TBTI GLOBAL BOOK SERIES

SMALL IN SCALE BIG IN CONTRIBUTIONS

ADVANCING KNOWLEDGE OF SMALL-SCALE FISHERIES IN BANGLADESH

Edited by
Mohammad Mahmudul Islam

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Small in Scale Big in Contributions

Advancing Knowledge of Small-Scale Fisheries in Bangladesh

TBTI GLOBAL
Small-Scale Fisheries are Too Big To Ignore

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Too Big To Ignore Global (TBTI; toobigtoignore.net) is a research network and knowledge mobilization partnership supported by over 800 members from around the world. The network aims at elevating the profile of small-scale fisheries, arguing against their marginalization in national and international policies, and developing research and governance capacity to address global fisheries challenges.

TBTI Global Book Series is a publication series that aims to highlights why we need to pay close attention to small-scale fisheries. The series will be of use to anyone interested in learning more about small-scale fisheries, especially about their important contribution to livelihoods, well-being, poverty alleviation and food security, as well as to those who are keen to help raise profile of small-scale fisheries in the policy realm.

Cover graphic design by Vesna Kerezi
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Foreword

An image of the lush Sundarban mangrove forest might be the first impression that comes to mind when one thinks of Bangladesh. But those in the know might be thinking of the wetland ecosystem in the northeastern part, known as the '*haor*.' Both the coastal, marine areas, and the inland, freshwater systems, are lucrative grounds for fish and fishing livelihoods that feed and sustain millions of people in Bangladesh. It is hard to imagine going anywhere in Bangladesh and not appreciating the role that fish, fisheries, and fishing people play.

Small-scale fisheries are certainly big in Bangladesh, both in terms of number and importance. The book 'Small in Scale, Big in Contributions' contains evidences of this statement, illustrated in 37 chapters by 86 authors, under the editorship of Prof. Mohammad Mahmudul Islam of Sylhet Agricultural University. In addition to colleagues from his university, Prof. Islam has invited scientists and researchers from around the country, many of them early career scientists, to write about diverse topics of small-scale fisheries in various water bodies. Together, the book offers a rare opportunity to appreciate what small-scale fisheries in Bangladesh look like and why they are important, while presenting key concerns and challenges facing the sector. Despite their value and contribution, many people involved in small-scale fisheries, especially women in post-harvest activities, remain economically and politically marginalized, and are highly vulnerable to different types of changes around them.

Being big in number has a disadvantage in terms of gaining a full understanding about the whole system. Yet, as shown through this e-book, the collaboration and dedication of researchers and scientists from various disciplines and institutions can help fill in the gap and connect the dots for better understanding about small-scale fisheries in Bangladesh. This book truly enhances the knowledge about the sector, and it is with great pleasure and privilege that we share this volume with the world.

Ratana Chuenpagdee
TBTI Global Book Series Editor
Bangkok, March 2023

Acknowledgement

I extend my deepest thanks and immense gratefulness to TBTI Global Director and TBTI Global Book Series Editor, Professor Ratana Chuenpagdee of Memorial University, for inviting me to participate in the Too Big To Ignore (TBTI) Global Partnership, and for encouraging me to work on this edited volume. Throughout the whole process, she was immensely helpful with her guidance and advice. I feel privileged and rewarded to work with her in the TBTI project. I offer boundless appreciation to Vesna Kerezi, TBTI coordinator, who was instrumental in the technical production of the e-book, especially with language editing and copy-editing assistance. My sincere thanks go also to Amany Begum, Md. Ruyel Miah, and Madu Galappaththi for their important assistance.

Eighty six authors have contributed to this book. Words are inadequate in offering sincere appreciation to all authors. Without their insightful contributions, expertise, and dedication this project would not have been possible. Their enthusiasm and passion for fisheries research are evident in this edited volume. It has been an honour for me to have had the opportunity to work with a big group of talented authors.

The book is launched to help commemorate the establishment of TBTI Bangladesh Research Network, with a kick-off meeting with fisheries stakeholders, held at Sylhet Agricultural University on March 15, 2023. I would like to thank Department of Coastal and Marine Fisheries, Faculty of Fisheries and Sylhet Agricultural University for their support and for hosting the event.

I take this opportunity to express my deepest sense of veneration to the fishing people and their communities whose perceptions and voices are manifested in almost all chapters of this volume. Fishing communities are at

the core of all our research efforts and collaboration with them is the basic tenet of our activities. Nothing will be enough to express my heart-felt thanks to all of them.

The celebration of the book and the launch of TBTI Bangladesh come at the time when we feel the deepest sense of loss. On behalf of the small-scale fishing communities and fisheries researcher, I would like to take a moment to pay homage to our dear mentor and colleague, Prof. Dr. Mostafa Ali Reza Hossain. He was a passionate advocate for small-scale fisheries and believed in the importance of preserving the fisheries resources and sustaining the livelihood of fishing people of Bangladesh. Prof. Hossain dedicated his professional career to fisheries research. Earlier in his career, his research focused on fisheries biodiversity and conservation. In recent years, he took immense interest in research on fisheries-based livelihoods. A chapter written by him, which is included in this volume, is a testament of Prof. Hossain, the interdisciplinary scientist and the humanist. He was a dedicated mentor and helped countless students and early career researchers to develop their skills and knowledge of the fisheries research in Bangladesh. We dedicate this book to him, to honour him and his work.

I acknowledge the support from 'Transformative Social Innovations in the Governance of Small-Scale Fisheries in the Indian Ocean Region' project funded by the Social Science Research Council of USA and 'Vulnerability to Viability (V2V): Global Partnership for Building Strong Small-Scale Fisheries Communities' project funded the Social Sciences and Humanities Research Council of Canada. This book is a contribution to the International Year of Artisanal Fisheries and Aquaculture (IYAFA) 2022, and it is our pledge of continuing support to promote viable and sustainable small-scale fisheries in Bangladesh, and beyond.

Mohammad Mahmudul Islam (editor)
Sylhet
March 2023

I

Status, Diversities and Importance

1. Introduction

Mohammad Mahmudul Islam, Sylhet Agricultural University

Hilsa shad (Tenualosa ilisha), a prized delicacy with huge social, economic, and political significance (Photo: Mahmudul Islam, 2017).

The book is organized into three main parts in order to capture key thematic areas addressed in the chapters. The book opens with Part 1, focusing on ways of defining small-scale fisheries, given the diversity and complexity of the fishing practices, and the realities of their existence across various water bodies. Their multifaceted characteristics are illustrated in several chapters, underlying both their importance (Part 1) and the challenges they face (Part 2). Part 3 depicts the governance of *small-scale fisheries and outlines the responses to challenges.*

Status and definition

There is no official definition for small-scale fisheries in Bangladesh. However, some terminologies are often used to identify fisheries that are small in scale. Among these, 'artisanal' is a term that is most frequently used to describe small-scale fisheries. Globally, Bangladesh ranks third in inland capture fisheries and all fishing in these open-water bodies can be considered small-scale. These also include artisanal coastal and marine sector, which contributes more than eighty percent of the total marine landing (Hossain, Ch. 2). The Department of Fisheries refers to coastal small-scale fisheries as artisanal fishing occurring in shallow waters, typically below 40 meters in-depth and using mechanized or non-mechanized boats. Small-scale fisheries also include those fishing practices with low-technology and low-capital, undertaken by individual fishing households, who often make short fishing trips (rarely overnight) close to shore. Artisanal fisheries can be for subsistence and/or commercial purpose, providing for local consumption and exports (DoF, 2020). The Marine Fisheries Act of 2020 designates vessels with a capacity of 15 tonnes or less as a marine artisanal fishing vessel. The aquatic habitats of small-scale fisheries are diverse and fishing can take place in rivers (Chandan, Ch. 15), estuaries (Islam et al., Ch. 26), permanent and semi-permanent depressions inundated with water in the floodplains (locally known as *haors*, *baors*, and *beels*) (Alam et al., Ch. 18; Jewel & Haque, Ch. 19), mangrove ecosystems (Barman et al., Ch. 8), and human-made lakes (Suman, Ch. 4; Saha & Mozumder, Ch. 6), as well as in coastal and inshore waters up to 40 meters in-depth (Chowdhury & Islam, Ch. 11) (DoF, 2020).

Characteristics

Similar to what has been observed around the world, small-scale fisheries of Bangladesh are inherently complex, heterogeneous, and dynamic (Fagun & Rishan, Ch. 5; Saha & Mozumder, Ch. 6). Accordingly, the small-scale fishery sector in Bangladesh is highly diverse, both in coastal and inland waters. This diversity embraces a variety of fishing practices, from traditional to modern fishing, from non-motorized boats to larger mechanized vessels owned by commercial fishers. The small-scale coastal fisheries are multi-gear, multi-craft, and multi-species fisheries (Barman, Ch. 3). Traditional fishing crafts equipped with low-tech gears require labour-intensive fishing methods (Suman, Ch. 4). However, these traditional wooden boats are now in decline due to an increasing trend of mechanization, thus enabling variation in construction and equipment varies in terms of size, engine power, and gear handling systems, depending on the area of operation and the type of gear (Mustafa et al., Ch. 7; Ujjaman et al., Ch. 35). Nevertheless, traditionalism is firmly rooted in the fisheries with many gears having remained unchanged for centuries and with fishing knowledge being passed on through the generations. Although the majority of fishing gears are low-tech and labour-intensive technological, changes still synchronize with switching of the target species, changing climatic and environmental conditions, along with trajectories of socioeconomic and cultural modification (Mustafa et al., Ch. 7; Ujjaman et al., Ch. 35).

Importance

The Bangladesh fisheries employs more than 17 million people, which represents about 10 percent of the population (Shamsuzzaman et al., 2017). At the same time, there is no specific labour division among small-scale–and industrial fisheries. Still, it is fair to assume that a major part of the fishing population is employed in small-scale fisheries. Due to a number of drivers such as technological advancements, overcapitalization, and integration with distant markets, fishing activities have expanded rapidly and so has the volume of fishing labour (Jamil & Ullah, Ch. 9; Chowdhury & Islam, Ch. 11). Small-scale fisheries often absorb the excess labour when other livelihood options are lost due to extreme events, such as a cyclone or river bank erosion (Begum & Islam, Ch. 23). Among the fishing population, there are 1.4 million women (Shamsuzzaman et al., 2017) whose contributions remain largely invisible and underappreciated, despite the fact that fisherwomen have a larger range of fisheries job portfolios than man. Fisherwomen catch fish, make and repair nets and boats, and sort, wash, grade, process, package, transport, and market fish products, according to Sultana et al. (Ch. 10). Traditional low-caste fishers are firmly rooted in small-scale fisheries as a way of life and these play a significant role in livelihood, food, nutritional security, employment, culture, and faith (Chowdhury & Islam, Ch. 11; Ashab & Rashid, Ch. 17).

With a population of over 170 million and a growing need for animal protein, fish is an important source of food, nutrition, and income generation in Bangladesh. Particularly for some fish species, both consumption and non-consumption values are very high. Bangladesh is famous for its hilsa shad fish species (*Tenualosa ilisha),* a prized delicacy with huge social, economic, and political significance. The species generates billions of dollars in economic value per year and contributes about 1 percent to the country's GDP. Given this enormous economic value, experts often point out the need to call for to the 'hilsa economy' to be treated as an entire economy on its own, as a separate entity of Bangladesh's economy. Hilsa shad species is widely depicted in Bengali literature, tourism campaigns, on postal stamps, and in different symbols as a cultural icon of Bengali heritage The species is also immensely popular at different social events (such as Bengali New year) and is honoured religiously by Hindus. All of these consumers in India's state of West Bengal often depend on imported hilsa from Bangladesh but Bangladesh has officially banned foreign export of hilsa, including to West Bengal. The political discussion in Bangladesh demands a fair share of transboundary waters such as, for instance, Teesta River (Chandan, Ch. 15), before a ban on hilsa export in India can be lifted.

Challenges

Small-scale fisheries of Bangladesh face many challenges as described in several chapters. Although some challenges share commonalities with other global contexts, many of these challenges are unique to Bangladesh.

Small-scale fisheries in all ecosystems face serious multifaceted threats and stressors due to overexploitation, illegal fishing practices, pollution, habitat destruction, siltation, climate change overexploitation, extreme fishing pressure, and weak governance, among others (Barman et al., Ch. 8; Habib et al., Ch. 13; Alam et al., Ch.18; Pandit et al., Ch. 20; Rahman et al., Ch. 21). Some of these challenges often result in traditional fishers' desire to leave the fisheries. As shown by Chowdhury and Islam (Ch. 11), poor catch, scant recognition by the wider society, subjective insecurity due to criminal gangs' activities, and long-term debt bondage to middlemen often push traditional fishers to search for alternative livelihood options, even though they are firmly attached to fishing occupations due to strong traditional and cultural affinity.

Small-scale fisheries often compete with other sectors of growing economic and policy interest. As part of the blue growth agenda, the tourism industry attracted attention from the policymakers. However, unregulated tourism and irresponsible tourist activities have resulted in the degradation of the fisheries habitat (the coral habitat and mangrove), environmental pollution, and competition over coastal space between fishers and tourism entrepreneurs (Barman et al., Ch. 8; Baten et al., Ch. 14). Some of the challenges have originated beyond the national boundaries and have gravely affected the very existence of fishers' livelihoods. The damming of the free-flowing rivers in India coupled with the glacier retreat in the Himalayas diminishes river waterflow, leading to the most disastrous consequences in downstream Bangladesh, with fishers becoming the worst victims of environmental devastation (Chandan, Ch. 15; Ashab & Rashid, Ch. 17). The negative ramification of economic development activity is pervasive threat to fishing people. The residue of dyeing products and other waste from the garments industries has affected almost all of the fisheries and rivers throughout the economic zones of Bangladesh. Fertilizers and pesticides from the agricultural field, for example those from tobacco plantations in Chattogram, did an irreparable loss to the ecological trove of the Halda River fishery, as illustrated by Das and Paul (Ch. 25).

Another powerful example is the hazardous shipbreaking activity along the

Chattogram coast as pollutants discharged from shipbreaking yards destroy biodiversity of fisheries resources. Also, fishers have to compete for coastal space for mobility along the coastal space and with their fishing operations (Khan, Ch. 24). And while small-scale fisheries operate locally, they are not protected from the ever-growing global disturbances. Illegal fishing by neighbouring countries affects small-scale fishers (Mitu et al., Ch. 31), and, as further discussed by Miah (Ch. 29) and Ferdoushi (Ch. 22), any economic stress in Southeast Asia affects the local crab farmers as well.

Small-scale fishers experience different physical and mental stresses due to their fishing occupations. As shown in global statistics, fishing in Bangladesh is still one of the most dangerous employments, with poor safety standards and a lack of safety training (Hoque et al., Ch. 16). Fishers, either on board or on land, face unsafe working environments, including long periods spent in rough weather or with no protection from the sun while at sea (Jamil & Ullah, Ch. 9). Those working on land are regularly exposed to pesticides in the dry fish yards (Sultana et al., Ch. 10). Fishing labourers are poorly treated, having no employment contracts and no job security, and the benefits of labour rights are minimal (Jamil & Ullah, Ch. 9). Thus, it is no surprise that small-scale fishing people are among the most vulnerable groups in Bangladesh. Poor economic systems, limited access to resources, the lowest position in the societal power hierarchy, poor education and training, rapid population growth, higher dependence on climate-sensitive fish species, low fish catch, and a decrease in fishing income, along with dangerous settlement locations, unprotected buildings and infrastructures, fragile local economy, social vulnerabilities, and a lack of disaster preparedness all create unsafe conditions for fishers, making them precariously vulnerable to any disasters (Begum & Islam, Ch. 23; Barua et al., Ch. 27).

Fishing people are seemingly at the periphery of policy focus as their voice is often unheard in development planning (Mozumder et al., Ch. 28; Rahman, Ch. 32), including in the context of marine spatial planning, which will likely further squeeze the rights of the traditional fishers. Systematic economic and environmental injustices against fishers date back to the British colonial periods without any significant efforts by the policymakers to address equity issue in independent Bangladesh; distributive and procedural injustice against artisanal fishers continue in different dimensions (Uddin, Ch. 33). Overall, the opportunities and prospects of small-scale fisheries are shrinking with the expansion of other sectors. The government prioritizes compliance with fishing laws for estuarine and marine fisheries. In inland fisheries management, the government is also emphasizing the expansion of aquaculture. Marine fisheries management is predominantly focused on expanding fishing efforts in the industrial fisheries sector. Consequently, small-scale fisheries have been shrinking in inland waters while small-scale coastal fisheries are increasingly becoming non-remunerative and unregulated (Barman, Ch. 3; Uddin, Ch. 33;).

Governance and responses

Small-scale fishers are adaptable and creative in the way they respond to different challenges. These responses are mostly short-term, adopted simply to cope with the unfavourable situations. The long-term response is somewhat limited as reflected by the case studies presented in this book. Many authors offer a range of suggestions for better governance so fishers can survive and thrive in an ever-changing socio-ecological system. As unprivileged and vulnerable group, the fishing communities are entitled to stronger government intervention. Fishers need ownership of different assets; they need a capacity building environment and good leadership (Islam et al., Ch. 26). The government intervention should only scale up the adaptive capacity of small-scale fishers (Barua et al., Ch. 27). Since small-scale fisheries are not without wealth, there is a potential to alleviate extreme poverty if the wealth can be fairly distributed more equitably across the value chain (Chowdhury & Islam, Ch. 11). Equity and justice are big subjects for small-scale fishers and several case studies in this volume call for ensuring procedural and distributive justice as the right step forward (Islam et. al, Ch. 26; Barua et al., Ch. 27; Uddin, Ch. 33).

Justice and equity should be maintained in accessing improved compensation schemes for fishing bans (Sunny et al., Ch. 30) and small-scale fishers should be treated equitably and fairly as legitimate users of coastal and marine space in designing any agenda related to blue growth, as argued by Begum (Ch. 34). Since small-scale fishers are mostly unorganized and because their voices are often not heard or are sidelined, ensuring justice and equity is a real challenge. Strengthening traditional fisheries organizations is one of the ways forward to empower the fishers, who need to be better organized in order for their voice to be heard (Neogi et al., Ch. 36). Co-management has been suggested as an effective tool in this regard in alignment with the Voluntary Guidelines for Securing Small-Scale Sustainable Fisheries in the Context of Food Security and Poverty Eradication. Such an approach will help address vulnerabilities, secure viable fishing livelihoods, and strengthen fishers' social resilience (Begum et al., Ch. 37).

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About the author

Mohammad Mahmudul Islam is an Associate Professor in the Department of Coastal and Marine Fisheries at Sylhet Agricultural University, Bangladesh. With a background in marine science and fisheries development studies, he is an interdisciplinary marine social scientist with interests in coastal social-ecological systems. He has more than twelve years of experience in conducting research on coastal communities, small-scale fisheries and marine conservation in Bangladesh. Some of his works focused on policy and marine management, thus he had gathered experiences in working at the science-policy-interface.

2. The Criticality of Small-Scale Fisheries Biodiversity in Bangladesh: Importance, Status, and Conservation Needs

Mostafa Ali Reza Hossain, Bangladesh Agricultural University

Bangladesh is globally ranked third in freshwater fisheries production (Photo: Tanvin Yeasin Tanay, 2022).

Small-scale fisheries make multiple contributions to economies, societies, and cultures, including the role they play in supporting livelihoods, food and nutrition security, and employment of millions of people. In Bangladesh, however, the researchers as well as the policymakers have failed to recognize the rich biodiversity that prevails in the country's small-scale fisheries. There is a clear lack of integrated knowledge and concerted research efforts in this regard. This paper provides an overview of the current state of knowledge on present biodiversity status, its trends over the years, and the reasons for biodiversity losses in the small-scale fisheries sector across the country.

Introduction

There is no specific definition of small-scale fisheries in Bangladesh, although the terms 'artisanal' and 'inland open water' are often used to identify the fisheries that are small in scale. Bangladesh is endowed with a mosaic of aquatic habitats that include rivers and estuaries (853,863 ha), permanent and semi-permanent filled depressions such as *haors* and *beels* (114,161 ha), inundated floodplains (2,712,618 ha), mangrove ecosystems such as the Sundarbans mangrove forest (177,700 ha), human-made Kaptai Lake (68,800 ha), as well as coastal and inshore waters up to 40 m in depth. Within the 4.76 million hectares of inland waters of the country, about 0.83 million ha are considered closed water bodies (e.g., ponds, seasonal floodplains, *baor*, shrimp/prawn gher, crab ponds, culture pens) while the remaining 3.93 million ha consists of open waterbodies (DoF, 2020). These open water bodies are used for artisanal fisheries that can be considered small-scale fisheries.

Small-scale fisheries also include the marine artisanal coastal sector. In Bangladesh, the artisanal coastal sector is the most productive, contributing 83 percent total landing volumes (artisanal 528,997 mt and industrial trawler 108,479 mt). The Department of Fisheries interprets coastal small-scale fisheries as artisanal fishing occurring in shallow waters normally below 40 meters in depth and using mechanical or non-mechanical boats. It further refers to small-scale, low technology, and low capital fishing practices undertaken by individual fishing households. Many of these households are of coastal or island national groups. They often make short (rarely overnight) fishing trips close to the shore. Artisanal fisheries can be both subsistence and commercial, providing for local consumption as well as the exports (DoF, 2020). In terms of the catch/production from small-scale fisheries, the sector contributed 1.69 million mt fish in 2016-2017 (Table 1). During the period of 2009 to 2017, the sector showed an increasing trend at a rate of 1.69 percent, though the production decreased during the year 2011-2012 owing to an unexpected decline in floodplain catch.

Small-scale fisheries of Bangladesh, including both inland and coastal fisheries, are rich in biodiversity and critically important in ensuring food security, income, and employment to millions of people. The inland fisheries sector, in particular, is one of the richest fishery resources globally and ranked third in terms of production. Overall, the fisheries sector provides full-time employment to an estimated 2.0 million fishers while many more are involved as small fish traders, fish transporters, packers, and perform other related activities. In addition to the consumptive values, the country has immense non-consumptive values generated by the artisanal fisheries.

Table 1. Fish catches from small-scale fisheries sectors in Bangladesh during 2010-2017 (Data from the Department of Fisheries, the Bangladesh Government).

		2016-2017	2015-2016	2014-2015	2013-2014	2012-2013	2011-2012	2010-2011	2009-2010
River and Estuary	853,863	271,639	178,454	174,878	167,373	147,264	145,613	144,566	141,148
Sundarbans	177,700	18,086	16,870	17,580	18,366	15,945	21,610	22,451	20,430
Beel	114,161	98,117	95,453	92,678	88,911	87,902	85,208	81,564	79,209
Kaptai Lake	68,800	9,982	9,589	8,645	8,179	9,017	8,537	8,980	7,336
Floodplain	2,712,618	765,782	747,872	730,210	712,976	701,330	696,127	797,024	781,807
Inland open water	**3,927,142**	**1,163,606**	**1,048,242**	**1,023,991**	**995,805**	**961,458**	**957,095**	**1,054,585**	**1,029,937**
Artisanal marine	-	528,997	521,180	515,000	518,500	515,958	505,234	504,668	483,100
Total		**1,692,603**	**1,569,422**	**1,538,991**	**1,514,305**	**1,477,416**	**1,462,329**	**1,559,253**	**1,513,037**

Small-scale fisheries and biodiversity

The rich aquatic biodiversity of the country associated with small-scale fisheries has been attributed one of the world's largest wetlands (Bengal Delta) and the three large river systems of Brahmaputra, Ganges, and Meghna. The fish that inhabit these waters exhibit an extraordinary diversity in terms of their size, shape, colour, habitat, feeding habits, and breeding behaviors. The major groups of the fish include major carp, minor carp, barb, loach, needlefish, halfbeak, catfish, perch, perchlet, goby, pipefish, river shad, snakehead, eels, featherback, anchovies, glass fish, sleeper, pony fish, gourami, scat, croaker, hairtail, sole, pufferfish, and mullet. There are 62 shrimp and prawn species, 54 species of crabs, 6 species of lobsters, 327 species of mollusks, 325 of freshwater fish species, and 475 species of marine water fish reported in Bangladesh.

