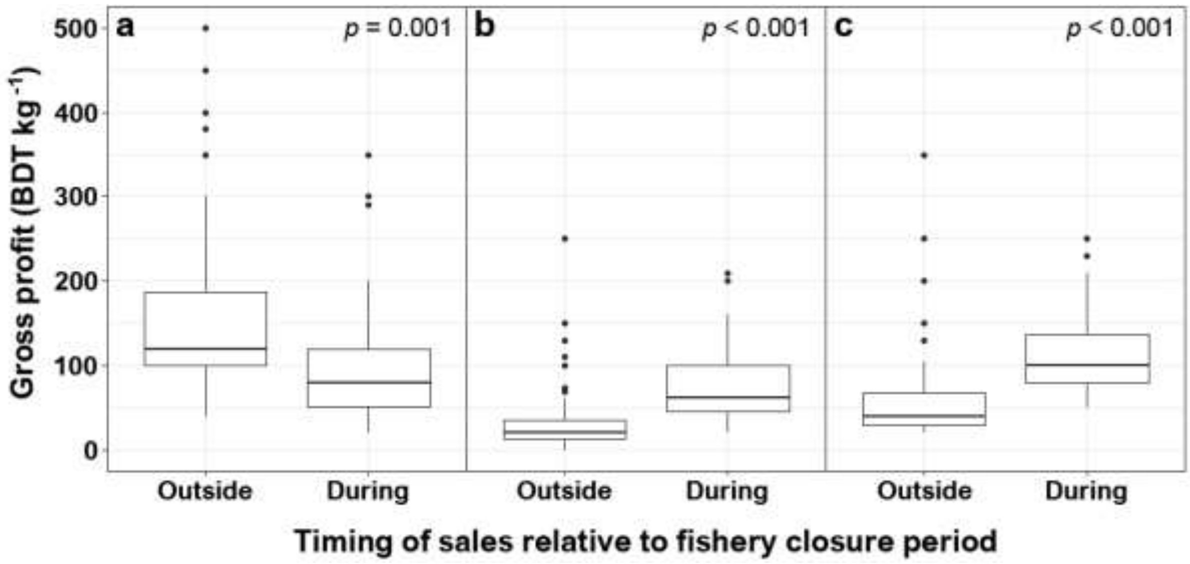

Figure 3: Profit of fishermen (a), mid-level actors who sold their product locally (b) or in distance cities (c), during and outside the closed season in 2020 in Kaptai Lake, Bangladesh. Midline within the box is the median; upper and lower limits of the box represent the third and first quartile (75th and 25th percentile) respectively. Points are outliers.

Supplementary information

Form S1: Data collection form for study of illegal fishing motives on Kaptai Lake, Bangladesh

[Translated into English, original version was in Bengali]

[The collected data will be used for research purpose only; results will only be presented in a summarised / collective form; personal identity of the respondents will not be disclosed]

Date of interview:

Part A: Basic information

1. Name of the respondent — Unique ID:
2. Address: — Contact No.
3. Age of the respondent (in years):
4. Fishing experience in the lake (in years):
5. Education level of the respondent (as schooling years):
6. BFDC fishermen licence holding status: Yes / No
7. Land holding status

Part B: Knowledge of fishing laws or bans

1. Aware of fishing ban period in the lake: Yes / No
2. Training on fisheries law and regulation:
   Details of training if the answer is yes.

Part C: Social, economic and political factors

1. Are you a member of any fishermen cooperative society?
   If yes, please provide details.
2. Apart from cooperatives, do you have any other memberships?
   If yes, please provide details.
3. Do you have a secondary occupation / income source?
   If yes, please mention monthly income.
4. Have you received any training on alternative income generation?
   If yes, please provide details.
5. Have you taken financial loan from formal sources? (e.g. bank/NGO)
   If yes, please mention loan amount, source and interest rate
6. Have you received finance from informal sources? (e.g. individuals)
   If yes, please mention loan amount, source and interest rate
7. Is there any other income generating person in your household?
   If yes, please provide details.
8. Are you a registered member of any political party?
   If yes, please provide details.

Part D: Subsidy during the fishery closure

1. Have you received subsidy? Yes / No
   If yes, was the amount adequate?
   If yes, was the distribution timely?
2. What is your expectation regarding subsidy?