The biodiversity of these fish, however, is presently in great danger with many being either endangered or critically endangered. A survey conducted by the Fish Museum & Biodiversity Centre (FMBC), Bangladesh, during 2009-2010 found more than 100 riverine fish species were under severe threat. In 2015, International Union for Conservation of Nature (IUCN) in Bangladesh assessed 253 inland fish species and found that nearly one-third (91 species) are under threat (9 Critically Endangered, 30 Endangered, 25 Vulnerable and 27 Near Threatened). In addition, there were 40 Data Deficient fishes, which may have already gone extinct. They also assessed crustacean in a separate Red List of 2015 including 141 species. In this list, 11 species were categorized as threatened, of which 1 was Endangered and 10 were Vulnerable. The remaining were categorized as Least Concern (48 species) or Data Deficient (79 species).

Threats

There are several major threats to the biodiversity in Bangladesh. These include rapid growth of population, lack of proper management policy, large-scale extraction of water for irrigation, construction of water barrages and dams, overexploitation of fish using harmful fishing gears and methods (e.g., dewatering, poisoning, use of explosives), siltation of water bodies by a natural process, introduction of alien fish species, and pollution (see Figure 1).

Intensive fishing constitutes a major threat to aquatic biodiversity and conservation of fish species. For example, intense fishing of prawn and shrimp larvae from coastal regions has resulted in physical destruction of nursery grounds (Ahmed & Troell, 2010). Moreover, large berried fish have declined or even disappeared due to destructive gear use (Siddiqye et al., 2018). Fishing by dewatering water bodies and poisoning, particularly during winter (dry season) are destructive fishing methods. Indiscriminate killing of juvenile fish occurs due to unregulated fishing pressure and total removal of them due to seasonal changes in water bodies that completely dry up in the dry season. Introduction of new culture species such as tilapia, Chinese carp, and Thai pangas is also a significant threat to the biodiversity of indigenous fish species despite the contribution to aquaculture production. Several such species are highly carnivorous, predatory, and eat almost all species, including the small indigenous fish (SIS), which grow to a maximum length of 5- 25 cm (Felts et al., 1996). Several other exotic species also compete with SIS and gradually occupy their niches.

Since 1960s, hundreds of development projects have been implemented in Bangladesh, including Flood Control and Drainage (FCD); Flood Control, Drainage, and Irrigation (FCDI); closures of rivers and canals; channel diversions; and withdrawal of water from rivers and natural depressions for irrigation during dry seasons (Ali, 1997). These have caused obstructions in natural migration and recruitment of fish and other aquatic animals between rivers and floodplains. As a result, many fish and prawn species of river floodplains and estuaries have become threatened and endangered (IUCN, 2000).

Figure 1. Siltation caused by urban pollutants and infrastructure development that has degraded the aquatic habitat in Surma River (Photo: Mahmudul Islam, 2023).

Boosting up crop production involves the use of pesticides and fertilizers in cropping fields. Pesticides, however, are poisonous and hazardous to aquatic organisms, affecting ecosystem integrity and disrupting its functioning. Many pesticides used in the areas adjacent to water bodies spread through rainwater and degrade the quality of water, which poses a major threat to aquatic organisms (Rahman et al., 2019). Moreover, the peripheral areas of the *beels* have been converted into agricultural fields, a process that continues in many parts of Bangladesh and threaten many species. The conversion of many natural wetlands into prawn farms has also resulted in an impediment to water flows and decreased the migration scope for many fish species (Ahmed et al., 2008).

In Bangladesh, rivers carry 2.4 billion mt silts annually that gets deposited on the river beds, floodplains, and *beel* bottoms (Spillmann & Bachler, 1993). Siltation in river basins and floodplains degrades aquatic habitats and feeding grounds. This mainly affects regular spawning and migration cycle of hilsa and other fishes impacting both fisheries and the biodiversity (Hossain, 2010). Pollution of aquatic ecosystems due to industrial and domestic wastes and pesticides seriously affects fish habitats and the overall aquatic ecosystem. Rivers and canals near urban areas are threatened by sedimentation and siltation mainly due to soil erosion and compounded by industrial expansion. Most of these water bodies have already become too polluted to support any biodiversity (Ghose, 2014). Human-made causes like water pollution; excessive use of insecticides; industrial, agricultural and municipal wastes; non-biodegradable polythene use, and plastic materials continue to destroy the spawning, nursing, and grazing grounds of fish species in riverine ecosystems (Flowra et al., 2013).

Climate change also impact a wide range of aquatic settings, reducing species abundance levels and altering species compositions (Ashely et al., 2007) and associated livelihoods. Furthermore, drought, coupled with siltation and lower water levels, is reducing overwintering habitats for indigenous fish species resulting in less recruitment into grazing fields while directly impacting inland fisheries. Reduced water flow in major rivers has severely depleted riverine fisheries (Hossain, 2014). Decreasing groundwater and surface water levels has caused an increasing trend in converting floodplains into crop fields, brick kiln, and other infrastructures, resulting in an alarming decline in fish diversity and production.

Biodiversity conservation within the context of small-scale fisheries: Next steps

Although much of the damage to the habitats and biodiversity supporting Bangladesh's small-scale fisheries over the recent decades is likely irreversible, there is still time to act. There is an urgent need to adjust the country's existing laws and legislation to promote an integrated resource management approach. In doing so, fish biodiversity requires explicit recognition, not only from the researchers, but also from governmental and non-governmental organizations, international bodies, and policymakers. A key step in building fisheries co-management and fish biodiversity conservation with community participation is to bring all the various stakeholders to a common front to share resources and knowledge, create an environment for meaningful discussion on cross-cutting themes, and respect each other. In particular, a community-led fish catch monitoring system should be adopted to track biodiversity and address data deficiency in small-scale fisheries. Sustenance of fish diversity can only be achieved with public support and improved awareness of the protecting fish diversity.

Area-based conservation measures such as Marine Protected Areas (MPA) are also required to conserve keystone fish species and megafauna in some of the country's biodiversity hotspots. Such an initiative will also support the achievement of United Nation's Sustainable Development Goals (SDG) and Convention of Biological Diversity (CBD) commitment to the global community. Effective coordination of programs over the long term also requires coordination among all stakeholder, including fishers, fish farmers, general public, local leaders, researchers, policymakers, and the government and non-government organization (NGO) representatives . Furthermore, implementing the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication through a better governance framework can also help safeguard aquatic biodiversity, while maintaining sustainable yields. Overall, better solutions to overcome environmental challenges and other issues pertinent to the loss of biodiversity should be based on well-coordinated scientific research, outreach, and extension initiatives. Such an endeavor inevitably needs the support of government and other partners to ensure that implementation is done in a consistent and coordinated way for the sole benefit of biodiversity, ecosystems, and the people who rely on them.

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3. Dynamics and Stock Status of the Artisanal Fishery of Bay of Bengal, Bangladesh

Partho Protim Barman, Sylhet Agricultural University

Artisanal mechanized fishing boats in the Bakkhali River estuary, Cox's Bazar (Photo: Partho Protim Barman, 2018).

Using twelve years (2007-2018) of catch-effort data and one-year monthly catch data, this chapter evaluated the catch-effort dynamics and stock status of the artisanal fishery in the Bay of Bengal. Though artisanal fishing depends on the season and condition of the Bay, September to March is reported as the standard fishing period in Bangladesh. A total of 62 fish and shrimp species were reported from artisanal fishery catch. The stock information indicates the unsustainable status of the fishery that is affected by overfishing. Moreover, the biomass level is not sufficient to produce maximum sustainable yield (MSY). The overfishing hurts the coastal and marine ecosystem by changing the food chain and truncating the food web, threatening the ocean health. To reverse the overfishing, it is strongly recommended that the annual catch of artisanal fishery should not exceed the MSY limit (529,000 t year^{-1}). In addition, some immediate management strategies should be put in place to ensure the sustainability of the artisanal fishery and protect the livelihoods of artisanal fishers of Bangladesh.

Introduction

The marine fisheries of Bangladesh are divided into two subsectors, namely industrial and artisanal fisheries (Shamsuzzaman et al., 2017). As a whole, marine fisheries contribute only 20-24 percent to the national fish production, while artisanal fishing represents more than 80 percent (534,600 tonnes in 2018) of the total marine production (DoF, 2018; Alam et al., 2021). In the Bay of Bengal, fish is harvested at three different ranges: (a) ≤ 40 m from the coast, where artisanal fishing is done; (b) between 40-200 m from the coast, where mid-water trawlers operate; and (c) from 200 m up to the end of the Exclusive Economic Zone (EEZ) where long-liner trawlers operate (Akhtar et al., 2017; Islam et al., 2017). In Bangladesh, artisanal fisheries play a pivotal role for the communities in the coastal areas. Usually, artisanal fishers harvest fish from nearshore water for their livelihoods, using traditional fishing techniques and gears such as simple traps and traditional boats (Batista et al., 2014).

Despite the importance of artisanal fisheries, the marine fisheries management is predominantly focused on the industrial fisheries sector, which led to an uncontrolled expansion of fishing efforts in the past decades. As a consequence, artisanal fishing has already become non-remunerative and unregulated. In recent time, poor small-scale fishers have been using more fine mesh nets to catch less valued and undersized fish in order to survive. Additionally, extreme pressure from the growing coastal communities is causing over-exploitation and decline of the artisanal fish stocks at an alarming rate (Shamsuzzaman et al., 2017). Therefore, scientific research and studies are needed to ensure the sustainability of the artisanal fishery in the coastal water of Bangladesh. However, there are very few studies on the livelihood, opportunities, and challenges of artisanal fishing; the comprehensive knowledge or reflections on the artisanal fishery stock in Bangladesh is usually inadequate or absent. Therefore, this study aimed to focus on the catch-effort trends and stock status scenario and to provide baseline management information to the concerned stakeholders or policymakers with regards to achieving the Sustainable Development Goal 14b that will contribute towards the sustainability of the artisanal fishery of Bangladesh.

In this study, a total of 12 years (2007-2018) catch, and effort data were used from the Yearbook of Fisheries Statistics (YFS), produced by the Department of Fisheries (DoF) in Bangladesh. In addition, the month-based catch biomass data, gear efficiency, species composition, etc. were collected from different published literature (Ghosh et al, 2016; Nazrul et al., 2018). To estimate the catch-effort trend, biomass status, exploitation status, and stock scenario of the artisanal fishery of Bangladesh, the CMSY$^+$ model was used. The CMSY$^+$ is a Monte Carlo-based approach where a Bayesian state-space implementation of the Schaefer Model (BSM) is incorporated that provides important management information (see details at Froese et al., 2017). An R-code (CMSY_2019_9f.R) downloaded from http://oceanrep.geomar.de/33076/ was applied to run the CMSY$^+$ and BSM model.

Artisanal fisheries characteristics: Gears, crafts, and effort status

Artisanal fishing activities in the coastal water of Bangladesh were carried out by traditional wooden, non-mechanized craft until the mid-1960s (Ghosh et al., 2016). Later, the Bangladesh Fisheries Development Corporation (BFDC) and the Bangladesh Jatio Matshyajibi Samobay Samity (BJMSS) introduced marine engines to start the mechanization of artisanal fishing boats. Today, different types of traditional gears are mostly used in artisanal fishing. While some gears are operated by mechanized boats, the majority are operated by non-mechanized boats or without a boat. Presently, 34,810 non-mechanized and 32,859 mechanized boats are operating in coastal and marine artisanal fishing activities in Bangladesh (DoF, 2018). Artisanal fishers in the coastal area of Bangladesh use 3 kinds of cast nets, 9 kinds of fixed nets, 11 kinds of drag nets, 3 types of set bag nets (i.e., marine set bag net, estuarine set bag net, and large mesh set bag net), 5 types of gill nets (i.e., large mesh gill net, fixed gill net, mullet gill net, drift gillnet and bottom set gill net), 16 types of trammel, many types of mosquito nets, 26 kinds of traps, 9 kinds of harpoons, and many kinds of hooks and bottom long-lines (Hoq et al., 2013). More than half of the total artisanal catch is caught by the gill nets, while estuarine set bag net (ESBN) contributed to 30 percent of the total artisanal catch from the coastal waters of Bangladesh. Many studies reported that ESBN is a widely used fishing gear for artisanal fishing in the coastal waters of Bangladesh. The ESBN can catch juveniles, young fish and other aquatic animals, and as a result, the catch per unit effort (CPUE) value is higher than for other artisanal fishing gears. However, the gear selectivity often depends on the type of fishery as well as the finances and logistic support available to the fishers. In addition, gear selection depends on the water depth and different types of gears operated by fishers at different water depths. The marine set bag net (MSBN) is operated in up to 25 m of depth, while ESBN is operated in up to 20 m of depth. Drift gill net and large mesh drift gill net can suitably operate in up to 30 m of depth, trammel net can operate in up to 20 m of depth, and beach seine net can only operate in up to 10 m of depth in the coastal waters of the Bay of Bengal. A couple of decades ago, artisanal fishing was done only within the shallow waters - up to 10 m. Still, due to the innovation of modern fishing technologies, artisanal fishers are allowed to do fishing up to 40 m. But the desire to catch more fish, on the other hand, leads the artisanal fishers to fish to depths of more than 40 m (Ghosh et al., 2016). Here, the depth refers to the water depth (in meters) during high tide.

Artisanal fisheries catch dynamics

The catch composition of artisanal fisheries varies greatly depending on the fishing season. The season or month of fishing directly affects the catch and production of the artisanal fishing. January is the lean period for artisanal fisheries in Bangladesh. However, from April, the catch is sharply increasing until it reaches its peak production in July. July belongs to the monsoon season when the coastal waters of Bangladesh offer a suitable environment for both migratory and native species. Because of the high richness of species and the high abundance of fish, artisanal fishers can harvest a large volume of catch in July. The artisanal fishing activity mostly depends on the weather conditions in the Bay of Bengal. However, in Bangladesh, the period between September to March is recognized as the artisanal fishing period when the weather is favourable, and the sea is calm. The total annual catch also varies with the use of different fishing technologies. The data from the last decade (2007-2018) shows a trend of gradual increase in the amount of the annual catch of artisanal fishery (Figure 1). The highest catch was recorded to be 534,600 t in 2018 and the lowest catch was 452,047 t in 2007.

On the other hand, the maximum number of gear (242,450) was recorded in 2012 and 2013 while the minimum effort was observed in 2018 (188,707). Thus, the fishing effort was increasing until 2013, after which it has been on a decline. This is a result of a few management strategies that have been implemented, such as licensing a fishing vessel or craft, controlling the use of illegal fishing gear, and banning fishing (Ghosh et al., 2016; DoF, 2018).

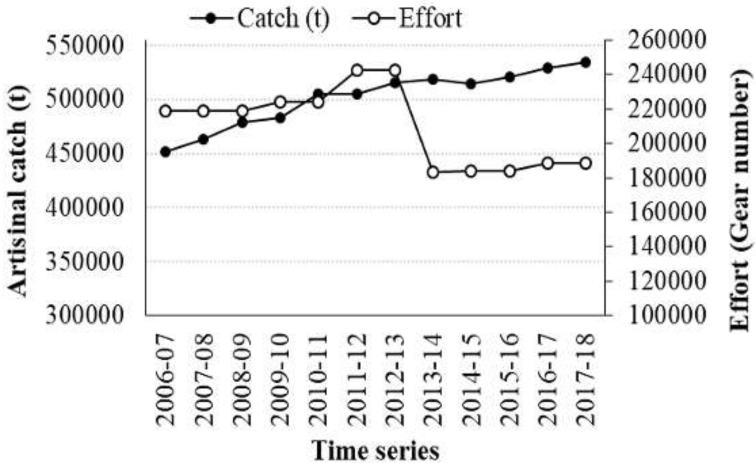

Figure 1. Catch-Effort trend of artisanal fisheries in Bangladesh.

A total of 52 species of finfish and 10 species of shrimp were reported from the artisanal catch in the coastal waters of Bangladesh (Table 1). Among them, *Otolithoides argenteus, Trichiurus haumela, Tenualosa ilisha, Escualosa thoracata, Harpadon nehereus, Arius sp., Leigonathus sp., Johnius argentus, Cynoglossus sp* are the most abundant and have the highest commercial value. Among the shrimp, *Penaeus monodo*n is the main target species because of its high market demand; at the same time, *Metapenaeus monoceros* was reported as the highest contributing species among the total shrimp catch (Ghosh et al., 2016).

Table 1. Available fish and shrimp species harvested by the artisanal fishers from the Bay of Bengal water, Bangladesh, with their IUCN status (LC=Least Concern, NT=Near-threatened, NE=Not Evaluated, DD=Data Deficient).

SL	Scientific Name	Local Name	English Name	IUCN Red List Status
1.	*Lates calcarifer*	Bhetki	Giant Seaperch	LC
2.	*Cynoglossus lingua*	Kukur jeeb	Long Tung Sole	LC
3.	*Cynoglossus bilineatus*	Kukkurjib	Fourlined tonguesole	LC
4.	*Arius gagora*	Gagla	Gagora catfish	NT
5.	*Mystus gulio*	Nuna Tengra	Long whiskers catfish	LC
6.	*Ephippus orbis*	Hatir Kaan	Spade Fish	NE
7.	*Gerres filanmentosus*	Dom Machh	Silverbiddies	LC
8.	*Pentaprion longimanus*	Jagiri	Longfin Mojarra	LC
9.	*Harpadon nehereus*	Loittya Machh	Bombay duck	NT
10.	*Drepane longimanna*	Pann Machh	Sicklefish	NE
11.	*Lactarius lactarius*	Sadha Machh	False Trevally	NE
12.	*Lutjanus johni*	Ranga Choukya	Red Snapper	LC
13.	*Lujanus sanguineus*	Ranga Choukya	Blood Snaper	LC
14.	*Lutjanus malabaricus*	Ranga Choukya	Malabar Red Snapper	LC
15.	*Leigonathus brevirostris*	Taka Chanda	Shortnose Ponyfish	NE
16.	*Mene maculata*	Chan Chanda	Moon Fish	NE
17.	*Upeneus sulphureus*	Sonali Bata	Goat Fish	LC
18.	*Planiliza tada*	Gool Bata	Tade Grey Mullet	DD
19.	*Liza subviridis*	Khurul Bata	Green Back Grey Mullet	NE
20.	*Mugil cephalus*	Khorul Bata	Flathead Gray Mullet	LC
21.	*Valamugil speigleri*	Patha Bata	Speigler's Gray Mullet	NE
22.	*Nemipterus japonicus*	Rupban	Threadfin Bream	LC
23.	*Pomadasys hasta*	Sadha Datina	Lined Silver Grunter	LC
24.	*Pomadasys maculatus*	Guti-Datina	Blotched Grunter	LC
25.	*Polynemus indicus*	Lakhua	Indian Salmon	NE
26.	*Polynemus paradiscus*	Tapsi	Paradise Threadfin	LC
27.	*Eleutheronema tetradactylum*	Thailla	Fourfinger Threadfin	NE
28.	*Platycephalus indicus*	Murabaila	Flat-head Fish	DD
29.	*Priacanthus tayenus*	Pari Machh	Purple-spotted Big Eye	LC
30.	*Psettodes erumei*	Samudra Serboti	Indian Halibut	DD
31.	*Rachycentron canadus*	Samudra Gajar	Cobia	LC
32.	*Saurida tumbil*	Achila	Greater Lizard Fish	LC
33.	*Sillago domina*	Tolar Dandi	Lady Fish	NE
34.	*Otolithiodes pama*	Lambu	Pama Croacker	DD
35.	*Otolithes maculatus*	Gotipoa	Toothed Croacker	LC
36.	*Otolithes cuvieri*	Poa	Tiger-toothed Croacker	LC
37.	*Protonibea diacanthus*	Kala Katina	Spotted Croacker	NT
38.	*Johnius argentatus*	Lalpoa	Silver Pennah Croacker	LC
39.	*Argyrops spinier*	Lal Datina	Longspine Sea Bream	LC
40.	*Sphyraena forsteri*	Dharkuta	Forster's Barracuda	NE
41.	*Pampus chinensis*	Rup Chanda	Chinese Pomfret	NE
42.	*Pampus argenteus*	Foli Chanda	Silver Pomfret	NE
43.	*Coilia dussumieri*	Olua	Pointed Tail Anchovy	LC
44.	*Escualosa thoracata*	Hichiri Machh	White Sardine	LC
45.	*Ilisha fillgera*	Choukya	Big Eye Ilish	DD
46.	*Hilsa ilisha*	Ilish/Hilsa	Hilsa Shad	LC
47.	*Sardinella fimbriata*	Takhia	Fringe-scale Sardine	LC
48.	*Chirocentrus dorab*	Karatia-Chela	Wolf Herring	LC
49.	*Parastromateus niger*	Hail Chanda	Black Pomfret	LC
50.	*Scomberooides commersonianus*	Chapa Kori	Talang Queen Fish	LC
51.	*Selar boops*	Moori/Salar	Oxeye scad	LC
52.	*Alepes djeddaba*	Moori	Djeddaba crevalle	LC
53.	*Penaeus monodon*	Bagda Chingri	Giant black tiger Shrimp	NE
54.	*Penaeus semisulcatus*	Bagatara Chingri	Green Tiger Shrimp	NE
55.	*Penaeus japonicus*	Dorakata Chingri	Tiger	NE
56.	*Penaeus indicus*	Chaga Chingri	Indian white Shrimp	NE
57.	*Penaeus merguiensis*	Baga Chingri	Banana Shrimp	NE
58.	*Metapenaeus monoceros*	Horina Chingri	Brown/Speckled Shrimp	NE
59.	*Metapenaeus brevicornis*	Loilla Chingri	Brown/Yellow Shrimp	NE
60.	*Metapenaeus spinulatus*	Chingri/Icha	Brown	NE
61.	*Parapenaeopsis sculptilis*	Ruda Chingri	Pink/Rainbow Shrimp	NE
62.	*Parapenaeopsis stylifera*	Rida Chingri	Pink/Kiddi Shrimp	NE

Stock status and management information

Both the CMSY and BSM models delivered important stock information and biological reference points (BRPs) for the artisanal fishery in the coastal waters of Bangladesh. The BSM-derived BRPs are considered as the management information. The BSM delivered maximum carrying capacity (*k*) of 3,784×10^3 t, where CMSY produced *k* was 3,383×10^3 t. The catchability coefficient (*q*) estimated from the BSM model was 1.28e-06. The catch fit diagram (Figure 2(a)) showed the fit represented by the median of predicted catch posterior, with 95 percent confidence limits (grey shaded), compared to the observed catch, and the CPEU fit (Figure 2(b)) shows a similar graph for predicted versus observed CPUE. The catch fit diagram depicted a gradual increase of both observed and predicted catch till 2011; later, the observed catch was higher than the predicted catch. The CPUE fit diagram displayed a baleful fluctuation between observed and predicted CPUE after 2011, during the highest number of fishing efforts reported. The observed CPUE was higher from 2014 to 2016 compared to the predicted or expected CPUE, which could lead to the decline of stock biomass and limit or hamper the production of the Maximum Sustainable Yield (MSY) of the artisanal fishery in the coastal water of Bangladesh. However, because of the control of the fishing effort in later 2016, there was no remarkable variation between the predicted and the observed catch and CPUE respectively in the last year (2018). This is a good sign for retaining the sustainability of this fishery. Nevertheless, this finding is not enough to justify and ensure the sustainability of artisanal fisheries of Bangladesh because MSY is considered to be the most important target reference point for sustainable fisheries management. The catch diagram (Figure 2(c)) of the artisanal fishery shows the relative catch estimation of MSY from the BSM model, with an indication of 95 percent confidence limits in the grey area. The BSM analysis results revealed that catches have been steadily increasing from 2007 to 2018, crossing the MSY line. Meanwhile, MSY for 2018 was 529×10^3 t year^{-1}, with 95 percent CL ranging from 445×10^3-630×10^3 t year^{-1}. The catch value in 2018 was estimated as 534,600 t (534.6×10^3 t year^{-1}), which was higher than the previous year's MSY value (529×10^3 t in 2018), indicating the impacts of overfishing in the coastal waters of Bangladesh. To maintain the safe status of artisanal fishery in Bangladesh, the total allowable catch in a year should be strongly maintained as per the delivered MSY limit of BSM.

The stock biomass size exhibits the growth of relative total biomass (B/B_{MSY}), with the grey area specifying the uncertainty (Figure 2(d)). In 2018, Biomass (B) was estimated as $1{,}777 \times 10^3$ with 2.5th percentile to 97.5th percentile, ranging from, $1{,}161 \times 10^3$ to $2{,}407 \times 10^3$ t. The artisanal fishery population size at the maximum growth rate (B_{MSY}) was measured as $1{,}892 \times 10^3$ t with a 95 percent confidence level, ranging from $1{,}234 \times 10^3$ to $2{,}902 \times 10^3$ t. Further, the value of B/B_{MSY} was calculated as 0.939 with 2.5th percentile to 97.5th percentile ranging from 0.614 to 1.270. Here, the estimated biomass (B) value is smaller than the value of Biomass that can produce MSY (B_{MSY}). The $B< B_{MSY}$ directed that the biomass level is insufficient to produce MSY in artisanal fishery in the Bay of Bengal.

The exploitation figure explains relative exploitation (F/F_{MSY}), with F_{MSY} corrected for reduced recruitment below 0.5 B_{MSY} (Figure 2(e)). Maximum rate of fishing mortality F_{MSY} (the proportion of a fish stock exploited and removed by fishing) was 0.28,with 95 percent CL = 0.182 - 0.431 (if $B > 1/2$ B_{MSY} then $F_{MSY} = 0.5$ r) and $F_{MSY} = 0.28$, 95 percent CL = 0.182 - 0.431 (r and F_{MSY} are linearly reduced if $B < 1/2$ B_{MSY}). The fishing mortality (F) in 2018 was estimated at 0.299 with 2.5th percentile to 97.5th percentile ranging from 0.221 to 0.458. The exploitation (F/F_{MSY}) was 1.08 and the $F> F_{MSY}$ showcases that the overfishing is occurring. In addition, the exploitation figure shows that the relative exploitation line was always above the MSY line, indicating the excessive harvesting of fish in the Bay of Bengal.

To show the existing stock status and exploitation rate to target reference points (TRPs) such as F_{MSY} and B_{MSY}, Kobe phase plot was used. There are four colour quadrants (orange, red, yellow, and green) in a Kobe plot defined for the stock biomass and fishing mortality relative to B_{MSY} and F_{MSY}, respectively. The orange-coloured area specifies the healthy stock sizes that are about to be depleted by overfishing. The red-coloured quadrant indicates that the stock is overfished and is undergoing overfishing conditions where the biomass levels are not capable to produce maximum sustainable yields**.** The yellow quadrant shows the too low biomass level, but the stock can be restored or recovered in a sustainable state if the fishing pressure is reduced. The green-coloured area is the target area for the management, indicating sustainable fishing pressure and a healthy stock size capable of producing high yields close to MSY. In the Kobe phase plot, the 'banana' shape around the assessment of the final year triangle indicates uncertainty, with yellow for 50 percent, grey for 80 percent, and dark grey for 95 percent confidence levels. The legend in the upper right of the plot indicates the probability of the last year falling into one of the coloured areas, such as that there is a 31.0 percent probability that the stock is in the green area, a 5.5 percent probability that it is in the yellow area, a 57.2 percent probability that it is in the red area and a 6.3 percent probability that it is in the orange area. However, the BSM-derived management information indicated that the Bay of Bengal artisanal fishery stock status is now in the red quadrant (Figure 2(f)). Furthermore, F/F_{MSY} is >1 while the B/B_{MSY} value is <1, estimated based on the BSM model. The calculated F/F_{MSY} on B/B_{MSY} and the stock in the red quadrant indicates that the stock is being overfished with current biomass levels being too low to produce the MSY.

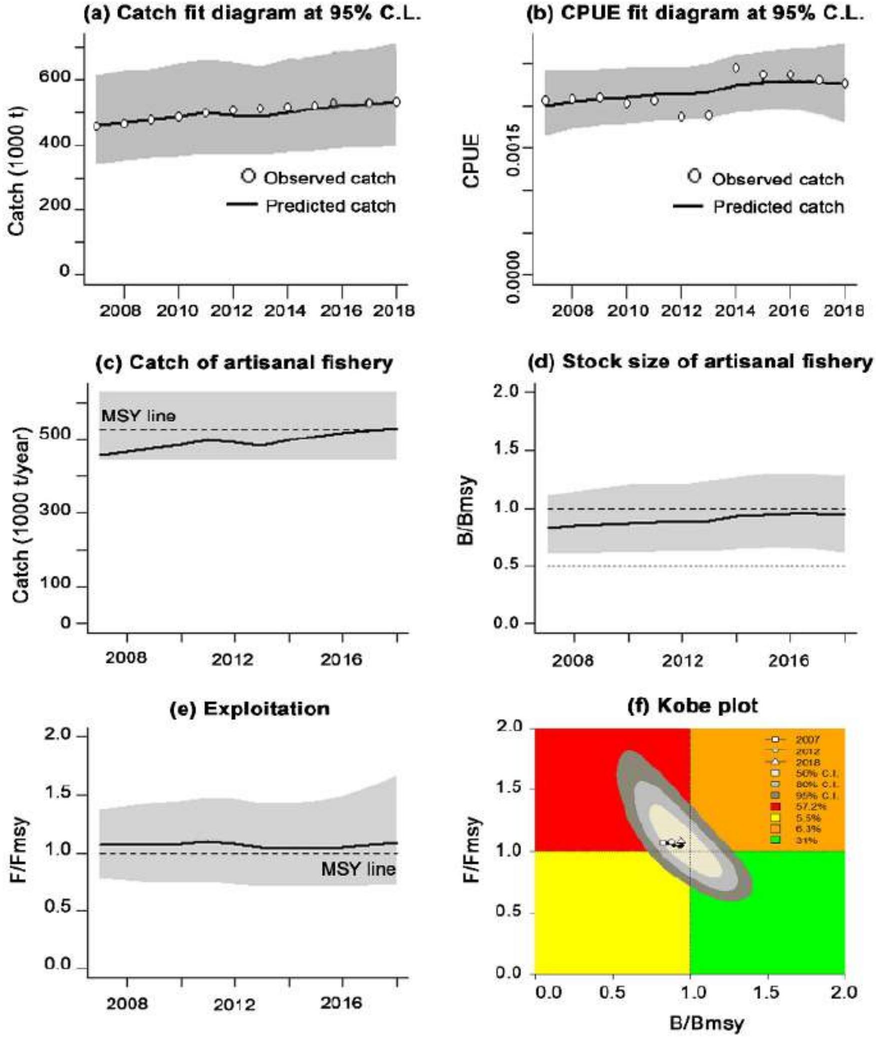

Figure 2. The CMSY and BSM-derived information representing the stock status of the artisanal fishery of Bangladesh.

Conclusion

For a long time, the artisanal fishery has been contributing a major portion of marine catches and has played a significant role in the livelihood of millions of people in coastal areas of Bangladesh. Year after year, the number of fishers and fishing efforts are increasing, resulting in exploitation of this important fisheries sector. Though fish is a renewable resource, overfishing causes the depletion of fish biomass and decreases the fishery. As such, continuous scientific stock-assessment is important to ensure the sustainability of such exploited fishery. This study provided basic information about the stock status and indicated the unsustainable status of the artisanal fishery of Bangladesh. The people of the coastal region are considered to be the most vulnerable communities due to natural disasters and marine challenges. Furthermore, mismanagement or unsustainability of artisanal fisheries resources can be a big threat to the existence of the artisanal fisheries community in Bangladesh. Based on the findings of this research, the government and related stakeholders should take immediate measures to save the fishery and thus ultimately secure the future of the artisanal fishing communities of Bangladesh.

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4. Small Fish, Big Roles: Unlocking the Scenario of Biodiversity and Conservation Challenges of Small Indigenous Fish Species (SIS) of Kaptai Lake, Bangladesh

Kamrul Hassan Suman, Ministry of Fisheries and Livestock

Non-mechanized boat fishing in the Kaptai Lake (Photo: Bodhi Kandu Chakma, 2021).

Small indigenous fish species are rich in essential micro-nutrients that can help tackle micronutrient deficiencies globally. They are the key regulator of Kaptai Lake fishery, the largest man-made lake in Bangladesh. Though small indigenous fish species are indispensable for meeting the animal protein demand and livelihoods of small-scale fisheries of Kaptai Lake, detailed studies about this sector are lacking. This chapter investigates the biodiversity and conservation status of small indigenous fish species and their threats and subsequent impacts on small-scale fisheries. A total of 49 small indigenous fish species were recorded from the lake, and the majority of them (61 percent) fall under 'least concerned' category according to the IUCN Red list. However, pollution, habitat destruction, siltation, climate change, overexploitation, and extreme fishing pressure were identified as major causes that lower fish production capacity and pose threats to the biodiversity of the small indigenous fish species in the lake. Better management strategies such as protection of natural breeding grounds, controlled pollution, proper implementation of fishing laws, scientific fishing policies, and integrative research could ensure sustainable management and conservation of these fish in the Kaptai Lake. These findings will be helpful in planning and accomplishing proper lake management strategies for the wellbeing of the ecosystem and connected small-scale fishers.

Introduction

The fish species that can grow to a maximum size of 25 cm or 9 inches in their mature or adult stage of life cycle are considered small indigenous fish species (SIS) (Roos et al., 2003; Kostori et al., 2011). Unlike rice or other grains, fish can simultaneously address multiple dimensions of food and nutritional security by providing essential and accessible micronutrients, such as iron, vitamins, minerals, and polyunsaturated essential fatty acids, critical to human health (Bernhardt & O'Connor, 2021). This is especially true for the SIS as they are an excellent source of vitamin A and D, which are crucial for human bones, teeth, skin, and eyes; they are also rich in essential fatty acids, phosphorus, and iodine, which are necessary to balance the immune system of the human body (Villif & Jorgensen, 1993; Roos et al., 2003; Thilsted, 2012). However, the role of SIS, a rich source of bioavailable micronutrients essential to human health, is often overlooked. Nevertheless, nutrient-rich SIS have a great potential in the developing countries as a way to combat hidden hunger and micronutrient deficiencies by supplying essential nutrients, specifically vitamin A, calcium, iron, and zinc to vulnerable people.

SIS have become essential for the majority of the people of Bangladesh, particularly for poor rural households, as a source of food, subsistence, and supplemental income. SIS are available in almost all water bodies, can be harvested by low-cost gear, are cheaper to buy, can be eaten as a whole, and are easy to distribute among family members during meals. All of this makes SIS a potential tool for addressing hidden hunger and micronutrient deficiencies of poor people in rural areas where nutritional insecurity is prevalent. In rural areas, small fish makes up 50-80 percent of all fish intake in the peak fish production season (Thilsted, 2012). Micronutrient dense SIS are highly preferred for daily diet (typically eaten whole with bone, head, and eyes) due to their abundance, easy digestion, taste, and low price (Nurullah et al., 2003). There are about 260 fish species available in the freshwaters of Bangladesh, and among these over 150 species have been classified as SIS (Roos et al., 2003; Kostori et al., 2011). SIS can play a significant role in eradicating the malnutrition problem in Bangladesh, as they contain essential protein, vitamins, macro-and micro-nutrients (Kostori et al., 2011). It was found that SIS like Punti *Puntius* sp., retains a double amount of iron compared to many carps like Silver carp *Hypophthalmichthys molitrix* and Roho Labeo *Labeo rohita*. Mola carpet *Amblypharyngodon mola* has fifty times more vitamin A and three times more calcium than Silver carp and Roho Labeo (Villif & Jorgensen, 1993).

The H-shaped Kaptai Lake is the largest freshwater reservoir in South Asia. The lake was constructed in 1961 to produce hydroelectricity by damming the River Karnaphuli at Kaptai. The main flow of the lake is formed nearby in the hill district of Rangamati, Bangladesh. The lake's total area is 68,800 hectares (ha), with a water surface area of 58,300 ha

(IUCN Bangladesh, 2015a; Suman et al., 2021). The Kaptai Lake plays a vital role in the country's GDP through freshwater fish production, tourism, navigation, agriculture, flood control, and income generation for surrounding communities. The lake supports small-scale fisheries and retains seventy-six fish species, including seven exotic species. The largest portion of the total fish yield of the Kaptai Lake is contributed by the SIS, notably Ganges river gizzard shad *Goniolosa manmina* and Indian river shad *Gudusia chapra* (they are locally called as Chapila), Ganges river sprat *Corica soborna* (locally known as Kachki, Keski), Indian carplet *Amblypharyngodon microlepis* and Mola carplet *A. mola* (also known as Mola), and Gangetic ailia *Ailia coila* (Suman et al., 2021). Over the years, the lake has been affected by various natural and anthropogenic pressures, which resulted in biodiversity loss, reduced fish-production capacity, and insufficient income for those relying on the lake. As an adaptation strategy, many fishers are forced to further exploit the fisheries resources in order to maintain their basic livelihoods (Kawarazuka, 2010; IUCN Bangladesh, 2015a). Thus, to achieve sustainable fishing livelihoods, it is essential to maintain the fisheries stock to a sustainable level through effective management strategy that will elevate production capacity and restore fish biodiversity of the lake. Though the importance of SIS in the prevention and control of micronutrient deficiencies is recognized in the National Strategy on Prevention and Control of Micronutrient Deficiencies, Bangladesh (2015-2024), the major efforts for SIS management by the government and NGOs are nevertheless directed towards the expansion of SIS aquaculture. The SIS diversity in open water fisheries is accessible to the poor people in the rural areas and, as such, it is essential to revitalize the SIS diversity in open water fisheries in order to address the malnutrition and hidden hunger of many rural people. Using Kaptai Lake SIS fisheries as an illustrative example, the present study was conducted to explore SIS diversity, their conservation status, and threats, as well as to highlight the pragmatic measurements towards sustainable management of SIS fishery and the livelihoods of the SIS small-scale fishers.

Table 1: Small indigenous species fish (SIS) composition with IUCN conservation status recorded in the Kaptai Lake, Bangladesh.

No	Local Name	English Name	Scientific Name	*IUCN Conservation Status
Order: Cypriniformes				
01	Fulchela	Finescale razorbelly minnow	*Salmostoma phulo* (Hamilton, 1822)	NT
02	Dhela	Cotio	*Osteobrama cotio* (Hamilton, 1822)	NT
03	Bata	Bata labeo	*Labeo bata* (Hamilton, 1822)	LC
04	Reba/ Aikhor	Reba carp	*Cirrhinus reba* (Hamilton, 1822)	NT
05	Darkina	Indian flying barb	*Esomus danrica* (Hamilton, 1822)	DD
06	Chapchela/ Baspata	Sind danio	*Danio devario* (Hamilton, 1822)	VU
07	Pioly/ Morar	Morari	*Cabdio morar (*Hamilton, 1822)	VU
08	Sarpunti	Olive barb	*Puntius sarana* (Hamilton, 1822)	NT
09	Jat punti	Pool barb	*Puntius sophore* (Hamilton, 1822)	LC
10	Tit punti	Ticto barb	*Pethia ticto* (Hamilton, 1822)	VU
11	Teri punti	Onespot barb	*Puntius terio* (Hamilton, 1822)	LC
12	Mola	Indian carplet	*Amblypharyngodon microlepis* (Bleeker, 1853)	LC
13	Mola	Mola carplet	*Amblypharyngodon mola* (Hamilton, 1822)	LC
14	Bou, Rani	Bengal loach	*Botia dario* (Hamilton, 1822)	EN
15	Gutum	Annaldale loach	*Lepidocephalichthys annandalei* (Chaudhuri, 1912)	VU
Order: Clupiformes				
16	Goni Chapila	Ganges river gizzard shad	*Goniolosa manmina* (Hamilton, 1822)	LC
17	Chapila	Indian river shad	*Gudusia chapra* (Hamilton, 1822)	VU
18	Kachki/Keski	Ganges river sprat	*Corica soborna* Hamilton, 1822	LC
19	Phasa	Gangetic hairfin anchovy	*Setipinna phasa* (Hamilton, 1822)	LC
Order: Siluriformes				
20	Madhu pabda	Pabdah catfish	*Ompok pabda* (Hamilton, 1822)	EN
21	Batasi	Indian patasi	*Pachypterus atherinoides* (Bloch, 1794)	LC
22	Baspata/ Kajuli	Gangetic ailia	*Ailia coila* (Hamilton, 1822)	LC
23	Kalo bojuri	Striped dwarf catfish	*Mystus vittatus* (Bloch, 1794)	LC
24	Bujuri tengra	TengaraTenggara catfish	*Mystus tengara* (Hamilton, 1822)	LC
25	Golsha tengra	Day's mystus	*Mystus bleekeri* (Day, 1877)	LC
26	Garua Bacha	vacha	*Eutropiichthys vacha* (Hamilton, 1822)	LC
27	Shing	Stinging catfish	*Heteropneustes fossilis* (Bloch, 1794)	LC
28	Magur	Philippine catfish	*Clarias batrachus* (Linnaeus, 1758)	LC
Order: Perciformes				
29	Baila/Bele	Freshwater goby	*Glossogobius giuris* (Hamilton, 1822)	LC

30	Meni/Bheda	Gangetic leaffish	*Nandus nandus* (Hamilton, 1822)	NT
31	Napit koi	Badis	*Badis badis* (Hamilton, 1822)	NT
32	Baila	Scribbled Goby	*Awaous personatus* (Bleeker, 1849)	VU
33	Lal kholisha	Dwarf gourami	*Trichogaster lalius* (Hamilton, 1822)	LC
34	Khalisha	Banded gourami	*Trichogaster fasciata* (Bloch & Schneider, 1801)	LC
35	Koi	Climbing perch	*Anabas testudineus* (Bloch, 1792)	LC
36	Nama Chanda	Elongate glass-perchlet	*Chanda namamama* (Hamilton, 1822)	LC
37	Taki	Spotted snakehead	*Channa punctatus* (Bloch, 1793)	LC
38	Raga/Cheng	Walking Snakehead	*Channa orientalis (*Bloch & Schneider, 1801)	LC
		Order: Mugiliformes		
39	Kechki	Yellowtail mullet	*Minimugil cascasia* (Hamilton, 1822)	VU
Order: Beloniformes				
40	Kakila	Freshwater garfish	*Xenentodon cancila* (Hamilton, 1822)	LC
Order: Synbranchiformes				
41	Tara Baim	Lesser spiny eel	*Macrognathus aculeatus* (Bloch, 1786)	NT
42	Guchi baim	Barred spiny eel	*Macrognathus pancalus* (Hamilton 1822)	LC
Order: Tetraodontiformes				
43	Potka	Ocellated Pufferfish	*Leiodon c*utcutia (Hamilton, 1822)	LC
44	Tepa	Milkspotted puffer	*Chelonodon patoca* (Hamilton, 1822)	DD
45	Foli	Bronze featherback	*Notopterus notopterus* (Pallas, 1769)	VU
Order:Decapoda				
46	Golda Chingri	Giant freshwater prawn	*Macrobrachium rosenbergii* (de Man, 1879)	LC
47	Chatka chingri	Monsoon river prawn	*Macrobrachium malcolmsonii* (H. Milne Edwards, 1844)	LC
48	Lotia Icha	Short-leg River Prawn	*Arachnochium mirabile* (Kemp, 1917)	LC
49	Tengua Icha	Birma river prawn	*Macrobrachium birmanicum* (Schenkel, 1902)	LC

Biodiversity and conservation status of SIS

The present study recorded 49 SIS under 9 orders. Cypriniformes was the most dominant order consisting of 15 species following the order Perciformes (10), Siluriformes (9), Clupeiformes (4) and Decapoda (4); meanwhile 3 and 2 SIS were recorded in the orders Tetraodontiformes and Synbranchiformes, respectively (Table 1). Only one species was found under each order of Mugiliformes and Beloniformes. According to the IUCN Red List in Bangladesh, a total of 10 SIS species, recorded in the present study, are considered threatened (8 VU and 2 EN) (Table 1). The majority of reported fish species , i.e., 30 (61 percent) are considered as least concern. Among these, the threatened fish species were highest in the Cypriniformes order. The vulnerable species were *Danio devario, Cabdio morar, Pethia ticto, Lepidocephalichthys annandalei, Gudusia Chapra, Awaous personatus, Minimugil cascasia,* and *Notopterus notopterus. Botia Dario* and *Ompok pabda* were identified as endangered species (Table 1). Habitat destruction due to pollution (i.e. agricultural, plastic, industrial and municipal), encroachment of water bodies, increased siltation, destructive fishing (i.e. poisoning, banned gears, *jhak* and brush fishery), and poor management are largely responsible for the increased number of threatened SIS from this lake.

Currently, the KL species are abundant; out of 76 fish species in the lake, 49 belong to SIS as illustrated in Table 1. About 63.76 percent of the total fish production is derived from Kachki and Chapala together, 3.01 percent from the two species of Mola, while only 1.56 percent is contributed from the carp species (Suman et al., 2021). This drastic alteration in species variation and total fish yield may be the consequences of self-recruiting nature of SIS species, early maturity, and rapid proliferation capability of SIS in highly polluted water bodies. In addition, over-exploitation of larger fish and seasonal bans (90 days annually) may also provide suitable conditions for growth. The overall findings denote that both the revenue of Bangladesh Fisheries Development Corporation (BFDC), Rangamati, and the livelihoods of small-scale fishers are closely dependent on and regulated by the abundance and production performance of SIS. Hence, SIS occupy great demand for being included in the design and implementation of policy decisions and programs to enhance lake production and upgrade the livelihood of small-scale fisheries.

Livelihoods and management

The livelihood plight of the small-scale fishers connected to the SIS fishery resembles the overall small-scale fisheries situation in Bangladesh. There are about 22,000 fishermen who are dependent on the Kaptai Lake for their livelihood. They are mainly categorized as professional fishers, seasonal fishers, and subsistence fishers. Most fishermen are illiterate, have no access to fishing equipment (i.e., fishing gears, vessels), and rely on fish traders for investment capital and productive assets necessary for fishing. Usually, they work as day labour and live from hand to mouth. Existing 260 fish traders are key players in small-scale fisheries through controlling fishing and marketing activities through patron-client relationships. The small-scale fish traders collect fish from the fishing boats across the lake and sell them to the master traders on land. The master traders transport and disburse the fish to different markets in the countries after paying the royalty with the BFDC landing stations (*pontoon*). For instance, for each kilogram of *Chapila* and *Kachki*, BFDC collects Tk 17.5 (0.20 USD) as tax from the fisherman. The BFDC regulates, governs, and manages the Kaptai Lake fisheries resources by implementing closed seasons, issuing licenses, implementing fish acts, and stocking. It is estimated that an average of 30 MT of fish are landed daily at the fish landing centers. The most commonly used fishing gears are gill net (mainly monofilament gill net- current jal), lift net (*Dharma jal*), push net (*Thela jal*), cast net (*Jhaki jal*), seine net, hook and line, and wounding gear such as Borshi, Polo and Koch, among others. Different types of non-mechanized and few mechanized vessels are employed for fish capture. The fish availability decreases during winter (December and January) due to a reduced water level. Each year there is a 90-day period (usually from May to July) during which fishing bans are imposed in the Kaptai Lake to promote fish breeding and conservation. Small-scale fishers suffer most during this ban period as they have no alternative ways to earn and meet their family needs.

Threats to resources

The SIS fishery of the Kaptai Lake has been experiencing negative impacts of intensification of natural resource utilization, agricultural and industrial pressures, including poor water management in the hill tract region that surrounds the lake. Habitat loss and degradation, due to massive siltation and conversion of water bodies (i.e., flood control projects, constructions of roads, townships) is the major threat to the SIS fishery. In addition, the uncontrolled and rapid expansion of *Jhoom* cultivation in hilly areas causes severe siltation in the Kaptai Lake. The lake had already lost 25 percent of its total volume due to siltation (IUCN, 2015a).

Water pollution caused by municipal sewage, navigation, tourism, industrial and agricultural waste, either directly discharged into the lake or entering as runoff, leads to frequent eutrophication, excessive turbidity, and oxygen depletion in many parts of the Kaptai Lake and mass mortalities of fish. The water quality of the Kaptai Lake has been reported as unhealthy, both for drinking and household activities due to the heavy load of pathogenic microbes and excess concentrations of toxic metals. Over the decades, the Kaptai Lake has experienced over- and unplanned exploitation along with encroachment of the lake areas. Overfishing affects the commercial species and affects the non-targeted small species as by-catches (IUCN, 2015a). A huge number of fish aggregating devices (FAD), including brush fishery (also known as *jhag, jakh, katta*), illegal net fencing with bamboo, were reported during this study. These are highly responsible for the post-stocking reduction of carp fingerlings and extreme exploitation of all types of fish, irrespective of their size (see also, Ahmed et al. 2006; IUCN, 2015ab; Suman et al., 2021). Consequently, the fish catches drastically declined, which led to the poor income of the fishers in the Kaptai Lake. The gradual decrease in the average size of the harvested fish due to rapid population expansion is an indicator of overfishing, and leads to meager income for the fishers. Despite annual carp stocking of the lake, there has been an alarming reduction of these fish due to fishing, dewatering, poisoning, small mesh-size nets, and monofilament gill nets.