Part E: Illegal fishing in the lake (over phone)

1. Have you harvested fish during the fishery closure this year?
    - If yes, why have you gone for fishing?
    - If yes, have you motivated by others or self-motivated?
    - If yes, what did you do with the harvested fishes?
        - If sold, please mention price, place and other relevant information
2. What fishing gear have you used for during the fishery closure?
    - Common characteristics of the gear and its catch composition
3. Did you fish during the ban in the past?

Table S1: Summary of the motives for illegal harvesting (i.e. poaching) of resources, after Muth and Bowe Jr. (1998).

Motives	**Remarks**
Commercial gain	Explained and used during the interviews
Household consumption	Explained and used during the interviews
Recreational satisfaction	Explained and used during the interviews
Trophy poaching	Not used
Thrill killing	Not used
Protection of self and property	Not used
Poaching as rebellion	Explained and used during the interviews
Poaching as a tradition of right of use	Explained and used during the interviews
Disagreement with specific regulation	Explained and used during the interviews
Gamesmanship	Explained and used during the interviews

Table S2: Component loading of fishermen characteristics (Kaptai Lake, Bangladesh), obtained through principal component analysis. Boldface indicates the highest component loading for each factor.

Factors	**PC1**	**PC2**
Age	**0.94**	–0.12
Experience	**0.93**	–0.17
Education	–0.11	**0.99**
Variance explained (%)	59	35
Total variance (%)	94	

Table S3: Summary of the subset models explaining fishing status during the fishery closure period in Kaptai Lake (Bangladesh), yielded from global model. All models with ΔAICc value <2 are included here and examined (Table S3). The summary of the final model is presented in the main text of the paper.

Models		**df**	**logLik**	**AICc**	**delta**	**weight**
m1	Ban knowledge+Society membership+ Financial loan+Subsidy+Secondary income	30	–9.7	88.7	0	0.350
m2	Ban knowledge+Financial loan+Subsidy+ Secondary income	29	–11.1	88.9	0.2	0.317
m3	Ban knowledge+Society membership+ Financial loan+ Subsidy+Secondary income+ Other earning member in HH	31	–8.9	89.8	1.1	0.202
m4	Ban knowledge+Age+ Financial loan +Subsidy+ Secondary income	30	–10.7	90.7	1.97	0.131
Final model: *Ban knowledge + Society membership + Financial loan + Subsidy + Secondary income*						

Table S4: Factors affecting fishing during the fishery closure period in Kaptai Lake (Bangladesh), based on models in Table S2. Model m1 (not shown) is the final model, based on model averaging, and already presented in the main manuscript (Table 2).

Model	**Factor**	**Coefficient estimate**	**SE**	***z***	***p***	**95% CL**
m2	Ban knowledge	–20.25	1467.89	–0.01	0.989	NA to 147.30
	Financial loan	0.46	0.13	3.668	**<0.001**	0.23 to 0.68
	Subsidy	–5.30	0.66	–7.97	**<0.001**	–6.38 to –4.12
	Secondary income	–3.53	0.70	–5.03	**<0.001**	–5.04 to –2.25
m3	Ban knowledge	–20.39	1470.60	–0.01	0.989	NA to 147.37
	Society membership	0.86	0.95	0.90	0.367	–1.01 to 2.70
	Financial loan	0.47	0.13	3.63	**<0.001**	0.23 to 0.69
	Subsidy	–5.38	0.69	–7.79	**<0.001**	–6.91 to –4.16
	Secondary income	–3.50	0.70	–4.99	**<0.001**	–5.00 to –2.22
	Other earning member in HH	0.05	0.52	0.09	0.927	–0.93 to 0.91
m4	Ban knowledge	–20.22	1531.70	–0.01	0.989	NA to 153.8
	Age	2.23	2.20	1.02	0.310	–2.08 to 6.63
	Financial loan	0.46	0.13	3.62	**<0.001**	0.22 to 0.73
	Subsidy	–5.17	0.67	–7.74	**<0.001**	–6.64 to –3.99
	Secondary income	–3.53	0.70	–5.04	**<0.001**	–5.03 to –2.25