Climate change impact is another grave concern. Fish biodiversity of the Kaptai Lake has been threatened by fluctuations in temperature, shoreline siltation, rise of silt bed, seasonal variations, and alteration in fish migration routes, all linked to the global climate change. Another key challenge is related to the security issues of the fishing communities. There are criminal gangs in the Kaptai Lake and surrounding hills who are known to extort and kidnap for ransom. Thus, fishers are always afraid of being assaulted, and in fear of their assets (i.e., boats, nets, furniture) being taken or destroyed by the criminal gangs.

Conclusion and recommendations

The vast majority of children and women in Bangladesh suffer from micronutrient deficiencies as the usual diets they consume are typically deficient in one or more micronutrients, notably vitamin A, iron, iodine and/or zinc (Jahan & Hossain, 1998). The consequences of micronutrient deficiencies are far-reaching, as they increase the risk of mortality, compromise quality of life, and impact development and productivity. Improving food security and dietary diversification can help to address malnutrition and micronutrient deficiencies (Institute of Public Health Nutrition, 2015). Nutrient-dense SIS diversity can ensure dietary diversity and food security in economic and ecologically sustainable ways. To this end, the government should devise strategies to protect and revitalize SIS diversity in natural water bodies. Total fish production of the Kaptai Lake increased remarkably over the decades. However, still the current production trend of the Kaptai Lake (181.42 $kg.ha^{-1}$) is much lower than the river and estuary (376 $kg.ha^{-1}$), *beel* (869 $kg.ha^{-1}$), and floodplain fisheries (283 $kg.ha^{-1}$) of Bangladesh (DoF, 2018; Suman et al., 2021).There must be zero tolerance for encroachment, poaching, and detrimental fishing practices, including destructive gears like gill net, set bag net, poisoning, and dewatering. During infrastructural developmental activities, eco-friendly fish passage, irrigation channels, and dams must be ensured. Proper measures are required for the strict imposition of a ban on the discharge of untreated industrial effluents and municipal waste into the lake. A comprehensive and long-term program should be established to rehabilitate the degraded aquatic habitats through the re-excavation of the water bodies of the Kaptai Lake. Fishing regulations should be strictly applied to protect the post-larvae, juvenile, and brood of the threatened fish species.

The ecological sustainability of the SIS fishery of the Kaptai Lake is dependent on the livelihood sustainability of small-scale fishers who are dependent on the SIS fishery. To sustain food security and enhance the livelihood of small-scale fishers, the following pragmatic measures need to be taken. Firstly, co-management approaches (through cooperative society, community-based fish culture, technology adaptation, market linkage, and livelihood innovations through a novel and strategic planning) should be adopted for the lake fisheries management. Secondly, promotion of compatible alternative livelihood strategies to alleviate poverty and reduce pressure on lake fisheries, particularly during the annual fishing restriction periods (90 days) should be emphasized.

Lastly, employment of trained and skilled fisheries staff is inevitable for a robust monitoring and sustainable management of the lake fishery. The BFDC should redesign and reinforce existing laws toward effective management of small-scale fisheries of the Kaptai Lake. To ensure sustainable small-scale fisheries, integration and collaborative actions between government, NGOs, fishers, traders, local communities, and other stakeholders are prerequisites.

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5. Untangling the Complexities of Tanguar Haor Fisheries' Social-Ecological System through Ostrom's SES Framework

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Swamps, reeds, and forests constitute the unique fishery of the Tanguar Haor (Photo: Iftekhar Ahmed Fagun, 2017).

This chapter presents a case study addressing the complexities of the Tanguar Haor fisheries' social-ecological system. The study adopted Ostrom's Social-Ecological System (SES) framework to analyze the complexities. The study identified how the actors interact with the biophysical system through a governance system. As a result, the actors involved with fishing faced a more complex governance system, which has implications on social equity and sustainability of the SES system. The analysis revealed the necessity of developing a long-term participatory management initiative and improving the system's sustainability. The research will be helpful as a diagnostic tool for identifying management challenges and complexities that lead to a disadvantaged socioeconomic position of Tanguar Haor's small-scale fishers, who are already living on the fringes of society.

Introduction

A *haor* is a low depression in the form of a basin or saucer, often described as a backswamp, found in the northeastern region of Bangladesh, which remains inundated with water for around six months in a year. The Tanguar Haor is home to at least 141 freshwater fish species, 150 wetland plant species, 11 amphibians, 34 reptiles (including 6 turtles, 7 lizards, and 21 snake species), 208 bird species, and 19 mammal species (IUCN Bangladesh, 2016). In addition, it serves as important grazing, spawning, breeding, and nursery area for freshwater fish and prawn species. These rich fisheries resources add a considerable value to the national economy by contributing 14 percent of the yearly catch of the open-water fisheries production in the Sunamganj district and 0.67 percent at the national level (IUCN Bangladesh, 2016). As such, Tanguar Haor directly supports the livelihoods of around 60,000 people from 88 nearby communities and contributes significantly to the nation's aquatic food production and food security. On average, more than sixty percent of the surrounding communities earn a living from fishing or related activities from this ecosystem (Alam et al., 2015). However, the natural fish populations have decreased significantly over the years due to increased fishing pressure and anthropogenic activities that cause siltation, water pollution, and loss of natural habitat for spawning and growth (Akhteruzzaman et al., 1998). Tanguar Haor's ecosystem, communities, and livelihood are also vulnerable to natural calamities like flash floods (Munasinghe, 2000).

Dominant elites controlled the Haor's fisheries through a lease system that drastically exploited its fisheries resources from the 1930s until the end of the last century. The leaseholders used their power, cash, and muscle to prevent the impoverished fishers and the locals from accessing the natural resources of the Tanguar Haor. Consequently, this became a sad example of fishing rights violations. Until recently, while the *Haor*'s lease system was functioning, fishers had to fish illegally and were forced to poach to sustain their subsistent living. And if the leaseholders caught them, they faced repercussions. Some fishers were allegedly killed in several circumstances (The Daily Star, 2009).

The Tanguar Haor was declared an Ecologically Critical Area (ECA) by the Government of Bangladesh (GoB) in 1999, in recognition of its ecological significance as well as its critical condition caused by the overexploitation of its natural resources (GoB, 2004). On July 10, 2000, it became the second Ramsar site of Bangladesh due to its global importance as a migratory habitat for waterfowls and its enormous biodiversity (IUCN Bangladesh, 2016). The leasing system was phased out in 2001, and the ownership of the Tanguar Haor was transferred to the Ministry of Environment and Forests (MoEF) from the Ministry of Land (MoL), following the Ramsar site designation (Kabir & Amin, 2007). The district administration of the Sunamganj District was in charge of the management.

The National Conservation Strategy Implementation Project was the government's first conservation effort, launched in the mid-1990s. In 2006, a project entitled 'Community Based Sustainable Management of Tanguar Haor' (CBSMTH) was initiated by the MoEF, with the financial assistance of the Swiss Agency for Development and Cooperation (SDC) and technical assistance of the International Union for Conservation of Nature (IUCN) in Bangladesh. A preliminary phase (2006-2009), a development phase (2009-2012), and a consolidation phase (2012-2016) have already been completed for the project (IUCN Bangladesh, 2016). At the end of this project, the government initiated a new project titled 'The Tanguar Haor Bridging Phase (THBP) project (2016–2018)'. Currently, no remarkable development or management project is happening in the Tanguar Haor region. Therefore, the complex interaction between the most important resource user (fisher) and threatened resource system (fisheries) needs to be analyzed to implement management strategies that will improve fishing livelihoods and sustainably conserve the fisheries resources. Against this backdrop, this study aims to address and explore the complex fisheries-based social-ecological system of the Tanguar Haor.

The empirical data of this study is gathered from fieldwork and desk studies based on the literature review. The study employed the Social-Ecological System (SES) framework proposed by Ostrom (2009), which provides the most utilized tools to analyze the complexity of social-ecological systems. The SES framework is a common framework for studying various aspects of a social-ecological system through time.

Ostrom's framework for the fisheries-based SES of the Tanguar Haor

The resource system, the resource units produced by that system, the governance system, the actors in that system, and the focal action situations – interactions and outcomes, are eight primary tiers that make Ostrom's SES framework. The SES framework has been adapted to improve its ability to evaluate complicated SESs and allow social and natural scientists to use this framework (Hinkel et al., 2015). McGinnis and Ostrom's (2014) framework of 56 second-tier variables was used in this study (Table 1). The fisheries-based SES of the Tanguar Haor was developed following Ostrom's framework and is presented in a narrative style.

Table 1: Second-tier variables of a social-ecological system (adapted from McGinnis and Ostrom, 2014).

Social, economic, and political settings (S)	Governance system (GS)
S1—Economic development	GS1—Government organizations
S2—Demographic trends	GS2—Non-government organizations
S3—Political stability	GS3—Network structure
S4—Other governance systems*	GS4—Property-rights systems
S5—Markets*	GS5—Operational-choice rules
S6—Media organizations*	GS6—Collective-choice rules
S7—Technology*	GS7—Constitutional-choice rules
	GS8—Monitoring and sanctioning rules
Resource systems (RS)	Resource units (RU)
RS1—Sectors	RU1—Resource unit mobility
RS2—Clarity of system boundaries	RU2—Growth or replacement rate*
RS3—Size of resource system	RU3—Interaction among resource units*
RS4—Human-constructed facilities	RU4—Economic value
RS5—Productivity of system	RU5—Number of units
RS6—Equilibrium properties	RU6—Distinctive characteristics
RS7—Predictability of system dynamics	RU7—Spatial and temporal distribution
RS8—Storage characteristics	
RS9—Location	
Actors (A)	Related ecosystems (ECO)
A1—Number of relevant actors	ECO1—Climate patterns
A2—Socioeconomic attributes	ECO2—Pollution patterns
A3—History or past experiences	ECO3—Flows into and out of focal SES*
A4—Location	
A5—Leadership/entrepreneurship	
A6—Norms (trust-reciprocity)/social capital	
A7—Knowledge of SES/mental models	
A8—Importance of resource (dependence)	
A9—Technologies available	
Action situations: Interactions (I) → Outcomes (O)	
Interactions (I)	Outcomes (O)
I1—Harvesting	O1—Social performance measures
I2—Information sharing	O2—Ecological performance measures
I3—Deliberation processes	O3—Externalities to other SESs
I4—Conflicts	
I5—Investment activities	
I6—Lobbying activities	
I7—Self-organizing activities	
I8—Networking activities	
I9—Monitoring activities	
I10—Evaluative activities	

Resource Systems (RS)

[RS1] All parts of the environment and *haor* ecosystem that sustain the fish population, feeding, breeding, and nursery grounds in the Tanguar Haor are included in the fisheries resource system. The swamps and reed beds exclusively support the fish population. [RS2] One-third of the *Haor* is in Tahirpur Upazila (sub-district) and the rest is located in Dharmapasha Upazila; both are part of the Sunamganj District of the Sylhet Division, near the Indian border, along the Meghalaya hill region. [RS9] The *Haor* is located between 25°06″ to 25°11″N and 91°01″ to 91°06″E (Chowdhury, 2010). [RS3] The Tanguar Haor spreads over an area of 10,000 hectares, approximately 50 percent of which is covered by water bodies. A total of 54 *beels* (lake-like wetland with stagnant water) comprises the *haor* ecosystem. These *beels* hold the remaining water during the dry season and shelter the brood fish. During the rainy season, all of the *beels* merge into one enormous lake, forming the Tanguar Haor, the largest freshwater wetland of Bangladesh. [RS5]

The Tanguar *Haor* is a highly productive ecosystem in fish production, biodiversity preservation, meeting local and regional demand for fish, and providing a good source of fish seed supply for other water bodies. The estimated fish stock of Tanguar Haor is 6,701 tons (Ahmed, 2015). Low sedimentation rate caused by the absence of major rivers passing through the *Haor*, safe breeding ground and shelter support from natural reeds and swamps, availability of food and nutrients, and natural ecological balance make the Haor suitable for feeding, breeding, and growth. [RS4] Local fish landing sites are located in Tahirpur Upazila, Dharmpasha Upazila (of Sunamganj district), and Mohanganj Upazila (of Netrakona district). The only well-structured fish landing center, established by the Bangladesh Fish Development Corporation, is located in Dobor Ghat, Sunamganj. Unfortunately, the center is far away from fishing zones and is not being adequately maintained.

Fish processing activities and facilities are limited in the Tanguar Haor region. Instead, fish is dried using the traditional, open sun drying process. [RS8] The fish collectors collect fish from the 88 villages and preserve harvested fish in locally manufactured iceboxes in seven collection points in the surrounding area. [RS6] The most unsustainable fishing tactics utilized in Tanguar Haor include harvesting the last remaining fish through dewatering, using unlicensed and harmful gear (e.g., monofilament gill nets), drying out water bodies, and over-harvesting. In addition, unsustainable usage and destruction of swamp forests and reeds, coal storage and transportation, and water contamination put the entire resource system's integrity in jeopardy. [RS7] All of these concurrent negative factors that contribute to the decline in the health and productivity of the system are preventing fishers and local people from making accurate predictions about the system's productivity. Thus, they believe that the dynamics of the ecosystem cannot be adequately predicted.

Resource Units (RU)

The fish species that inhabit in Tanguar Haor are considered RUs. [RU5] The identified number of RUs (fish species) is 141 under 35 families (IUCN Bangladesh, 2016). The number of fish species is around half of the total 260 freshwater fish species found in Bangladesh. [RU6] Aside from providing habitat to many species, this Haor also harbours many rare and threatened fish species. The critically endangered species like *Bagarius bagarius* (Devil Catfish), *Clupisoma garua* (Garua Bachcha), *Crossocheilus latius* (Gangetic Latia), *Ctenops nobilis* (Frail Gourami), *Eutropiichthys vacha* (Batchwa Vacha), *Labeo boga* (Boga Labeo), *Mystus seenghala* (Giant River-Catfish), *Notopterus chitala* (Clown knifefish), *Pangasius pangasius* (Yellowtail catfish), *Rasbora elanga* (Bengal barb), *Rita rita* (Rita), *Rohtee cotio* (Cotio), *Silonia silondia* (Silond Catfish), and *Tor tor* (Tor mahseer) can all be found in Tanguar Haor. Indigenous fish species are dominant in this ecosystem. However, three species are considered extinct: *Channa barca* (Barca snakehead), *Labeo boggut* (Boggut labeo), and *Labeo nandina* (Nandi Labeo), while 16 are critically endangered, and 26 are endangered (Giesen and Rashid, 1997).

[RU1] The fish stock is maintained through a natural recruitment process, and recruitment occurs both within and outside the Tanguar Haor. After spawning, a remarkable number of fingerlings/juveniles scatter to the other *haor* ecosystems every year. This dispersal of larvae/juveniles from Tanguar Haor enriches the fish stock of eight districts in Bangladesh. Simultaneously, non-native fish from other *haors* also immigrate to the Tanguar Haor for shelter and growth. The fish population of the Haor follows different types of migration. *Ujja*, or pre-monsoon migration, breeding of fish within Tanguar Haor, and the return migration in September and October represent the main types of movement. Migration takes place *beel* to *beel* through a river, Tanguar Haor to the Surma River, Tanguar Haor to the Jadukata River, or vice-versa. [RU7] The Jadukata and Patlai rivers are considered special breeding grounds for many fish species in Tanguar Haor. In March-April, small fish breed in connecting channels, hill streams, and inlet channels. Medium-sized fish breed in connecting channels of the Tanguar Haor. [RU4] The monetary or economic value of this vast fisheries resource is USD 1,765,626.91 per year (Solayman et al., 2018).

Actors (A)

The actors are fishers whose livelihoods depend solely on catching fish resources in the Tanguar Haor. [A1] There are both full-time fishers (2,070) and part-time fishers (6,930) (Ahmed *et al.*, 2015). However, more than 70 percent of the households in the adjacent villages occasionally fish for income or food (Minkin *et al.*, 1997). [A2] Fishers' socioeconomic conditions can be interpreted as backward and bleak. Around 80 percent of fishing households have no or minimal alternative income-generating opportunities. Dietary diversity is also low as fish, vegetables, and rice are the main food ingredients. About 27 percent of fishers have a monthly income of USD 35-80. More than 30 percent of fishers have a monthly income between USD 58-80, while 25 percent have an income between USD 18-35. Around 6 percent of fishers have a monthly income that is less than USD 18. The fishers lack access to many necessities such as electricity, water, sanitation, schools, and marketplaces.

The households of 78 percent of fishers are made of clay and bamboo, and only a few are made of bricks (7 percent) (Mamun *et al.*, 2018).

[A3] Fishing is the hereditary profession of most actors. During the years 1780-1900, there was a significant outward migration from the Tanguar Haor due to a succession of natural disasters that led to a population decrease. However, by the second half of the nineteenth century, the situation changed as the *haor*'s basin ecosystem recovered from the environmental stress and restored its productivity. Starting in the first quarter of the twentieth century, the area saw the return of settlers from the surrounding regions, latterly those involved in fishing (Nishat, 1993). Furthermore, during the monsoon season, many fisherfolks (1200-2000) and their families settled in temporary fishing camps at the Tanguar Haor and then back to the villages (IUCN Bangladesh, 2015).

[A4] The fishers from Tanguar Haor reside in 88 island-like villages, some of which are as few as five houses while some villages contain as many as 571 households. [A5] Usually, the group of fishers meets before a fishing trip. The traditional *katha* fishing (by piling tree branches and aggregating fish within it) is always headed by a group leader and consists of 5-12 group members. Notably, community leadership capacity was built under the CBSMTH and THBP projects. The fishers were involved with cooperative societies, learned to harvest fish sustainably, and became conscious of protecting biodiversity. Currently, societies are experiencing challenges due to complicated governance systems at the local levels and wider social-political instability.

Nonetheless, the leadership of the central cooperative society's remained active. [A6] To protect fish biodiversity and the ecosystem, community patrolling was introduced and supported by law enforcement agencies. Sometimes fishers were faced with the most perplexing dilemma: by paying a bribe of merely one USD to administrative authorities such as Ansars (a paramilitary auxiliary force responsible for the preservation of internal security and law enforcement in Bangladesh), certain corrupted fishers, and agents of local water lords so they can continue illegal fishing. In fact, illegal fishing (e.g., poaching) happens all year around (Alam et al., 2015). [A7]

However, the majority of the actors held a conservationist view as more than ninety percent of the actors are willing to participate in sustainable ecosystem management activities (Mondal et al., 2010). Thanks to community-based management projects implemented in the *Haor* region, the actors are now aware of the value of the social-ecological system.

[A8] According to an IUCN survey conducted in 2008, more than ninety percent of the residents reported some dependence, via their occupation, on Tanguar Haor. More than sixty percent were involved in fishing-related activities. [A9] The fishing gears used by the fishers can be classified into three main groups: fishing traps, hooks, and nets. They generally use 10-15 different types of fishing traps, including: closed traps (*Icha Chai, Banjali, Sat Muikkha, Burchunga Chai, and Gui*) and open traps (*Katha, Chai Ban, Light Trap, and Garojal*). Hooks are frequently used to catch fish. *Pocha hook, Tanga hook, Daitta borshi, Laar borshi, Chip borshi, Khili borshi, Tuni borshi, Dori borshi,* and *Fol* are commonly used hooks. Fishers widely use around 15 nets to catch fish, including *Chowhanda Jal, Garojal/Chackjal/Jhap Jal, Ber Jal, Push Jal, Fash Jal, Thela/Felun Jal, Gon/Gan/Ghuraina Jal, Koi Jal, Chela Jal, Koni/Jhaki Jal, Bachuri/Eknaia/Bichani Jal, Utar/Gaitya Utar, Naia Utar Jal, Tana net, Koti/Horhori Jal*. *Katha* fishing is a traditional fish harvesting technique that involves aggregating fish to a specific region by erecting shelters. Branches or entire treetops were taken from swamp forests to construct *Katha* enclosures. Before fishing, they encircle the harvesting area with a nylon net. Then, they progressively pull the lower and upper parts of the net from all sides, enclosing both portions of the net and catching the fish that became entangled in the net.

Governance System (GS)

[GS1] As a local government administration of the Department of Fisheries (DoF), the Upazila Fisheries Officers of Tahirpur and Dharmapasha Upazilas (sub-districts) of Sunamganj district are in charge of managing the Tanguar Haor. During the CBSMTH project, a three-tiered community-based governance system was formed by the Government of Bangladesh (GoB) with the technical assistance of IUCN. After that, the co-management system in Tanguar Haor remained operational, primarily through the Tanguar Haor Management Committee (THMC), which connected community organizations with the government. The Deputy Commissioner (DC) of the Sunamganj district leads the THMC.

At the national level, a Project Steering Committee (PSC) was formed and headed by the secretary of MoEF. THMC and PSC were established through GoB gazette notification. [GS2] Different non-government organizations such as the Center for Natural Resource Studies (CNRS), Efforts for Rural Advancement (ERA), HELVETAS Swiss Inter-cooperation Bangladesh, Bangladesh Environmental Lawyers Association (BELA), and *Gana Unnayan Sangstha* (GUS) have actively participated in the community-based management system with the GoB and IUCN. [GS3] The CBSMTH project formed a Central Co-management Committee (CCC), which was registered as 'Tanguar Haor Somaj Bhittik Soho-Bebostapona Society' (THSBSS). Four Union Co-management Committees (UCCs), including 74 Village Co-management Committees (VCC), functioned under the CCC. Later, the THBP project converted 41 VCCs into registered cooperative societies. A central cooperative society led these societies with representatives from all village cooperative societies across the Tanguar Haor. [GS4] On March 13 2008, through GoB gazette notification, the MoEF set the proportion of fisheries resource earnings for the three stakeholders: 40 percent would go to fishers (harvesters), 36 percent to community groups, and 24 percent to the district administration (local government).

[GS5] Several methods for commercial and non-commercial fish harvesting were developed and approved by the government. In 2011, five fish sanctuaries were established. Commercial harvesting operated under direct supervision and authorization within the core region, and non-commercial harvesting without permission and supervision outside the core area (refer to buffer region) within the Tanguar Haor boundaries. [GS6] The internal rules of the cooperative societies are based on democratic procedures of election by following the Central Co-management Committee's constitution. [GS7] At the local level GS, the village cooperative societies follow the 'Tanguar

Haor Management Rules' under the supervision of the THMC. [GS8] An executive magistrate with 12 police, 24 *ansars* (national para force), and 29 community guards were assigned to protect fisheries resources from illicit harvesting and maintain law and order.

Action situations: Interactions (I) → Outcomes (O)

[I1] Two fish harvesting rules (commercial and non-commercial fishing) were devised to keep fish harvesting at a sustainable level. A community-led monitoring system was created and practiced (Table 2) to ensure that the fishing ban period is enforced and the sustainable yield level is maintained (Ahmed et al., 2015).

Table 2. Summary of commercial fish harvesting from 2009 to 2014 (January to April).

Year	No. of *Beels*	Harvested Fish (kg)	Fish Price (USD)	No. of Days of Fishing
2014	8	13,920	29799.97	26
2013	8	8,316	8458.60	52
2012	12	55,580	69945.78	75
2011	5	6,195	7702.89	16
2010	10	18,738	45935.33	54
2009	7	20,218	26707.98	26

[I2] The fishers involved with the village cooperative societies and the leaders organize weekly and monthly meetings. In these meetings, the actors share relevant resource conservation issues. [I3] Since its inception, the three-tier community organization has been operating and has built democratic and accountable deliberative processes. [I4] Conflict may arise due to cattle grazing, irrigated water distribution, fishing location, domestic issues, marriage, political issues, etc. Local elites, public representatives such as chairmen and members of the Union (smallest and the third tier of local government administration after Upazila and district), religious leaders, and village leaders often arbitrate conflicts. If local efforts fail, it may lead to filing cases with the police station, which may end up in the courts.

[I5] The fishers invest their money in buying and repairing fishing equipment and vessels and buying seasonal licenses/permits for non-commercial fishing. [I6] The fishers participate actively in the THMC's bottom-tier village co-management committee or cooperatives. [I7] The fishers can engage in sustainable fish harvesting, collect their share, and continue community guarding to protect the resource system through the CBSMTH project. However, in recent years, complexities have arisen around self-organization due to a lack of supporting projects. [I8] Full-time fishers catch and sell around 2-3 kg/day to the village fish trades and mobile collectors who look for fish as commission agents of the sellers in Dhaka city. [I9] The fishers played the role of community guards to protect the fish resources from illicit harvesting. They seized 15,075 kg of fishing net, 1,143 boats, and 9,940 traps that were used for illegal fishing during the project phases. [I10] The project CBSMTH introduced participatory resource monitoring and evaluation to the community that helped assess the health of Tanguar Haor fisheries resources (IUCN Bangladesh, 2016).

[O1] Apparently, the income distribution among fishers achieved a high level of equity during the CBSMTH project phases. However, after the project was phased out, most of the fishers believe that the revenue distribution among them became unequal due to the influence from the local elites; meanwhile, illegal fishing has increased. On a positive note, knowledge of community-based resource management, leadership capabilities, and social strength have increased. [O2] Over-harvesting, illegal fishing, use of illegal gear, water pollution, unregulated eco-tourism activities, and swamp deforestation negatively impact the aquatic environment biodiversity and are responsible for the extinction of several indigenous fish populations from the *haor.* [O3] However, establishing five fish sanctuaries and restoring swamp and reed beds supports the fish populations, enabling safe breeding and feeding and enhancing the ecosystem's health.

Related Ecosystems (ECO)

[ECO1] Tanguar Haor's climate is sub-tropical-monsoon, with three distinct seasons: summer, monsoon, and winter. In the northern part of Sunamganj, the average annual rainfall is around 8,000 mm, with summer accounting for 65-69 percent of total precipitation. Evaporation increases rainfall during the spring, generating flash floods in the Tanguar Haor region. Summer lasts from April to June, with temperatures ranging from 30.9 - 33.4 degrees Celsius, monsoon lasts from May to September, and winter lasts from October to February, with temperatures ranging from 8.5 to 16.6 degrees Celsius (IUCN Bangladesh, 2016). In the wet season, humidity is around 83 percent, while in the dry season, it's around 64 percent (Alam et al., 2012). [ECO2] Environmental pollution in the Tanguar Haor is a severe problem, most notably water pollution. The significant factors of water pollution include the use of pesticides (35.5 percent), sewage leaks from unsanitary latrine (35.5 percent), burned oil spilling from mechanized boats (17.2 percent), water washed from the coal mines (11.8 percent) (Islam et al., 2014). Fish species die due to water pollution and toxic substances in the water. During the monsoon season and after a flood, the Haor area has a surplus of fish. On the other hand, water logging and rotten paddies create water pollution, which leads to mass mortality of fish species.

Social, economic, and political settings (S)

[S1] In the Tanguar Haor region, fishing is the primary source of income. However, because each fisher only harvests a small number of fish, income from fishing is insufficient for lifting people out of poverty (Alam et al., 2015). [S2] Due to certain fishing restrictions, the fishers recognized the long-term benefits of abstaining from over-fishing and fishing during breeding seasons. Therefore, they started looking for alternative income-generating opportunities. The fishers started carrying coal and worked as day labourers, stone brokers, ferry boatmen, and seasonal farmers. However, no significant change occurs in the demographics of the fishing communities of the adjacent villages. [S3] A continuous power struggle is going on over the access to fisheries resources. From the 1930s till the end of the last century, the Tanguar Haor fisheries were run by powerful elites through a leasing system. Negative propaganda from local elites against community-oriented initiatives was a severe worry for the CBSMTH project.

Challenges and conclusion

The Tanguar Haor ecosystem and its vast fisheries resources attracted much attention from the government, NGOs, and international donors as an ecosystem of immense ecological significance. Both CBSMTH and THBP projects have positive and negative social, ecological, conservation, and governance outcomes. The achievements include improving fishers and people's knowledge base, reestablishing fishers harvesting rights, organizing national and local level governance systems, establishing fish sanctuaries, restoring swamps, initiating community patrolling, and formulating profit distribution ratios and sustainable practices management guidelines. In addition, the small-scale fishers of the Tanguar Haor learned the importance of conserving the fisheries resources through training and their fishing right was reestablished by developing community-centric management.

On the other hand, the fishing community's self-organizing capacity, awareness about sustainable fisheries management, leadership, governance, and decision-making ability has not yet been built. As such, the democratic processes of local-level community organizations became questionable. Fishers' reliance on natural resources has increased, and their socioeconomic conditions worsen due to a lack of options for alternative income-generating during fishing restriction seasons. Local conflicts and power struggles over the access and control of resources became a severe issue. The prevalence of illegal and unauthorized fishing is increasing due to the limited manpower of the law enforcement agencies to protect a large area and the corruption of the assigned ones. Unregulated and uncontrolled eco-tourism activities are negatively impacting the ecosystem and fish populations.

The comprehensive approach adequately portrayed the socio-ecological system, demonstrating the interactions of actors with resources and the influence of GSs on social and environmental performance. This study shows that governance is a crucial component of achieving sustainable resource usage; a long-term participatory ecosystem management project should be designed, which will enable small-scale fishers to manage the vast fisheries resources and the ecosystem confidently on their own, free from dependence on any external funds and influence. The social-ecological system of Tanguar Haor can only be sustainable if the small-scale fishing communities become conscious about ecosystem management, benefit from sustainable management, and make their own decisions without interventions and facilitation from any project.

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6. Unraveling Complexities: Towards a Typology of Small-Scale Fisheries in Kaptai Lake, Bangladesh

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Non-mechanized subsistent fishing is an important livelihood activity in Kaptai Lake (Photo: Bodhi Kandu Chakma, 2021).

A typology of small-scale fisheries in the Kaptai Lake, Bangladesh, is developed to unpack its complexities, heterogeneity, and dynamics. Based on the level of financial investment in fishing activities, three types of small-scale fishing activity were identified. They include: Type-1 fishers with the highest financial investment; Type-2 fishers with a lower financial investment; and Type-3 fishers with no financial investment. While each group faces different threats and challenges, a list of common threats to their livelihoods is identified. This typology identifies the multiple dimensions of small-scale fisheries in similar contexts. As developing countries have limited resources to support fishers, this typology will be helpful to point out the specific problems and needs of particular fisher groups. Thus, policymakers can invest in the most effective way where support is most needed.

Introduction

In small-scale fisheries, heterogeneity and complexity are inherent (Johnson, 2006). Small-scale fisheries may differ in socioeconomic settings, local arrangements, and cultural contexts (Coronado et al., 2020). The complexity of small-scale fisheries is rooted in the geomorphologic and ecological characteristics (e.g., coastline length and size, oligotrophic ecosystems) (Tzanatos et al., 2006), as well as in the availability of resources, fishing effort, production, socioeconomic conditions, markets and economic incentives (Coronado et al., 2020). According to Johnson (2006), to make sense of the world, the surrounding complexity can be reduced through categorization by selecting and ordering identical or different things, ranked or relationally neutral.

According to the Cambridge dictionary, the lexical meaning of typology refers to a system or study of dividing things into separate types. Typology simplifies the understanding of a complex system by categorizing the elements of that particular system according to their similarities and disparities. Structuring typology for small-scale fisheries is an approach to organize and accumulate a variety of its element based on similarities and differences among them. It categorizes a highly complex fisheries system to ease its overall understanding (Coronado et al., 2020). This categorization is important because standardization of small-scale fisheries information is an arduous task due to their temporal and spatial fragmentation and haphazardness (Jacquet et al., 2010; FAO, 2017; Chuenpagdee et al., 2019). Against this backdrop, a typology can help organize dispersed data, identify information gaps, and generate sound information for better fisheries management (Glaeser, 2016; Coronado et al., 2020). Further, it puts forward new research questions about the monitoring and management tactics of small-scale fisheries (Coronado et al., 2020). This research was focused on developing a small-scale fisheries typology for Kaptai Lake fisheries. Small-scale fisheries-specific typology, as presented here, is the first attempt in Bangladesh to categorize a fishery system and its threat towards developing broad lessons for sustainable management.

Overview of small-scale fisheries of Kaptai Lake

The Kaptai Lake is the largest among the man-made freshwater lakes in the south and south-east Asia (Hoque et al., 2021). It is the largest lake in Bangladesh (Bashar et al., 2015). The average surface area of this 'H' shaped lake is 58,300 ha (Uddin et al., 2014). This reservoir's maximum and mean depths are 32 and 9 m, respectively (Bashar et al., 2015). The lake was created in 1961 by creating a large dam, 666 meters long and 43 meters high, with 16 spillways across the Karnaphuli River at Kaptai, about 40 km downstream of Rangamati District and 70 km upstream from the estuary of this river (Karmakar et al., 2011; Haque, 2015). Though the primary purpose behind the creation of the lake was to produce hydroelectricity, it contributes to flood control, irrigation and drainage, riverine communication, transportation of harvested forest resources, tourism, and freshwater fisheries production. The total fish production was 12,696 metric tons in the 2019-20 fiscal years, representing 0.28 percent of the country's total fish production (DoF, 2020). The fisheries system harbours 49-71 indigenous and five exotic fish species and supports small-scale fisheries by providing income and employment opportunities (Karmakar et al., 2011; Hoque et al., 2021).

Fishing in the Kaptai Lake can be done with or without fishing vessels. The fishing vessels may be non-motorized or motorized, and the length of these vessels ranges between 3.15-11.7 m. The motorized boats are wooden, without any roof, and use engines ranging from 3 to 16 horsepower (HP). The daily fuel cost for the motorized vessels ranges between 1.23-11.40 USD (1 USD = 85.56 BDT). The non-motorized boat may be with or without a bamboo roof. The main fishing gears used in the lake include hand lines, long lines, reel lines, cluster hooks, spares, traps, push nets, seine nets, and gill nets. Some fishers dive and catch fish with their bare hands. Fishers catch fish in places that are adjacent to their homes as well as those in distant areas. Their daily fishing area ranges between 644–311,724 m^2. Some catch fish alone, while most fish in a group. In groups, the number of fishers ranges from 2 to 13. The small group of fishers, with two to three members, is usually composed of family members, whereas in larger fishing groups, members come from the same communities. The fishers can be both full-time and part-time. Some wealthy fishers have their fishing gear and vessels, while fishers in the other two groups don't own fishing gear and boats. Among them, one group hires productive assets from the owner of fishing gear and vessels. The third group is represented by a fishing unit comprised of fishers who work as hired crew with other groups. Most fishers sell their catch at the local market to the fish dealers, who later transport fish to different parts of the country. The most catch is sold fresh, and a small percentage of the amount is sold as dried fish.

All fishers generally practice some rituals before using new gear. This is especially true for Hindu small-scale fishers, who also avoid fishing activities during the days of religious festivals. There are no strict social or religious rules related to fishing among the Muslim fishers, but some stop fishing on Friday and during religious festivals. Some fishers of the Chakma ethnic community do not fish during a full moon and religious festivals. Fishing is prohibited around the religious establishments of Buddhist people, which is maintained either all year-round or only on the days of festivals. The gift of a large fish in marriage events is treated as a matter of honor in the Chakma ethnic community. The government prohibits fishing from May to July of each year. Although most fishers comply with this ban, some continue fishing during the ban. Moreover, a monofilament gill net is used rigorously in this lake.

Table 1. Key attributes of Kaptai Lake fisheries.

Key attributes	
Vessel size	Between 1.7 - 3.15 meter
Vessel type	Non-motorized wooden: with bamboo roof, without the roof; Motorized wooden: without the roof
Size of engine	3-16 HP
Daily fuel consumption	1.23- 11.40 USD
Gear type	Hand lines, long lines, reel line, cluster hook, dive, spare, traps, push net, seine net and gill net
Monetary investment	Up to 14,843.84 USD
Distance of fishing area from living place	Close to and far from their living place
Fishing area	644- 311,724 m^2
Number of crew	2-13
Occupational status	Full time and part-time fishers
Fishing unit	Individual or family; a group of fishers from different families in a community
Disposition of catch	Household consumption; sales to local and national markets
Processing of catch	Mostly fresh and some dried

Typology of Kaptai Lake fisheries

Based on the degree of monetary input in fishing, small-scale fisheries of Kaptai Lake are categorized into three types.

Type-1: High economic input

Fishers of this type are locally known as '*Boddar*'. They own fishing gear and vessels, and they predominantly invest in fishing gear, boats, maintenance, fuel cost, and wages for the hired crew. They predominantly use seine nets and lift nets of different lengths and mesh sizes, made of different materials. They use both mechanized and non-mechanized wooden boats, ranging from 4.5 to 11.25 m. Mechanized boats have engines with 8-16 HP. They usually invest between USD 1,075-14,840 for gear and vessels, with the yearly maintenance costs estimated to be from USD 115 to 1,755. Annual fuel costs range between USD 775-3,310. They usually hire 6-15 fishing crews for nine months. The expense usually ranges from USD 8,835-23,670, which is used for paying wages, food, and accommodation for the crew. Usually, '*Boddars*' have to provide advance payment to the hiring crew, ranging from USD 175 to 470 for each fisher. Altogether, the yearly investment for type-1 fishers is between USD 9,725-28,735. Furthermore, they are forced to pay annual extortion to influential local groups, which is determined by the number of vessels and the quantity of the fishing gear. Sometimes they need to buy fishing space on a yearly basis.

Most fishers in this group take loans locally known as '*dadon*' from the fishing entrepreneur locally known as *'dadonder'*. In return, they are forced to sell their catch to '*dadonder',* at a lower price than the market value. In this way, '*boddars*' lose a large portion of their profit. Many '*Boddars*' consider '*dadon*' as a trap; if anyone falls in it, it is quite impossible to come out. Taking a loan from a bank requires complex paperwork and collateral assets that most fishers cannot afford. According to the agreements between the *'dadonders'* and the '*boddars*', the *'dadonders'* are bound to buy all the fish from the '*boddars*'. If in any case the '*dadonders*' are failed to take the fish from *'boddars'* due to limited carrying capacity of their boat, they have to pay equivalent money to the '*boddars*' for the fish.

The type-1 fishers are entirely dependent on fisheries for their livelihoods and income. Their annual fishing income ranges from USD 1,065 to 2,177. In terms of socioeconomics, these fishers are generally solvent, and they can meet their basic needs (e.g., food expenses, medical treatment, education) comfortably with their fishing income. Some of them hold leadership positions in society. They have a higher living standard, better managerial capacity to lead their communities, and manage one or multiple fishing units. They may be involved in fishing full- or part-time. Most permanent fishers are fully dependent on fishing for livelihood, which contributes about 80-100 percent of their yearly income. Part-time fishers do other jobs in the lean season to maintain their livelihood and earn 65-85 percent of their annual income through fishing. All *'boddars'* are required to obtain a license from the Department of Fisheries upon a payment of USD 6.00 that allows them to fish for nine months per year. There are pre-determined fishing zones (locally known as *kop*) for each *'boddar'*. For each haul, they usually cover an area of 7,284–201,430 m^2. They operate their net for 2-10 hauls in 24 hours, depending on the type and capacity of their gear. They catch all kinds of fish found in Kaptai Lake.

Type-2: Low economic input

These are fishing entrepreneurs who fish alone or with other family members and are occasionally supported by hired fishing crew. Their investment in fishing is lower than that of type-1 fisher. They own their gears and vessels and use the most diversified range of fishing gears, such as gill nets, seine nets, cast nets, push nets, fishing traps with different mesh sizes, wounding gears, and hook and lines. They sometimes capture fish bare-handed. The use of such diversified species-specific fishing gears helps to reduce the fishing pressure on a specific fish species. This type of fishing appears to be most sustainable as this group rarely implements unsustainable fishing practices.

The catch is either used for subsistent living or sold in local markets. With no pre-arrangements with fish dealers, fishers mainly sell their catch fresh in the local market or to fish retailers. A few fishers also sell the catch to fish dealers. Fishers mostly use non-mechanized fishing boats, which may be roofed or unroofed. A small number uses mechanized wooden boats (with 3-4 horsepower engines). The length of these mechanized and non-mechanized boats ranges between 3.15-6.75 m. The estimated fuel cost for the mechanized wooden boat ranges between USD 330-885/year. The fishers in this group invest between USD 35-622 for fishing gear and vessels. The income from fishing ranges between USD 630-2,101. These fishers are poor to moderately poor, and they can maintain their livelihoods with their fishing income.

Both part-time and full-time fishers are included in this category. The full-time fishers are entirely dependent on fishing to support their livelihood, and fisheries provide 75-100 percent of their yearly income. The seasonal fishers do other jobs in the lean season to maintain their livelihood and earn 40-77 percent of their annual income from fisheries. They usually fish within shorter distances, and their mobility ranges between 779-16,188 m^2. They can catch fish in any area except the zone used by the type-1 fishers. Due to poor economic status, some fishers use hackneyed boats, which are prone to sinking. There is a chance that fishing gear and boats can be stolen. To avoid this risk, at night fishers stay at the fishing site in a group and store their fishing traps in a protected place. Sometimes net and traps get smashed by the propeller of other vessels. Most of these fishers don't obtain licenses and continue fishing throughout the ban season.

Type-3: No economic input

These are paid fishers who work as fishing crew for type-1 fishers. They have no financial investments in fishing. They receive payments through two types of arrangements: either as a monthly wage or they work as a member of a fishing team and get a daily share of fishing income. The monthly waged fishers are further bifurcated into two sub-groups. Some take accommodation and meal support along with their monthly payment from their team owner (Type-1). In contrast, others take a portion of their daily fish catch for family consumption besides their monthly salary. The annual pay of those, who take accommodation and meal support, ranges from USD 945 to 1,050, and the majority of them are migrant fishers from other regions of the country. On the other hand, the annual earnings of the fishers, who take only a portion of their daily catch along with their monthly salary, range from USD 1,472 to 1,577, and they are mostly local fishermen. 73-100 percent of annual income of the monthly waged fishers comes from fishing. However, the fishermen, who are paid a daily part of the fishing group's earnings, manage 75-100 percent of their annual fishing income, which ranges from USD 1,260 to 1,895. Their earnings fluctuate based on the amount of fish caught and the price of fish. In such groups, the team owner (Type-1) keeps one-fourth of their daily income for ownership of the gears and vessels, and the rest balance is divided equally among the crew fishers. Both local and migrant fishers are there in these groups of income-sharing fishers.

Migrant fishers often complain of high work pressure and inadequate compensation. Moreover, they don't receive wages if absent due to sickness or other emergencies.

Threats and coping strategies

The fishers reported several threats and stressors that hamper their fishing occupations, income, and wellbeing. The average size of fish caught decreases as nowadays larger-sized fish is almost extinct. The majority of catches are small and have a low market value. The amount of catch per fishing effort is also dramatically decreasing. While crabs are increasing in this lake, some high valued fish species, including Kuria Labeo (*Labeo genius*), Mottled Nandus (*Nandus nandus*), Gangetic Hairfin Anchovy (*Setipinna phase*), Olive barb (*Systomus sarana*), and Indus Garua (*Eutropiichthys murius*), are gone. Among the indigenous species, Gangetic Ailia (*Ailia coila*), Humped Featherback (*Chitala chitala*), and Loaches (*Lepidocephalichthys* spp.) significantly decreased. Low priced fish such as Indian river shad (*Gududia chapra*), Ganges River-sprat (*Corica soborna*), Nile tilapia (*Oreochromis niloticus*), and Mozambique tilapia (*Oreochromis mossambicus*) are now the major target species. Some fishers reported the introduction of predatory species Piranha (*Pygocentrus nattereri*) in the lake. An increase in water hyacinth is another nuisance.

The pollution of lake water is another big concern, and the major sources include land usage change, plastic (e.g., polythene bags), and oil from vessels. Furthermore, climate change has substantial negative impacts in terms of increased temperature, less rainfall, late arrival of winter, and warmer temperatures in the winter season. Such alterations in climatic variables in the lake cause destructive effects on the normal physiology of fish and their environment. Less rainfall reduces the water supply, and increased temperature propels the evaporation of lake water.

Despite a low amount of rainfall, rainfall in upstream hilly areas, deforestation, and shifting cultivation in hills (locally known as '*Jhoom*') are causing siltation that leads to reduced depth of the lake while the adjacent creeks are drying up. According to one estimate, in 1964, there were 2,163 families involved in shifting cultivation which increased to 35,000 families in 2002 (Tripura & Harun, 2003). The involvement of more people in *Jhoom* cultivation led to a more intense clearing of green hill covers. Thus, rainfall is likely to cause more denudation and ultimately more siltation in the lake. By plugging the pits inside the wooden logs and massacring the submerged vegetation, siltation is causing the rapid degradation of fish habitat. Siltation hampers migration routes and feeding areas of fish species. In addition, reduced depth caused by siltation facilitates a fast rise in water temperature and causes fish death. Again, a new layer of silt creates troubles for fishers when operating nets as they get stuck in this thick layer of silt. Siltation is reducing the water holding capacity of this lake. As a result, to keep the targeted amount of electricity production (which is the primary purpose of this lake construction), more water needs to be discharged, further lowering the lake's water level in the dry season. The Bangladesh Fisheries Development Corporation does not have any authority to maintain the water level of this lake, as fisheries management is a secondary purpose in the construction of Kaptai Lake (Ahmed & Hambrey, 2005).

Reduction in fish production is a major threat to fishers, reducing their income. Consequently, fishers start looking for alternative job opportunities. During the yearly fishing ban from May 1st to July 31st, already marginalized fishers face further economic shock. While the government has a compensation scheme to support the poor and vulnerable fishers for their income loss, the scheme is insufficient and does not cover all affected fishers. To avoid economic hardship, most of the type-1 fishers become further indebted to the middleman, and the type-2 fishers fish illegally by non-complying to the fishing ban. Some fishers have changed their gears to reduce fishing costs that require less manpower. A section of fishers uses fine-meshed fishing gears to catch even undersized fish, increasing their fishing effort to cope with no- or low-income situations.

Many fishers cannot cope with this situation and are shutting down fishing activity in the wintertime, which greatly reduces their profit. The remaining fishers take on additional debt from the middlemen. Some fishers have accused the government of mismanaging the duration of the fishing ban. Many fishers, mainly those in the type-2 group, do not obey the government's fishing ban, which diminishes the ban's effectiveness. Consequently, all other fishers failed to reap the benefits of not engaging in fishing activities during the ban. Almost all fishers have to pay extortion to multiple local political groups. Due to diminishing profit from fishing, the type-1 fishers cannot increase the wages for paid fishers (type-3) on their fishing team. As a result, the type-3 migrant fishers from other districts don't stay employed for long due to poor payment and the high intensity nature of the work. Some local influential groups are also involved in fishing and forcefully displace other fishers from fishing in certain zones.

There are also significant health risks. The increasing incidence of thunderbolts poses a real threat to the lives of fishers. Storms and torrential water during monsoons are additional risks for those who fish without vessels or in smaller size vessels. Accidents may happen during fishing operations, such as when pulling a seine net with bamboo structures; fishers can get injured by tearing the rope of the fishing net or breaking the bamboo structure. Fishers can get wounded by fish, wooden logs, or other submerged sharp materials during bare-handed fishing. There are also poisonous snakes in the bushes of water hyacinth. Fishers are usually careful to avoid these risks. Some fishers suffer from different dermal diseases due to fishing in polluted water. Some fishers regard superstitions as a risk. To protect themselves, they use religious shields.

Conclusion

The typology developed in this study reveals insight into the small-scale fisheries system in Kaptai Lake, which has not been previously generated for any other fisheries system in the country. The outcomes of this study confirmed the complexity and diversity within this small-scale fisheries system. The study discussed three types of small-scale fisheries in this region based on monetary input invested in fishing activities. This study has successfully simplified the complex structure of the Kaptai Lake fishery, which will help researchers identify information gaps, understand the structure of this fishery and use this knowledge in further research on Kaptai Lake. It also underscores the small-scale fisheries' attributes, which can differ within communities. Given that we have limited resources to support fishers, and this typology points out the specific problems and needs of specific fisher groups, this research will help respective authorities distribute support most effectively and devise efficacious management plans for this lake. Moreover, as a first structured typology, this model can be replicated for all other small-scale fisheries systems in Bangladesh, including coastal, *haor*, and riverine areas. Though this research addressed some threats and challenges to all three types of small-scale fishers, better management of the fisheries systems alone will not ensure their wellbeing and sustainability of resources. For effective and efficient fisheries management, it is important to understand the environmental variables that the fisheries system is experiencing (Cochrane & Garcia, 2009). In such a case, ecosystem-based management can be a priority. The fishers' involvement in management is essential. External drivers, including siltation due to *jhum*, pollution, the proliferation of exotic fish species, such as tilapia, and the fluctuation of water level by dam control, should be carefully monitored by the governing bodies.

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7. Artisanal Fishing Crafts and Gears of Coastal Bangladesh

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Fishing craft made of Styrofoam, wood, and bamboo used for nearby fishing in the Cox's Bazar coast (Photo: Md. Abu Redwan Khan, 2020).

This chapter presents the diversity and characterization of the common fishing crafts and gears used in the coastal artisanal fishery of Bangladesh. The coastal artisanal fishery of Bangladesh is a multi-gear, multi-craft, and multi-species fishery with small, traditional fishing crafts equipped with low-tech gears requiring labour-intensive fishing methods. Crafts are mostly traditional wooden boats with an increasing trend of mechanization, which varies in their construction and equipment in terms of size, engine power, and gear handling systems based on the area of operation and type of gear to be operated. Gears are mostly low-tech traditional types based on labour-intensive methods of operation. Many have remained the same for centuries, while others have been modernized through long modification processes in synchronization with the changes in the target fish, climatic and environmental conditions, and socioeconomic and sociocultural features over time. The fisherfolks choose different devices depending on the fishing area, target species, availability and price of the construction materials, and the applicable regulative and legislative issues in the region. Monitoring the current state and evolution of fishing crafts and gears throughout time and identifying the reasons for switching and mode of adoption to a specific device, is critical to understanding and managing the artisanal coastal fisheries of Bangladesh.

Introduction

The coastal artisanal fishery of Bangladesh is characterized by a multi-craft, multi-gear, and multi-species fishery. Crafts and gears used in artisanal fisheries are mostly traditional, labour-intensive, and require low technological input and investment (Kimani et al., 2009). A small-scale artisanal fishery includes small, low-tonnage vessels generally operating in nearshore areas accessible within a short time and different types of gears, excluding towed ones (Falautano, 2018). Crafts and gears of small-scale artisanal fisheries have usually been overshadowed in research and national fisheries policy by the perceived valuation in terms of the cash revenue of its large-scale industrial counterpart. These crafts and gears have very significant and broader linkages with the fisheries resources and the livelihood activities of many people along the whole value chain. However, these devices used in artisanal fisheries have received only scant attention in the past. It is important to study the characteristics and diversity, why fishers adopt diverse crafts and gears, and the relationship of these devices to the ecology and the socioeconomic status of the community. Fish capture devices related to selectivity or impact on the ecosystem are essential components of fisheries management. Knowledge of the features, diversity, and productivity of crafts and gears of a fishery is essential for the formulation and successful implementation of any developmental, management, or conservation plans. A thorough understanding of fishing crafts and gears is important for understanding the present exploitation and making suitable improvements and management (Bhattacharjya et al., 2004; Sultana et al., 2016). Based on the authors' direct observation and literature review, this chapter provides a general overview of the art of fishing crafts and gears used in the coastal artisanal fishery of Bangladesh.

Fishing crafts

Crafts used in small-scale artisanal fisheries of Bangladesh are mostly based on traditional wooden canoes that have been modernized by the addition of outboard gasoline motors, storage, and sometimes a small space for the fishers. The use of sail and paddle power is common. Fishing crafts are built traditionally with locally available materials by rural carpenters with planks and furnished by coal tar and burned oil (Azam et al., 2014; Sultana et al., 2016). The trend of mechanization of craft is dominant and only a small percentage are propelled by oars and sail. The fishing crafts vary in their construction and equipment in terms of size, engine power, and gear handling systems based mainly on the area of operation and the type of gear to be operated. The following are some major fishing crafts available in the coastal artisanal fisheries of Bangladesh.

Kosha Nauka

Kosha Nauka is a non-mechanized country boat with blunt ends (Figure 1a). The open deck without having any hood is made of whole or split bamboo pieces or wood in some cases, and oars are made of bamboo poles. Usually, there is no sail, but when present, the sail is situated in the anterior half of the boat (Sultana et al., 2016). The boat is used for fishing in small inland canals and shallow waters to catch small fish (Azam et al., 2014).

Figure 1. (a) Kosha Nauka, (b) Dinghi Nauka, (c) Trawler, (d) Tempu Nauka/Rotala, (e) Tempu Nauka/Matowala, (f) Chandi Nauka, (g) Balam Nauka, (h) Shampan Nauka. (Photos b, e, g & f by Azam et al., 2014).

Dinghi Nauka

Dinghi Nauka is a small, shallow rounded bottom boat with a pointed bow (Figure 1b), generally used in areas close to shore and inland water bodies. In smaller boats, there are no decks, but the bigger ones usually possess one deck made of bamboo splits or betel nut trees. Usually, there is no hood, but when present, it is located in the posterior part of the boat (Sultana et al., 2016). While Dinghi Nauka was traditionally non-mechanized, now mechanization is an increasing trend.

Trawler

The trawler is a very strong dug-out spindled shape boat with the fore and hind ends bluntly pointed. The bottom of the boat is rounded (Figure 1c). The stern is 1-1.5 m higher than the bow. Engines propel the vessel, and a team of fifteen crew members is required to operate the vessel. The boat is generally used for operating a gill net fixed purse net. Trawlers are also used for the transportation of goods and passengers.

Tempu Nauka

Tempu Nauka is a round-bottom, mechanized boat operated usually by a team of thirteen crew members. Some variations of Tempu Nauka are available based on shape and size, namely '*Rotala*' and '*Matowala*.' The front part of '*Rotala*' is pointed and has a round bottom and extended arrowhead (Figure 1d); in the case of '*Matowala* the front part is not- pointed and the back part is not as pointed as the front side (Figure 1e). The Tempu Nauka is generally used for gill net fixed purse net (*Behundi Jal, Bata Jal*) fishing.

Chandi Nauka

Chandi Nauka (Figure 1f) is slightly prolonged on both ends with a much-pointed anterior end. The bottom is flat or rounded. The stern of this boat is much higher than the bow. Strong flatforms made of wood are present on both ends, while the central region is provided with detachable split bamboo-decking. A bamboo or wooden hood is present in the anterior part. Usually, they have no sail, but a second topsail is sometimes seen over the sail to increase the speed.

Balam Nauka

Balam Nauka (Figure 1g) is a strongly built spindle-shaped boat with bluntly pointed anterior and posterior ends. The anterior and rear ends are 1-1.2 m higher than the bow. A hood made of wood is present in the posterior part. It has a robust platform made of wood on both ends. The bottom is rounded and the square-shaped sail is set in the anterior part if present. Also, it has a strong steering paddle made of wood attached to the posterior end.

Shampan

Shampan or Shampan Nauka (Figure 1h) is used mainly in Chittagong and Cox's Bazar regions. The posterior part is divided into two pointed parts; the bow is pointed and raised above the water. It is used for fishing in the estuaries and the shallow coastal waters of the Bay of Bengal.

Table 1. Characteristics of major fishing crafts of coastal Bangladesh.

Craft Name	Boat type	Dimensions (m)			Material	Bottom	Crews (No.)	Carrying capacity (Ton)	Life span (Yrs)	Main gear	Reference
		L	W	H							
Kosha Nauka	Non-mechanized	8-10	2-4	1-2	Wood, Bamboo	Flat	2-3		4-5	Monofilament gill net, Cast net	Azam et al., 2014
		6-7	2-3	1-2			3-5		3-5	Chandi jal	Sultana et al., 2016
Dinghi Nauka	Non-mechanized/ mechanized	6-7	2-3	1-2	wood, bamboo, iron	Rounded	4	0.6-0.8		Fixed purse net, Behundi jal, Bata jal	Present study
	Non-mechanized/ mechanized	5-6	2-3	1-2	Wood, Bamboo		5-6		4-5	ESBN, Chandi Jal	Azam et al., 2014
	Non-mechanized	5-8	2-2.5	1-2			3-6		3-5		Sultana et al., 2016
Trawler	Mechanized	16-18	6-8	2-3		Rounded	15	150-200		Gillnet, Fixed purse net (Behundi Jal, Bata Jal)	Present study
		8-10	2-4	2-3		Flat/Rounded	5-8		4-5		Sultana et al., 2016
Tempu Nauka	Mechanized	8-10	2-4	2-3			13	5-6.5		Gillnet, Fixed purse net (Behundi Jal, Bata Jal)	Present study
Choto Tempu	Mechanized	8-10	2-4	2-3	Wood, Iron	Rounded	5-8		4-5	ESBN, Chandi Jal	Azam et al., 2014
Chandi Nauka	Mechanized	10-15	2-4	2-3	Wood, Iron	Rounded	8-10		8-10	Chandi Jal	Azam et al., 2014
Balam Nauka	Mechanized	10-15	5-8	2-4	Wood, Iron	Rounded	10-15		8-10	ESBN, Chandi Jal	Azam et al., 2014

Fishing gears

Gears are mostly low-tech traditional types based on labour-intensive methods of operation, and many have remained unchanged for centuries. However, some have also been modified over time, in synchronization with the changes in the target fish, climatic and environmental conditions, and socioeconomic and sociocultural features. Both active and passive gears are being used with distinctive construction methods and modes of operation. Some of these can be operated from the shore requiring no crafts at all, but in this chapter, we focus mainly on the common gears that require crafts in any part of their operation. The following are some of the most common fishing gear used in the coastal artisanal fisheries of Bangladesh.

Gill nets

Gill nets are widely used gears in the coastal artisanal fishery of Bangladesh. The nets are rectangular, usually made of synthetic fibers like polyamide forming monofilament or multifilament twines. The net is knitted through one hand-knitted net made of natural fibers like cotton. While fish are trying to swim through a mesh of netting, which is a little smaller than the largest circumference of their body, they get stuck or, in other words, 'meshed.' Fish first get stuck because of their dorsal fin. Still, mostly it will be behind the opercula and the gills – i.e., they are 'gilled,' and gears constructed to catch fish by gilling are the so-called gillnets (Gabriel et al., 2005). Gillnetting is preferred and considered a typical small-scale fishery as it is very effective and requires little investment in purchasing and maintaining the nets. Moreover, no specialized vessels are required and in some cases these nets can be operated without a vessel by fishers swimming and diving (Gabriel et al., 2005).

There are different modified versions of gillnets under various local names used in Bangladesh waters (Table 2). Chandi Jal (Figure 2h) is used mainly for Hilsa shad (Tenualusa ilisha) fishing. The net has both sinkers and floats. The measurement of this net differs widely from district to district, and so does the period of operation of the net (Ahmed, 1961). Ilish Jal is another gear famous for catching Hilsa and provides a very high economic return, thus becoming one of the most popular choices among fishers. This is dominant gear in the coastal areas of Bangladesh (Rahman et al., 2017). Coral Jal (Figure 2j) is another form of gill net. Floats are attached to the net, and the net is drifted with the water current (Sultana et al., 2016). Poa Jal is a gill net made of polyamide monofilaments and nylon rope. Several nets are joined together and moved by boats. Two boats drag the net against the current while others move with the currents, driving fish towards the net, and producing sound in the water (Ahmed, 1961). Bata Jal is, also called Mullet gillnet, is a drift gill net used mainly for gilling Bata fish (Mugil Sp.) in the foreshore areas of Noakhali, Chittagong, and Khulna region (Ahmed, 1961). There are a few other gill nets: Lata Jal and Duba Jal.

Figure 2. (a) Estuarine Set Bag Net (ESBN)/Behundi Jal (in operation), (b) ESBN/Behundi Jal (mesh size), (c) Bata Jal (mesh size), (d) Moshari Jal (stationary), (e) Moshari Jal (movable), (f) Atto Jal, (g) Atto Jal (mesh size), (h) Chandi Jal (mesh size), (i) Ilish Jal (mesh size), (j) Coral Jal (mesh size), (k) Char Jal (during high tide), (l) Char Jal (during low tide). Photo k (Nabi et al., 2011).

Table 2. Characteristics of major gill nets.

Gear Name	Shape	Dimension		Mesh Size (inch)	Construction Cost (in thousand BDT)	CPUE (kg)	Major fish caught	Reference
		Length (m)	Width (m)					
Chandi Jal	Rectangular	650-700	10-12	4-4.5	300-400	8-150	Mainly Hilsa (*Tenualosa ilisha*)	Present study; Azam et al., 2014
		600 to 800	10 to 14	1.1-1.77	30-50	5-15	Hilsha, Poa, Taposhi	Sultana et al., 2016
		650-700	10-12	1.57-1.77	300-400	120-150	Mainly Hilsa (*Tenualosa ilisha*) and Poa (*Otolithoides pama*)	Siddiq et al., 2013
Bata Jal	Rectangular	6.5-33	1.25-2	1.5-2 and 0.2-0.5	50-70	0.1-10	Bata fish (Mugil Sp.)	Present study; Azam et al., 2014
		6.5-33	1.25-2	0.98-1.97	50	4-10	Bata (*Labeo bata*), Chewa (*Odontambylopus rubicundus*), Poa (*Otolithoides pama*)	Siddiq et al., 2013
		20	1	1				In Chittagong (Ahmed, 1961)
		30	1.37	0.5				In Khulna (Ahmed, 1961)
		100	0.61	0.5				In Noakhali (Ahmed, 1961)
Coral Jal	Rectangular	60-70	150-200	7			20-150	Present study
		150-200	10-15	1.97-3.12	50-100	4-7	Coral, Ayre, Pangus	Sultana et al., 2016
Poa Jal	Rectangular	60-70	3.6-4.5	1.38	5-100		Hilsa (*Tenualosa ilisha*), Poa (*Otolithoides pama*), Bata (*Labeo bata*)	Siddiq et al., 2013
		600-700	3.5-4.5	0.69-1.38	20-30	5-10	Poa (*Otolithoides pama*), Taposhi (*Polynemus paradiseus*), Hilsa (*Tenualosa ilisha*), Faisha (*Setipinna phasa*)	Sultana et al., 2016
		200 feet	3.66-4.57	0.5			Poa, Faisha (*Engraulis sp*), Silond, Pungus	Ahmed, 1961
				3.5-4	100-200			Azam et al., 2014
				1.18-1.97	11	12	*Otolithoides pama, Setipinna phasa, Thryssa purava, Labeo bata*	Rahman et al., 2017
Ghongra Jal	Rectangular			10-15	100-200			Azam et al., 2014
Ilish Jal	Rectangular	35-40	12-150	4-6.5	300-400			Present study
		1250-2500	10-25	3-3.5	250-300			Rashed et al., 2016
Lata Jal	Rectangular			0.5-1	50-100			Azam et al., 2014
Duba Jal	Rectangular	100-150	15-20	5-6				Islam, 2002

Table 3. Characteristics of set bag nets, barrier net, seine net, and bottom long line.

Gear Name	Shape	Dimension		Mesh Size (inch)	Construction Cost (in thousand BDT)	CPUE (kg)	Major fish caught	Reference
		Length (m)	Width (m)					
ESBN/Behundi Jal	Conical	45-55	16-20	2-2.5 and 0.2-0.5	200-230	4-300	All types of small fishes	Present study; Azam et al., 2014
		12-15	11-12	1.97-2.46 and 0.2-0.5	40-50	8-15		Sultana et al., 2016
		15.24-60.96	18.29-47.72	0.5-1				Ahmed, 1961
		8.5-41	2-7 mouth opening	Mouth: 5.51-0.79 & cod end: 87-0.2				Islam et al., 1993
		12-15	11-12	1.97-2.46 and 0.19-0.49	200	100-300	Bata (*Labeo bata*), Kuchia (*Monopterus cuchia*), Koral (*Lates calcarifer*), Koi (*Anabas testudineus*), Chewa (*Odontambyoopus rubicundus*), Chiring (*Apocryptes bato*), Bashpata (*Brachypleura novazeelandiae*), Poa (*Otolithoides pama*)	Siddiq et al., 2013
			0.19-0.39	9-27	5		*Otolithoides pama, Labeo bata, Anabas testudineus, Lates calcarifer, Pseudapocryptes elongatus, Macrobrachium sp., Salmostoma bacaila, Gudusia chapra*	Rahman et al., 2017
Marine Set Bag Net (MSBN)	Conical	18-40	10-23 at mouth	0.47-0.98 Cod-end	9-35		Ribbon fish (*Lepturacanthus savala*), Silver Pomfret (*Pampus argenteus*), Bombay Duck (*Harpodon nehereus*), Anchovy (*Setipanna phasa*), Rainbow Shrimp (*Parapenaeopsis sculpitilis*)	Quayum et al., 1993
					60			Akerman, 1986
		20-55	10-14 at mouth	0.60- 1.38 Cod-end				Rahman et al., 2007
		8-40	5-30 at mouth	0.47-0.98 cod-end			Loitya (*Bombay duck*), Chingri (Shrimp), Poa (*Goatee Croaker*)	Rashed, et al., 2016
Set Barrier Net (Char Jal/ Charpata Jal)	Rectangular	150	2.5 (height)	0.3				Nabi et al., 2011
		6-12	3.05-3.66 (height)	0.5-1				Ahmed, 1961
			0.19-0.39	3-4	1		*Anabas testudineus, Sperata aor, Mystus vittatus, Puntius sp., Macrobrachium sp.,*	Rahman et al., 2017
			0.25-0.5	5-10				Azam et al., 2014
Seine Net/ Ber Jal	Rectangular	500-700	9-12	0.0-0.2	40-60			Sultana et al., 2016
		50-200	5-6	0.19-0.91	200-300		Pangas (*Pangasius pangasius*), Poa (*Otolithoides pama*) and Hilsa (*Tenualosa ilisha*)	Siddiq et al., 2013
			0.5-1	22	12		*Gudusia chapra, Taenioides cirratus, Macrobrachium sp.,Puntius sp., Xenentodon cancila*	Rahman et al., 2017
Bottom Longline	Longline				4	99 kg of croaker; 76 kg of other fish	Silverpennah Croaker (*Pennahia argentata*), Belanger's Croaker (*Johnius belangerii*), Spotted Croaker (*Protonibea diacanthus*), Pama Croaker (*Otolithoides pama*)	Huq et al., 1993

Table 4. Characteristics of trammel net, cast net, push net, moshari jal, moi jal, bagdhara jal, khara jal, and atto jal.

Gear Name	Shape	Dimension		Mesh Size (inch)	Construction Cost (in thousand BDT)	CPUE (kg)	Major fish caught	Reference
		Length (m)	Width (m)					
Trammel Net	Rectangular	28	Height of outer panel 1.8 m, inner panel 2.25 m	outer panels (5.91-10.43) inner panel (1.57-1.77)	1-1.2		Tiger Shrimp (*P. monodon*), Indian White Shrimp (*P. indicus*), Brown Shrimp (*M. monoceros*), Catfish (*Ariius spp.*), Bombay Duck (*H. nehereus*), Sardine, Bigeye Shad (*I. filigera*), Smooth mouth Herring (*R. russeltana*), Anchovy (*Thryssa spp.*), Hairfin Anchovy (*Setipinna spp.*), Hairtail or Ribbonfish (*L. savala*), Whiting (Sillago) Grunts (*Pomadsys spp.*)	Islam and Khan, 1993
Cast Net/ *Jhaki Jal*	Conical	3.7-6	6.1-12.2 m (mouth diameter)	0.5-3				Ahmed, 1961
		4-8	6 to 10 m (mouth diameter)	0.2-0.6	3-4 & 5-10	1-2	Bata (*Labeo bata*), Taposhi (*Polynemus paradiseus*), Baim (*Mastacembelus armetus*), Koi (*Anabas testudineus*), Poa (*Otolithoides pama*) and Prawn	Sultana et al., 2016
		3-6	6-12	0.625-1.25	5-10	1-5	Bata (*Labeo bata*), Chela (*Salmostoma baciala*), Taposhi (*Polynemus paradiseus*), Baim (*Mastacembelus armetus*), Koi (*Anabas testudineus*), Koral (*Lates calcarifer*), Kuchia (*Monopterus cuchia*) and Prawn	Siddiq et al., 2013
Push Net/ *Thela Jal*	Triangular	Arms is 2-3 m & front is 1-1.5 m	0.08-0.39	0.2-1			Gulsha (*Mystus cavasius*), Koi (*Anabas testudineus*), Chewa (*Odontambyoopus rubicundus*), Bashpata (*Brachypleura novazeelandiae*) and Prawn	Siddiq et al., 2013
			0.1-0.2	5-6				Azam et al., 2014
			0.19-0.39	0.5	1		*Macrobrachium sp., Colisa fasciata, Chanda nama*	Rahman et al., 2017
			0.02-0.39	0.4-0.5	0.5-1.5		Gulsha (*Mystus cavasius*), Koi (*Anabas testudineus*), Chewa (*Odontambyoopus rubicundus*), Poa (*Otolithoides pama*) and Prawn	Sultana et al., 2016
Moshari Jal	Triangular	8-10	3-4	0.1-0.5	0.5-2	8-20		Present study
Moi Jal/ Moia Jal	Rectangular	2-3	1-2	0.02-0.39	1-1.5	1-2	Mainly Prawn	Sultana et al., 2016
		2-3	1.2-2.2	0.79-1.97	1-1.2	5-20		Siddiq et al., 2013
		3.05	1.83	¼ inch				Ahmed, 1961
			0.19	1	3		*Macrobrachium sp.,Taenioides cirratus, Puntius sp., Gudusia chapra, Pseudapocryptes elongates*	Rahman et al., 2017
Bagdhara Jal	Triangular		0.1-0.5	2-3				Azam et al., 2014
Khara Jal	Triangular		0.1-0.2	10-12				Azam et al., 2014
		5-7	2.5-3.5	0.19-0.79	10-20	1-5	Ketchki (*Corica soborna*), Bele (*Glossogobius giuris*), Shoal (*Channa striatus*), Taki (*Channa punctatus*), Punti (*Puntius spp.*), Koi (*Anabas testudineus*), Pangus (*Pangasius pangasius*), Poa (*Otolithoides pama*), Tengra (*Mystus vittatus*) and Prawn	Siddiq et al., 2013
Atto Jal	Triangular	Arms is 2-3 m front is 1-1.5 m	0.2-1.0				Mainly Prawn	Present study

Entangling nets

These are particular types of nets constructed to catch fish mainly through entangling, unlike gilling in the gillnets. Although both can happen in the same fishing gear, sometimes gilling and entangling are different in their principle (Gabriel et al., 2005). Entangling nets could be single-walled, similar to gillnets, or triple-walled. Among the different entangling nets, the triple-walled trammel net locally called '*Teen Porolla Jal*' or '*Teen Polla Jal*' or *Pondora Jal*' or '*Tong Jal*' is being used in the coastal waters of Bangladesh. The trammel net was introduced to Bangladesh in late 1982 and operated mainly in the Teknaf, Moheskhali, and Cox's Bazar areas (Islam and Khan, 1993). The trammel net has three panels of nets attached to the same head and ground ropes. The interior wall is a smaller mesh of loose netting that hangs with a considerable slack between two wide, mesh outer walls. When a fish swims through the large outer mesh it encounters, it pushes the loose interior net, forming a pocket or bag around the fish in which it becomes entangled. The large mesh of the two outer walls must be kept exactly opposite to each other so that the pocket will not be prevented from developing to make it more successful (Gabriel et al., 2005). This net is usually operated in the shallow coastal areas (around 8-20 m depth) of Bangladesh for catching mostly shrimp and demersal fishes.

Fixed purse nets or set bag nets (SBN)

Fixed purse nets or set bag nets (SBN) are purses or bag-shaped nets that operate in water in motion. These nets are mainly of two types: estuarine set bag nets (ESBN) and marine set bag nets (MSBN). The ESBN, locally called *Behundi Jal* (Figure 2a), is a type of fixed purse or bag net with a rectangular mouth that tapers at the end, resembling a trawl net (Islam et al., 1993). It is the popular SBN used in Bangladesh. The net comprises of four panels, and the mesh size decreases from the mouth to the cod-end. Different sized-ESBNs are being used in different regions of Bangladesh (Islam et al., 1993). This net is usually found to be operated near the coast and fore-shores. The net is set in the tidal stream, against the current, by attaching the extended sides of the net (wings) to hold fasts using long bamboo poles or hollow drums and steel wires, keeping the net parallel to the direction of the tidal current (Islam et al., 1993). The set bag nets catch those species of fish that drift with the current or do not swim fast enough to stem the current and, thus, maintain a fixed position in the seabed (Kashem & Ikbal, 1985). The catches, especially in the ESBN, are mostly juveniles and young fish in small size ranges (Islam et al., 2004; Parvez & Nabi, 2015). ESBN is mostly operated by the poor segments of the coastal fisherfolk, which mainly involve juvenile fishing (Khan et al., 1994). MSBN is a fixed purse net operated in marine water. The structure, shape, and method of operation of MSBN are almost similar to ESBN. MSBN is generally more prominent than ESBN and usually operates in 10-30 m depth of water in areas with a salinity of 20-30 ppt (Quayum et al., 1993). MSBN is operated during the winter season. Fishing activities are suspended during the summer season because of the difficulty in operating the gear due to monsoon weather conditions (Quayum et al., 1993).

Seine net

These nets encircle water stretches for capturing fish by manipulating the head and round ropes (Ahmed, 1961). The common names of the seine nets are *Ber Jal* or *Tana Ber Jal*. Seine nets are rectangular in shape with a small mesh-sized net. The length, depth, and meshes vary depending on the place of operation and the target fish (Ahmed, 1961). The operation of *Ber Jal* requires the collective effort and hard work of a group of fishers. After surrounding the part of a water body, the two ends of the net are drawn together, and the ground rope is hauled up from the center of the water body to collect the fish. As it has a very fine mesh size, this gear catches fish irrespective of their size or species and threatens aquatic biodiversity (Mia et al., 2018).

Set barrier net

Set barrier net is made of net fencing along the shore in the intertidal zone supported by fixing the net with bamboo or wooden poles at suitable intervals. The net is widely used in Cox's Bazar region, called *Char Jal* or *Char Ghera Jal* (Figure 2k, 2l). The lower edge of the net is always kept fixed and fastened with the poles in the ground. At low tide, the upper part is kept lying on the ground. Fishers lift the upper edge over the water level and fasten it at the upper end of the pole, creating a barrier after about 2-2.5 hours of high tide. Those fish that come inside the fence with the water flow during flood tide are trapped and collected during the next low tide. A variation of the net is used in Khulna and Barisal region, known as *Charpata Jal*.

Cast net

Cast net, locally called Jhaki *Jal*, is conical in outline, and the lower edges form pockets. One fisher operates the net by throwing it in water and hauling it without waiting for a long period. It is a very common gear found all over Bangladesh (Ahmed, 1961).

Framed or dip net

Push Net/*Thela Jal* is a triangular shape net locally known as Thela Jal. This net is made by attaching the net to a triangular frame made of bamboo pieces, and one of the bamboo pieces is kept longer to use as a handle during operation. One person can operate this net while walking in shallow water and pushing the net along the shore. Push nets are primarily used for wild shrimp post larvae (PL) collection. More than 60 percent of the total collection of shrimp seeds comes from push net operations (BOBP, 1992; Islam, 2003). Some other fishing gears are also used for PL collections like *Moshari Jal* (Figure 3d and Figure 2e), Bagdhara *Jal*, and Push Net/Thela *Jal*. The *Atto Jal* (Figure 2f, 2g) is a variation of a push net that is triangular in the Hatiya region of Noakhali. *Khara Jal* is a triangular framed or dip net. Two pieces of bamboo are attached at an angle of 35^{o} to make the triangular shape, and a bamboo frame stage is built for staying, pulling, and collecting the net from the water body. The triangular portion of the net is lowered to the shallow water areas, the lower part of the netblock passes the way of fish, and the fishes are trapped (Siddiq et al., 2013). *Moi Jal*/Moia *Jal* is a small fishing gear. Two pieces of bamboo are attached to the two shorter sides of the net, and two fishers drag the net by holding the bamboo vertically (Ahmed, 1961). Usually, it is operated from a boat by using a long rope.

Bottom longlines

In Bangladesh, the bottom longlines were introduced for croakers with the encouragement of some overseas buyers during the mid-1970s in the Cox's Bazar area (Huq et al., 1993). The line is shot at the beginning of high tide or ebb tide, and it is hauled in two hours after setting, and hauling in takes about two hours. The bait used is cuttlefish, anchovy, Big Eye Shad, croaker, Ribbonfish, and Queenfish- cut in pieces in the case of the larger fish varieties (Huq et al., 1993). The hooks are baited while sailing to the fishing ground and are arranged serially on a plank at the bow of the craft with the coils of lines placed on the deck. Longlines mostly target highly-priced species. Fishing season with bottom longline extends from mid-August to mid-February, and fishing is done only during the neap tide period. The bottom longline for croaker is conducted in areas south of Chittagong, Noakhali, and Patuakhali and southwest of Cox's Bazar, roughly with 10 and 30 m depth contours (Huq et al., 1993).

Conclusion

Every fishery has its unique sorts of crafts and gears concerning the fishing area, the target resources, and the socioeconomic condition of the fishers themselves. The fisherfolks use a wide variety of fishing crafts and gears for fishing practices. Most of these have remained the same for centuries. Especially fishers who maintain a subsistence economy still resort to their primitive and traditional fishing crafts and nets. In contrast, some crafts and gears were also found to be modified throughout time in response to the changing target fish, climatic and environmental, and socioeconomic conditions. Fishers choose types of crafts and gears based on the area, scale and mode of operation, target species, suitability, availability, price of the construction material, and the applicable regulative and legislative issues. The selection and adoption of specific fishing gear and methods also vary according to the species' behaviour and fishers' motives for fishing: for-profit, food, and recreation. Additionally, fishers also change devices in response to the availability of fish and market competition. However, nowadays, a trend towards the mechanization or modernization of fishing gears and crafts is on the rise among the coastal fishing community of Bangladesh as a means to increase their catch and maximize the benefits. Monitoring the current status, changes, and modification of fishing devices over time, along with the reasons behind the choice and mode of adoption, would be very important to understand and manage the artisanal coastal fisheries of Bangladesh.

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8. Mangrove Matters: A Portrait of Livelihoods Relying on the Sundarbans Fisheries, Bangladesh

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Cast net fishing in a tributary of the Sundarbans mangrove forest (Photo: Sanzib Kumar Barman, 2021).

This chapter focuses on the Sundarbans fisheries and explores the livelihoods of resource users. The Sundarbans fisheries are based on the inshore and offshore capture fisheries, primarily relying on the commercially important finfish, shellfish, crustaceans, and other molluscs, etc. The fisheries resources of the Sundarbans support emergency food provision and provide alternative job opportunities for non-fishing resource users, especially after a disaster. However, this unique fisheries ecosystem faces serious, multifaceted threats and stressors caused by overexploitation, illegal fishing practices, and natural disasters. Thus, the livelihood security of the resource users will continue to be negatively affected now and in the near future. By considering the ecological and economic value of the Sundarbans, this chapter calls for the critical attention of policymakers to urgently adjust the Sundarbans fisheries management in light of new information and scientific approach.

Introduction

Mangroves are salt-tolerant swamp forests that originate in sheltered estuaries and riverbanks, and lagoons. They occur worldwide in tropical and subtropical countries. They are well-known for their distinct floral and faunal diversity, protection and preservation of coastal habitat, and the potential contribution to the national economy by providing a range of ecosystem services to millions of people. The Sundarbans is the world's largest mangroves forest, located in Ganges-Brahmaputra-Meghna (GBM) estuary, straddled between Bangladesh and India. It covers about 10,000 km^2, 6,017 km^2 of which contributes to a unique ecosystem in Bangladesh territory (Malik et al., 2017). The Sundarbans mangrove forest (SMF) occupies 4.2 percent of the total area of Bangladesh and constitutes 44 percent of the forest cover in the country. It is situated in the ancient delta of the Ganges River in the southwest coastal part of Bangladesh and stretches across districts of Satkhira, Khulna, and Bagerhat. The entire Sundarbans was declared a Reserve Forest in 1869 and is often considered to be the first scientifically-managed mangrove ecosystem globally. Given its global significance, the Sundarbans was declared a Ramsar site in 1992, and UNESCO has enlisted three of the wildlife sanctuaries in this forest as World Heritage Sites in 1997 (Uddin et al., 2013). Rural communities living within a 20 km-wide zone outside the forest boundary largely depend on the forest for their livelihoods and survival. It is also noteworthy that SMF directly provides four basic ecosystem services, including provisioning (benefits that people obtain directly, e.g., timber and food products such as fish), cultural services (non-material benefits, e.g., mangrove tourism), regulatory services (benefits obtained from the regulation of ecosystem processes, e.g., carbon sequestration and protection from cyclones) and supporting services (services necessary for the production of all other ecosystem services, such as nutrient recycling). However, many stakeholders are unaware of the actual value of mangroves, and even when they are, valuing goods and services provided by mangroves is a challenging exercise. Thus, understanding the importance of mangrove ecosystems and their services becomes increasingly important for policy and decision-making (Vo et al., 2015).

Fisheries ecosystem services, status, and exploitation

The ecosystem of the Sundarbans supports the habitat of many fish species that migrate here to spawn, find shelter against predators, or find food during the entirety or part of their lives. The mangrove ecosystems of the Sundarbans support as many as 678 aquatic species, including 210 species of fish, about 40 species of shrimps, 59 species of reptiles, 8 amphibians, 16 molluscs, and 11 cetaceans. which constitute about 35 percent of the total faunal species of Bangladesh (Aziz and Paul, 2015). Studies of Hussain & Acharya (1994) and Islam & Haque (2004) have revealed diadromous fish species such as *Pangasius pangasius, Lates calcarifer, Hilsa ilisha* are abundant in the lower saltwater zone. On the other hand, some species such as *Hilsa ilisha, Pomadasys hasta, Coilia spp., Polynemus spp., Johnius spp.* are dominant in the moderate saltwater zone. In addition, the highly saline zones are likely to shelter some species, especially *Trichiurus savala, Harpodon nehereus, Setipinna spp., Sardinella spp., Pampus spp., and Salar spp.*

The Sundarbans mangrove is also considered as the nursery ground of some commercially and ecologically important crab (e.g., mangrove mud crab (*Scylla olivacea*) and shrimp species (e.g., the giant river prawn (*Macrobrachium rosenbergii*)). Besides commercial fishing, the shrimp fry collection from mangrove estuaries and nearshore waters of the Bay of Bengal have been considered another important fishing activity for the last twenty years. The peak season of the shrimp fry collection is from mid-February to mid-March. Moreover, the local fishers also collect edible species of oysters, mussels, gastropods, and cockles used widely for local consumption. However, the fisheries resources will become overexploited in the near future due to the extensive use of destructive fishing gears (such as set bag net or locally called '*behundi jal*,' *ilisha jal* or hilsa gill net, etc.) and methods (use of destructive poisons for fishing) within the forest. Because of the existing fishing practices, the status of a number of fish species in the SMF is already threatened (see Table 1). The detailed exploitation scenario of some commercially important fisheries resources is presented in Table 2.

Table 1: The threat status of major fishery resources of the SMF (Source: IUCN, 2000).

Family	Species	Status	Global Status
Ambassidae	*Pseudambassis baculis*	VU	-
	Pseudambassis ranga	VU	-
Anguillidae	*Anguilla bengalensis*	VU	-
Carcharhindae	*Carcharhinus limbatus*	-	VU
	Glyphis ganeticus	-	CR
Eleotridae	*Butis butis*	NO	LR
Plotosidae	*Plotosus canius*	VU	-
Pristidae	*Pristis microdon*	-	EN
Scatophagidae	*Scatophagus argus*	EN	-
Schilbeidae	*Pangasius pangasius*	CR	-
	Silonia silondia	EN	-
Syngnathidae	*Hippocampus kuda*	-	VU
	Microphis deocata	EN	-

CR= critically endangered; EN= endangered; LR= lower risk; NO= not threatened; VU= vulnerable

The capture fisheries of the forest are largely divided into inshore and offshore fisheries. Inshore fishery occurs mainly in comparatively shallow waters (between 2-8m) and relies on non-mechanized small boats. About one-third of yearly fish production in the mangrove areas comes from the inshore fishery. Offshore fishing includes fishing in estuarine and coastal waters using mechanized boats. On average, about ten metric tons (MT) of fish are harvested every day from the Sundarbans, in addition to the collection of crabs and molluscs (Aziz & Paul, 2015). The commonly available mud crab (*Scylla olivacea*) fishery of SMF is under high fishing pressure and has been considered as overexploited in recent years. However, the exploitation status of the giant river prawn (*Macrobrachium rosenbergii*) is unknown, although the juveniles are facing heavy harvesting pressure.

Table 2: Exploitation status of important fishery resources of SMF (Chantarasri, 1994)

Species	Yield (tons)	Exploitation rate	MSY (tons)	Remarks
Tenualosa ilisha	762	0.41	523	Over exploited
Lates calcarifer	150	0.35	160	Fully exploited
Pomadasys hasta	232	0.40	457	Optimum
Johnius argentus	548	0.47	593	Optimum
Pangasius pangasius	135	0.42	92	Over exploited
Plotossus canius	141	0.36	92	Over exploited
Macrobrachium rosenbergii	274	0.30	711	Optimum
Penaeus monodon	180	-	226	Optimum
Scylla olivacea	375	-	283	Over exploited
Oyster	3,000	-	6,000	Under exploited
Gastropod	35	-	113	Under exploited
P. monodon fry	1,453 million	-	672 million	Over exploited

MSY= maximum sustainable yield

Mangrove-associated livelihoods

Inshore, estuarine and coastal fisheries of Sundarbans provide a major source of livelihood for about 200,000 fishers who operate daily in the Sundarbans water. Additionally, many people from other parts of the coast, mainly from the Chittagong region, travel to the Sundarbans' coastal islands each winter to engage in fish drying activities. A high level of poverty characterizes the livelihood characteristics of the Sundarbans resource users. Unique livelihoods of the small-scale fishers of the Sundarbans are associated with dynamic fishing and fishing-related businesses, for example, fish trading, processing, and transportation of fish fry. The income for small-scale fishers is not consistent year-round. The SMF offers alternative income opportunities during the scarcity or low income, such as fish fry collection, crab fry collection, harvesting *Nipa frutican* leaves, fuel wood collection, boat and net making, and day labouring fish farms.

Springtide and neap tide cycles characterize fishing operations in the SMF, indicating a peak week (*goon*) and lean week (*bhati*) of good and poor harvest, respectively. As a result, fishing takes place in a restricted capacity during these lean months, as most fishers do not go out for fishing at that time. Fishing mainly takes place in the tributaries and narrow canals of the Sundarbans. Fishers work together as a team which helps them to fish safely and protect themselves from tiger attacks. Generally, each team consists of three people, and each has a different role. One person operates the net, one operates the boat, and one is on the lookout for the tiger's movement. Women and children work individually to collect shrimp fry. Most fishers go out once every day for 3-4 hours, depending on the tide. The shrimp and prawn Post Larvae (PL) collectors fish twice daily.

The marketing system of the SMF capture fisheries varies depending on the harvested fish species. Generally, fishers tend to sell their catch to the suppliers at the local market. However, they often sell their harvested catch to distant markets to get a better price, using mini trucks, taxis, microbuses, and local buses/vans for transportation. Different aluminum containers are used for transportation, which contains about 10 to 20 liters of water. In addition, different oxygenated bags are used for transportation of PL, which generally goes through a number of middlemen before it reaches prawn farmers. The middleman usually transports these oxygenated bags to the local company or local farms. Some groups of fishers will catch fish for 5-7 days or more during a single trip. They keep their harvested catch on ice in a wooded box and transfer them directly to the local traders (locally called *Foria*). Fishers keep the harvested Golda (prawn) in a hand-made '*habor*' (locally made of bamboo, 60 cm in length), tied to the boat. The harvested onboard prawns and finfishes are graded and sorted according to their size and species (Ahmed et al., 2010).

The fishing households in the Sundarbans areas are mainly male-dominated. The majority of the fishers are middle-aged (30 to 40 years). The size of the average household is around five to six people. There is a common saying that a larger family has more people to extract natural resources from the Sundarbans than a smaller one. There is indeed a trend of having larger families in which children contribute to the family's livelihood by collecting shrimp and crab fry with a push net (Islam & Chuenpagdee, 2013). This concept also clarifies that it is preferable to work with family rather than starve. Also, the illiteracy problem is severe in the small-scale fishing community because there are no schools in most fishing villages; even the nearby schools are unreachable due to long distances, poor road infrastructure, as well as communication and transportation systems.

Mangrove fisheries: The last resort?

The Sundarbans mangrove forest provides suitable feeding, breeding, and nursery grounds for about 90 percent of the commercial fishes and 35 percent of all fish in the Bay of Bengal. The Sundarbans also provide continuous employment opportunities, especially in fisheries such as fish, prawns, shrimp, crab, molluscs, and other crustaceans. However, many fishers have switched from harvesting fish to harvesting crab in recent years due to a significant reduction in fish catch. Additionally, the conversion of paddy fields into aquaculture ponds and the expansion of shrimp farms are important factors that have resulted in more people entering fisheries, adding extra pressure to the system.

The fisheries resources of SMF also provide emergency food support for the communities during massive natural disasters, for example, cyclone *Aila* in 2009. This unexpected event has put many people on the road by cutting off their main source of income. Studies have shown that after cyclone Aila, about 80 percent of workers lost their jobs, and 40 percent were bound to change their profession. In turn, many people who previously didn't fish became involved in fishing activities, such as fish harvesting, crab harvesting, and PL collection, which reflects a local proverb that says: "*Nirdhon- jao bon;*

No assets - then go to the forest" (Islam & Chuenpagdee, 2013).

Multifaceted threats and stressors

The Sundarbans provide a range of ecosystem services to the local populations, but it still faces many threats. Many natural and anthropogenic drivers affect the SMF, including conversion for aquaculture, agriculture and plantations, infrastructure development, pollution, overexploitation, and climate change. These combined and interlinked threats to mangroves are on the rise, while at the same time, the dependence on mangrove goods and services is growing with the increased population in the impact zone. Consequently, the Sundarbans fisheries in the nearshore areas are facing intense pressure that is believed to overexploit the resources. It is also alarming that *Hilsa ilisha*, *Lates calcarifer*, *Pangasius pangasius*, *Plotossus canius*, and *Scylla olivacea* are commercially important fishery species considered to be overexploited (Rouf & Jensen, 2001). Because of the lack of labour-intensive agriculture and widespread poverty, everyone is more reliant on Sundarbans fisheries, resulting in overexploitation of these resources. Fine-meshed set bag nets and mosquito nets for extensive shrimp fry collection are particularly to blame for the colossal damage to biodiversity.

Rampant corruption in the management system of the Sundarbans is another driver of overexploitation. For example, forest-goers have to pay a certain fee for obtaining permits to collect forest products in the SMF. This management rule allegedly involves corruption. In addition, it is alleged that resource extractors of the Sundarbans (including fishers) have to spend approximately USD 28, 400 per year as bribes for conducting resource extraction activities in the forest (Khuda, 2008). In contrast, they often face kidnapping by pirates in the SMF. To recover these additional expenses, harvester usually resorts to illegal activities such as illegal logging, creating a vicious circle of overexploitation and corruption and negatively affecting the long-term sustainability of the Sundarbans ecosystem services.

Coastal development activities are another crucial threat to the Sundarbans mangrove forest, significantly impacting coastal fishers' livelihoods. The proposed coal-fired power plant at Rampal is another potential threat to the forest habitat as it will release approximately 8 million tons of CO_2, 0.75 million tons of fly ash, and 0.2 million tons of bottom ash annually to the Sundarbans wetlands ecosystem (Aziz and Paul, 2015). Development activities may cause leaching of oil and accidental oil spills. On December 9, 2014, a tanker carrying 75,000 gallons (3,57,664 litres) of oil sank in the Shela River of the Sundarbans (Aziz & Paul, 2015). The oil had spread at least 20 km upstream and 20 km downstream within a single day. The oil is mostly deposited on the soil, plants leaves, roots, pneumatophores, stems, and floating fruits. Consequently, this poses a serious threat to the biodiversity of flora and fauna in SMF. Additionally, the unplanned, eco-unfriendly tourism, the establishment of embankments (such as the Farakka barrage in India), dikes, and polders have negatively affected the Sundarbans ecosystems by drastically reducing the freshwater flow and increasing siltation along the riversides. Additionally, the high-elevation Himalayan glaciers, which provide up to half of the dry-season flow for the Ganges and the Brahmaputra Rivers, are thinning and threatening freshwater supply to the region. The dominant species of Sundari (*Heritiera fomes*) and Goran (*Cariops decandra*) are affected by the top-dying disease. These factors trigger the shifting of fish habitats, thus changing breeding and catch compositions, directly affecting the fishers' livelihoods by reducing fish catch (Inman, 2009; Islam et al., 2018; Islam et al., 2020).

Cyclonic storms and other natural events such as floods, tidal surges, and erosion affect the Sundarbans by uprooting plants, damaging branches and stems, and eroding soils. These natural disasters also affect human settlements. At least 70 major cyclones hit the coastal region of Bangladesh over the past two centuries. For instance, about 36 percent of the mangrove area was severely damaged by cyclone Sidr in 2007. Moreover, climate change-related risk is set to increase for the Sundarbans; with a one-meter rise in sea level, the Sundarbans are likely to disappear. Fishers of the Sundarbans are also facing severe health problems, such as skin diseases, gynecological problems in women and young girls, and mosquito bites in the forest due to adverse working conditions, with severe repercussions for their mental health. In addition, the unfortunate death of harvesters, as in the case of fishers attacked by tigers in the Sundarbans, is another significant threat for fishers.

Conclusion

The Sundarbans mangrove forest is a unique ecosystem of global importance. For a long time, this ecosystem has been providing humans with a wide array of ecological and economic values. Its associated ecosystem services, especially the mangrove fisheries, are crucial for fishers' livelihoods through income generation and food security. In addition, considering other forest resources, mangroves provide significant alternative economic values that indirectly diversify the livelihoods of local people. However, services from this largest mangrove forest are steadily decreasing due to various man-made and natural threats. As a result, the livelihoods of poor fishers and their families are impoverished and exposed to different hazards, making their life more vulnerable and daunting. This chapter calls for the critical attention of policymakers to urgently adjust the Sundarbans fisheries management in light of new information and scientific approach. A healthy Sundarbans ecosystem will not only meet the economic needs of Bangladesh by providing sustainable fisheries resources but will also provide potential, much-needed protection from natural disasters.

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9. Fishing Labour and Working Conditions in Small-Scale Fisheries of Bangladesh

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Fishing labourers at the southeast coast of Bangladesh organizing fishing gears (Photo: Muhammad Hasan Jamil Sakib, 2019).

The fishery sector of Bangladesh employs 9 percent of the country's workforce, with over 17 million people, 1.4 million of whom are women. Labourers perform a variety of jobs: they work as fishing crew members, boat skippers, dry fish processing workers, shrimp and fry collectors, etc. Because of technological advancements, capital intensification, and integration with distant markets, fishing activity has increased rapidly and so has the number of fishing labourers. The worker is hired at a predetermined wage rate by the boat owner or majhi. In the dry fish industry, two separate groups of labour (i.e., kuliya and dhulabanga) are recruited under different conditions. Besides, many children contribute to the fishing industry where they represent cheap labour. These labourers, including the children, work in very precarious workplace environments, both on land and on the sea. On land, in the dry fish processing area, they often get exposed to harmful pesticides on the sea, they spend long periods of time in rough weather. There are no formal job agreements nor any insurance coverage. Small-scale fishers and labourers in the processing industry have little to no right to bargain or to set their wages and working hours. Some of these conditions could be described as a modern-day slavery. The government should take steps to protect the rights of workers, monitor the child labour and reduce the gender wage gap in the small-scale coastal fishery of Bangladesh.

Introduction

The fishing industry of Bangladesh employs 9 percent of the country's total workforce, represented by more than 17 million people who directly or indirectly work in fisheries. This includes approximately 1.4 million women who rely entirely on fisheries for a living through open-water fishing, culture fisheries, handling, and further processing activities (BFTI, 2016; Islam, 2018). This workforce is expanding by 3.5 percent every year. Small-scale fishing often serves as an 'activity of last resort' for poor people in the aftermath of a natural disaster such as a cyclone or riverbank erosion once the source of income is lost (Islam, 2018). In the moments of crisis like, for example, in cyclones, coastal people find fishing a viable option to earn their livelihoods. They become involved in multiple fisheries-related activities, including fish farming, harvesting, handling and processing, and marketing-related activities.

Coastal and marine fishing accounts for 38.9 percent of all fishing labour, followed by 25.1 percent in fish marketing, 19.1 percent in processing, 9.8 percent in fishing in the Sundarbans, and 7.1 percent in fish farming (BBS-ILO, 2011). Notably, women account for 94.6 percent of the fish processing and marketing workforce (BILS, 2015). As a single, most important fishery, the hilsa shad fishery employs the greatest number of fishing labour: approximately 1 million fishers rely directly on hilsa fishery for a living, while another 3 million people rely on hilsa indirectly through trade, transport, marketing, and processing (Islam et al., 2016). In the fish processing sector, the projected total number of employed people in the fish drying industry is about 54,980. Of these, 7,719 (14 percent) are children, and 26.1 percent are female (BBS-ILO, 2011).

However, fishing in coastal Bangladesh is not safe due to a lack of safety gear and dismal working conditions. In addition, there are various forms of discrimination in the processing sector. For example, most of those who work in fish drying activities in the Sundarbans consider their situation as 'very bad' or 'hell' (BILS, 2015) that make them socio-economically marginalized. Although fishing labour constitutes a large portion of the working class of Bangladesh, studies about them and their working conditions are limited (BBS-ILO, 2011). Based on a review of scientific articles and grey literature, supplemented by insights from the fieldwork, this study illustrates the situation of fishing labour and working conditions in Bangladesh's small-scale fisheries.

Labour in small-scale fisheries

In Bangladesh, workers in the fishing industry can be classified into four types; (i) Traditional lower caste fishers, (ii) Non-traditional fishers, (iii) *Jalmahal* leaseholders (inland fisheries), trawler or mechanized boat owners (who are not fishers), and (iv) other common people who capture fish for subsistence income (BILS, 2015).

Since 1983–84, the overall marine capture fisheries have been increased from 1.65 lakh MT to 6,599 lakh MT in FY 2018–19 (FRSS, 2018-19). Compared to the last few decades, fishing activities have increased due to technical development, capital intensification, and integration with distant markets. Small-scale fisheries in coastal Bangladesh operate in up to 40 meters depth, covering an area of 55,400 km^2 (USAID, 2016). Small-scale fisheries land nearly all of the marine catch and employ a large number of small-scale fishers. However, the majority of fishers work for others since they can't afford to buy their own boat and fishing gear. About 44 percent of fishers have no fishing boat, while over half of all fishers (65 percent) work as fishing labourers or crew. The people who have boats and fishing gears (locally known as *bohaddar* or *mohajon*) hire small-scale fishers for meagre wages. They are also known as *dadondar* based on their credit support (known as *dadon*) to fishers. Small-scale fishers borrow money from the *dadondar* in advance, especially during the off-season, as a way to meet their family needs. In some cases, small-scale fishers catch fish on a catch-share (profit-share) basis with boat owners.

Along with the fishing activities, around 0.42 million people are involved in collecting shrimp and prawn post-larvae from wild sources, and over 50,000 people, especially women and children, are involved in post-harvest processing activities (USAID, 2006). While the majority of fishers are men, a major workforce in the post-harvest supply chain are women (Nuruzzaman et al., 2014). In the post-harvest drying industry, the men's tasks include washing fresh fish, using pesticides to keep flies away, hanging fish to dry on scaffolding, weighing and packaging dried fish, and loading it onto vehicles for transportation. Women are typically in charge of sorting and grading fish before and after drying and packing them. In addition, thousands of individuals, including men and women, work in fishing gear manufacturing and maintenance.

Recruitment practices

The boat skippers and crews are hired depending on fishing intensity, professional skills, and years of expertise. There is no formal agreement and the terms and conditions are verbally agreed between the parties. Workers are employed at a predetermined rate by boat owners or *majhi*. Labour is usually structured according to the 'catch share or catch bonus' scheme rather than wage in the inshore gill net or bag net fishery. In many places, both fishing boat workers and skippers have formed organizations that help resolve any issues arising from disputes with their employers.

During the Hilsa fishing season, migratory fishers, primarily from neighbouring or inland districts, move towards the coast. People from the inland areas migrate to capture hilsa fish as seasonal workers. Most migrant fishers are not just seasonal fishers or agricultural workers but individuals who have been uprooted or are 'drifting'. In many cases, they move towards the shore during the rainy season due to a lack of income-generating activities in their territory or because they have lose their assets due to river erosion (Islam & Herbeck, 2013). *Bohoddar* frequently recruits migrant fishers due to their bravery, willingness to take risks, and better skill at deep-sea fishing compared to the locals.

Two distinct communities of workers (locally known as *kuliya* and *dhulabanga*) are employed for fish drying activities. *Kuliyas* are primarily recruited by fishing camp administrators as their employers belong to the same fishing communities. This group includes children as young as ten years old. *Bohaddar* decides the number of *Kuliya* they need and offers a specific amount of money in advance to confirm *Kuliyas'* recruitment. *Kuliya* gets a portion of their salary in advance in return for agreeing to work for the whole season. The common ancestry ensures mutual liability.

On the other hand, *dhulabanga* are individuals from outside towns, primarily from the 'floating population,' who are impoverished, landless, jobless, and sometimes homeless. Before each season, *bohadda*r issues instructions for recruiting *dhulabanga* to labour chiefs (*dhulabanga* mahji). *Dhulabanga* mahji recruits some of their own labour, but sometimes they face difficulty hiring the adequate number of workers. In such a situation, they are assisted by brokers (locally called '*dalal*') in recruiting the workers. *Dalal* recruits with promises of well-paid job with decent circumstances, and transports them to fishing villages where they are sold to *dhulabanga* mahji in returns of USD 6-8 per child, which is literally termed as 'vending a kid' (locally called *'puya bikri'*) (Belton et al., 2018). Most children work in the dry fish industry so that their parents can get advance money from their employers. This practice indicates the significant demand for child labour in the dry fish industry (BBS-ILO, 2011).

Employment conditions

In inshore fishing, a boat skipper or *mahji* establishes a team of 10-12 fishers, depending on boat size. The crew members of each fishing trip bear the costs associated with the trip equally. In the case of offshore fishing, labourers receive their pre-agreed wages during the contractual term, regardless if fishery is taking place or not. An offshore fishing fleet typically consists of 18-20 fishers. Half of the earning from each offshore fishing trip is taken by the boat owner, and the rest is equally distributed among the crew members.

A significant number (18.6 percent) of fishing labourers work in the fish processing sector on a daily basis. Among them, 43 percent work on a monthly basis, 25.6 percent on work volume, 9.3 percent on contract and 3.5 percent work under alternative terms (BILS, 2015). However, none of the workers in the harvest and processing sector receive any additional benefits, such as bonuses for festivals or vacation pay.

The patron-client relationships between fishers and moneylenders (*dadondar*) play a significant role in making small-scale fishers bound to the moneylender. Small-scale fishers take credit support from the money lenders during the off-season to fulfill their family needs. Also, they seek monetary support to repair the net and boat. In such situations, *dadondar* provides fishers with the money they need. In return, small-scale fishers become bound to *dadondar* to sell their catches at lower rates than prevailing market prices. This kind of relationship between fishers and money lenders based on credit support is still in practice.

Child labour

Children perform many tasks in the fisheries industry, such as trip preparations, fishing, post-harvest activities (e.g., handling, processing and marketing), boat building, net manufacturing and repairing, among others. In general, boys are more engaged in fishing, whereas girls mostly do post-harvest activities or shrimp fry collection. There have been reports of enslaved children, under 15 years of age, being employed in fisheries-related activities, for example, loading and unloading fish trucks, and operating fixed bag nets in the Sundarbans mangrove forest. Children are frequently forced to work more than eight hours a day in fish processing industries. Child labourers are paid much lower than adult labourers since there is no labour wage regulations. Thus, many fish farms and traders at the fish landing centers take advantage of lower wages by hiring child labour, which is oftentimes coupled with debt bondage and mistreatment. A drying fish yard owners typically assign several child workers (ages 5 to 10) to sort and prepare fish at a rate of Bangladeshi Taka (BDT) 2.00 per kg. On average, a child worker makes BDT 25,000-35,000 per season, while an adult male worker earns BDT 40,000-45,000 per season.

Furthermore, child labours are more vulnerable to workplace-related hazards than adults. They work in enclosed spaces with hazardous materials and often face verbal abuse from their employers. In the fishing industry, child labourers are enslaved on fishing boats, landing centers, fishing platforms at sea, and in the processing industries. Children also work in severe environmental conditions where they may be exposed to extreme temperatures, sounds, or vibrations that are harmful to their health (BILS, 2015).

Working conditions

Small-scale fishers often live and work in dangerous conditions. They are poor and constantly face different hardships that are beyond their control. Inshore fishers go out to sea daily or on a 2-3 day trips. Most often labourers (fishing crew) and skippers work together so they face common constraints. Those in better financial situations, are more likely to evaluate skipper's character before agreeing to work for them. As a result, they can find boat owners they are comfortable with, especially if they are not happy with their current boat owner. Offshore fishery workers usually sail for longer trip so they cannot leave their boats until they reach their targeted catch. The majority of fisheries workers usually do not get notified if they are terminated or laid off. The rest of the workers are aware of the termination notice, although they rarely receive it due to labour shortages. Concepts such as appointment letters and attendance registers are practically unheard of. The majority of the labourers (76.4 percent) are unaware of their fundamental labour rights. Skippers or *mohajon* control workers through their channels, but they do not provide identification cards.

While at sea, the crew members receive four meals per day. Labourers are generally unable to take the vacation time during the fishing season unless they become ill. If any crew members are on leave, boat owners or *mohajon* are under strain to manage fishing due to workforce shortages. During the hilsa fishing season, the boat owner undertakes all liabilities for injured labourers until they heal. Even during a cyclone or storm season, most fishers violate weather forecast warnings and resume fishing in hopes of better catch, which sometimes leads to fatal accidents. The lack of or poor radio network can makes it difficult for fishers to return to shore. Workers rarely use safety gear due to costs and contempt for safety equipment, while only a basic first aid kit is readily available. Approximately 80 percent of fish workers believe they have insufficient safety equipment on board, and 97 percent of fishers believe harbour facilities in Bangladesh's coastal area are not good (The Daily Star, 2021). Additionally, they may face criminal gangs on the sea, Piracy is a real threat to fishers, especially during the hilsa fishing season. Fishers are abducted and held hostage for ransom. They are constantly terrified of being attacked and hijacked of their boats or nets. Surprisingly, the pirated stuff is subsequently sold back to the fishers via brokers or direct contact with the robbers. Fishing in the Sundarbans is equally dangerous since tiger-human confrontations may lead to fishers losing their lives. In addition, they are often forced to pay bribes or rent to officials, which hampers their income.

Furthermore, women and children working in the fish drying yards face a different set of issues. Female workers and adolescent girls receive poor wages compared to men. Sanitation conditions at the workplace are deplorable, with open-pit toilets shared by most workers. They are exposed to weather conditions for a prolonged periods of time and come in constant contact with pesticides. One-fourth of workers drink contaminated water in the workplace. As a result, many serious health problems commonly occur, such as diarrhea, backache, headache, and skin disorders. Labourers who solely process fish receive BDT 20,000-30,000 for a five-month long season. Usually, they spend an average of 10 hours per day in fish drying or processing enclosures. Male labourers work more (16.8 hours) than females (8.2 hours).

Coercion and the lack of freedom

Many small-scale fishers are landless and reside on government property (*khas* land). Those who own their house have hardly any additional land. The few who own a property, own a tiny amount that is sufficient for family settlement but insufficient for generating additional revenue. Access to growth and development efforts is hampered by a lack of infrastructure, distance, and inadequate transportation. Families headed by women that lose an earning family member due to a calamity, illness, or tiger attack are particularly vulnerable to poverty. In the absence of males in the fishing families, females lead the families. Our study found that the families led by females lead are more likely to experience food insecurity. Their livelihoods and coping abilities are hampered by low education, inadequate skills, and low earning potential, forcing them to seek income outside the home. The lack of collateral assets, such as lands, severely limits fishers' access to formal credit systems (i.e., banks). In the absence of formal credit support, small-scale fishers become trapped in informal credit systems by the money lenders.

It is hard for small-scale fishers to return the debt on time due to their low income and high family expenses. Conflicts with the money lenders are thus very common when it comes to returning their debt back. A similar situation is also observed for those who work in boats owned by others boats and have taken advance money. Boat owners are also willing to pay advance in order to ensure enough labour for the season. This prevents workers from absconding and leads to de facto incarceration for the duration of the fishing season. These workers are only allowed to leave once the advance is paid off. However, this is impractical since recruiters may trick them into gambling, drinking, and other vices that thrust them deeper into a debt cycle and forces them back to fishing. Further, migrant workers in the dry fish sector also face discrimination in respect to wages, food, workload, and workplace conditions. In many cases, child labourers get trapped in a job if their parents have taken advances from the company, making it difficult for them to leave that job despite facing numerous difficulties.

Conclusion

Small-scale fishers in Bangladesh are exposed to immense vulnerabilities because of the nature of their work and geographical position. Among them, fishing labourers are likely the most vulnerable due to the disadvantaged labour arrangement in the fishery sector. The awareness of labour rights among fish labourers was found to be extremely low. As the fishing labour constitutes the largest portion of the workforce employed in small-scale fisheries of Bangladesh, the well-being of the fishing labour should be a priority of the fisheries governance. The study recommended the following suggestions. First, steps should be taken to increase awareness among fishing labourers and their employers about occupational health. Second, the government should establish a wage board that implements the minimum wage for fishers and thus promote equal rights and pays for male and female worker. Third, there should be effective monitoring to register the sea-going boats and establish checkpoints to ensure that the boats are well equipped. Fourth, there should be a provision introducing life insurance and fishers' database providing ID cards for all sea-going fishers. Fifth, the government should revise the list of hazardous work to exclude children from hazardous fishing activities. Finally, overall technical education should be emphasized to enhance the employability of people.

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10. Gendered Journey: Exploring Women's Position in Small-Scale Fisheries of Bangladesh

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Women working in a fish drying yard from Nazirartek, Cox's Bazar, Bangladesh (Photo: Sabrina Jannat Mitu, 2019).

Women play an important role in the small-scale fisheries of Bangladesh, yet their contributions remain inadequately recognized and under-reported in both governmental and academic sectors. To date, women's contributions in the country's small-scale fisheries have been poorly studied, thereby available literature offers an incomplete illustration of the precise magnitude and type of participation of women in this sector. This chapter examines women's visible and invisible roles in Bangladesh's small-scale fisheries through literature review. This study illustrates how women in the fishing communities are deeply involved in both household and fisheries-related activities. They oversee a variety of household tasks, including caring for children and family members, preparing and serving food, fetching water, cleaning and maintaining the home, washing dishes and clothing, and raising livestock, to mention but a few. In addition to direct participation in catching fish, they are also actively engaged in a wide range of pre-and post- harvesting activities such as making and repairing net and boat, sorting, washing, grading, processing, packaging, transporting, and marketing. This chapter also explores how fisherwomen help their families cope with crises. Furthermore, the difficulties experienced by fisherwomen and the factors that affect them adversely are also outlined, accompanied by suggestions on how to alleviate these problems, and increase women's productivity in small-scale fisheries.

Introduction

Men are usually considered providers (i.e., hunters and fishers), whereas women are thought of as caregivers who reside at home and care for the family. However, today's women have been actively engaged in the labour force in various industries and thus function as both providers and caregivers, making such assumptions rather obsolete (Harper et al., 2013). Similarly, men's and women's traditional roles in society have contributed to the belief that women play a minor role in the fisheries sector (Koralagama et al., 2017; Herrera-Racionero et al., 2021). However, women are actively involved in many fisheries, taking part in capture, processing, and sale of fish, and they represent 47 percent of the world fishing workforce (World Bank, 2012; Mangubhai & Lawless, 2021). Yet, many of these contributions are often overlooked and underestimated and continue to be under-appreciated in fisheries research, management, and policy formulation (Weeratunge et al., 2010; Harper et al., 2020; Tilley et al., 2021).

As it becomes evident that women are increasingly employed in fishing worldwide, one of the most pressing questions is why is gender-specific data still lacking. A part of the explanation lies in how fishing is defined, i.e., who is considered a 'fisher' and what constitutes 'fishing' (Kleiber et al., 2015; Smith & Basurto, 2019). Traditionally, fishing has been described as catching fish from a vessel using specialized gears, which is done mostly by men. Meanwhile, collecting seafood and small fish from the shore, done mainly by women and children, has rarely been referred to as 'fishing' by male fishers, often falling under the category of 'gathering' and general food provisions (Kleiber et al., 2015; Harper et al., 2017; Smith & Basurto, 2019). The majority of women's work is unpaid, part-time, informal, or viewed as a supplement to their domestic duties, which is also cited as a reason for their ignored contribution (Harper et al., 2017). A biased sampling method for data collection is another important rationale for the omission of women's data on fishing activities. To describe women and men, nearly all the previous study used gender-neutral words like 'fisher' or even gender-specific terms like 'fisherman.' Furthermore, it has been noted in the literature that only data on men is collected, which may be conducted on deliberately or inadvertently employing techniques that restrict participants to only men (Weeratunge et al., 2010).

Bangladeshi rural women are active participants in the small-scale fisheries of the country, but their contributions remain inadequately recognized and under-reported in both governmental and academic sectors (Deb et al., 2015). Women's positions in the functional aspects of small-scale fisheries in Bangladesh are poorly studied. Existing literature provides an incomplete portrait of the precise magnitude and type of women's engagement in small-scale fisheries. The positions of all social groups, including women, must be acknowledged and appreciated for the small-scale fisheries sector to grow in a fair, inclusive, and sustainable manner and for a better understanding of how it operates (Deb et al., 2015; Islam, 2018). This chapter presents an overview of women's role in small-scale fisheries of Bangladesh, based on a review of a large proportion of the literature and data available on female involvement in small-scale fisheries. Additionally, the obstacles encountered by fisherwomen and the factors that negatively affect them are highlighted, along with recommendations for resolving these issues and increasing women's productivity in small-scale fisheries.

Fishing family dynamics and women's roles

Like any other traditional rural community in Bangladesh, women in the fishing community spend a significant amount of time on household-related activities. They usually invest their time in caring for their families and communities rather than engaging in economic activities. Since both the government and the research communities pay little attention to assess the contributions of women in the fishers' households, data on their roles in household activities is scarce. Nevertheless, they are responsible for a range of activities in families, the most important of which involve caring for children and other family members, processing and cooking food, serving meals, and reproductive practices (Deb et al., 2015). Besides, they devote a considerable amount of time in washing dishes and clothing, bathing, fetching water for household use, and collecting water for the cattle. They are also in charge of other duties like cleaning and maintaining home and homestead, gathering firewood, and other biofuels for domestic use. Additionally, they do homestead gardening and livestock rearing, which entails growing a variety of vegetables and fruits and raising chicken, duck, goat, and cow for personal consumption and sometimes for sale at markets (Farid et al., 2009).

Men in fishing community provide most of the financial support for the family as well as manage the heavy workload. On the other hand, women attend to all of the family's concerns and needs, keep and distribute the husband's meager earnings, and control the household budget (Islam, 2011).

Women also take part in a variety of activities to assist their families during crises. Reducing food consumption is the first tactic employed by some fishing households to cope with income crises where women and girls bear the burden (Islam & Herbeck, 2013). For instance, during times of food scarcity in nomadic fishing communities, women and girls are typically given less attention than their male counterparts when it comes to food consumption. As a result, they develop saving habits and make their own spending decisions (Islam, 2018). A common technique used by fisherwomen to smooth consumption is to borrow rice and other daily necessities from their neighbors (Islam & Chuenpagdee, 2013). Women, rather than men, have a reputation for maintaining the savings tradition. They often save money in secret as a form of protection against misfortune. Women supplement their income by growing vegetables and fruits in their yards, for example.

Some women work in fish marketing, while others make and mend nets to help their families. Almost all women and most young girls in fishing families of the Sundarbans area take part in income-generating activities such as collecting shrimp and prawn fry and crab, harvesting Nypa palm (*Nipa fruticans)* leaves, gathering fuelwood, and building a boat (Mozumder et al., 2018). Fisherwomen also work in shrimp farms, weed grass agriculture fields, collect paddy, mend and prepare nets, collect mangrove leaves for fuel, sew traditional quilts, and prepare and sell mangrove wood charcoal (Islam & Chuenpagdee, 2013). Thus, in some cases, women have become the primary source of income for fisher families. Many young girls from fishing families work in ready-made garment factories or the Export Processing Zone in the Chittagong district. As an investment, some women raise poultry and other livestock. This is used to meet daily needs during lean times or tackle unexpected shocks such as sickness and disaster, necessitating additional expenses (Islam, 2011). Another prevalent coping mechanism is to take children out of school; both boys and girls are forced to work in fishing jobs, despite being paid less than adults (Islam & Chuenpagdee, 2013).

Women consider themselves as helpers rather than leaders, and they are willing to put their own needs aside to fulfill their household obligations. When household incomes are insufficient, women obtain informal loans from relatives and neighbors via casual community or family connections. Although banks and other formal credit institutions accept men as borrowers, in many cases women are the ones who make the loans. To satisfy urgent needs, they seek out micro-credit loans from various NGOs. However, since they are predominantly uneducated, they unknowingly take on loans that provide only short-term benefits; they often become highly indebted in the long run when they cannot repay them (Islam, 2011). Some households, however, use microfinance to augment their income from fishing and other sources of income. In addition, women commonly use microcredit to begin a range of income-generating activities, such as purchasing livestock, sewing machines, and procuring goods for the shop. Microfinance is also indispensable for social needs such as improving their quality of life and smoothing consumption patterns, especially during lean and off-seasons when little to no income to buy food is available (Karmakar et al., 2011). Microfinance savings may also help families in developing countries deal with the financial costs associated with major illnesses, such as the cost of medical treatment and loss of income due to sickness (Gertler et al., 2009).

Gendered participation in small-scale fisheries

Women in Bangladesh play many different roles in the fisheries sector, with a significant representation in small-scale fishing. Though there is no recognized definition of small-scale fisheries in Bangladesh, the word 'artisanal' is frequently used to describe small fisheries in scale. Fishing was historically a profession of caste-based Hindus in Bangladesh, and only men in fishing communities were involved in catching fish. However, a growing number of women, regardless of caste, age, or marital status, are now found engaged in the fisheries sector across the country (Ahamed et al., 2012), and full-time engagement of women in fisheries is no longer a rare scenario (Ahmed & Solaiman, 2006).

Women's roles in Bangladeshi fishing communities are primarily related to small-scale fish processing and fresh fish marketing. Elderly or divorced women dominate the fresh fish trade, almost all of whom are members of

Hindu fishing groups (Deb et al., 2015). Before and after fish harvesting, women's involvement has attracted limited consideration culminating in their near-invisibility as contributors to this industry. But the economic and social importance of these pre-and post-production activities is enormous. Fisherwomen are actively involved in pre-and post- fishing processes such as making and repairing net and boat, sorting, cleaning, grading, drying and salting harvested fish (Rabbanee et al., 2012). Women generally contribute to these tasks mainly as family labour. In addition, they also make up the majority of workers in shrimp processing plants in Chittagong and Khulna (Islam, 2011).

Fish drying is an essential activity in the dried fish industry, and it is usually performed by female fishers or wives and children of fishers. Sorting and grading, washing, salting, packing, storage, transportation, and cutting are some of the other activities they perform (Mitu et al., 2021). They also carry out fish and sell as hawkers, stall keepers in permanent marketplaces, and weekly bazaars. In coastal areas, many women work in fish fry collection, transportation, fingerling marketing, and dry fish marketing (Rabbanee et al., 2012). There is also evidence of women mending fishnets and assisting with boat cleaning and maintenance (Islam & Herbeck, 2013). Furthermore, divorced or single women in Hatiya Islands collectively construct nets for local boats. Together with their male counterparts, women are engaged in activities like making fishing nets, gears, repairing or maintaining the gears, sorting of fingerlings, fish processing, transportation, and marketing (Frangoudes & Gerrard, 2019).

Women in Bangladeshi fishing communities are also actively involved in catching fish and seafood. In coastal regions, collecting shrimp and prawn fry and crab is a popular activity carried out primarily by women and children. Women and young girls of Sundarbans mangrove forest are reported to catch post-larvae (PL) of prawn and shrimp and crab (Ahamed et al., 2012). In the Sundarbans, women also enter the forest to catch crab with their family members (Islam & Chuenpagdee, 2013). Children and some women in Noakhali catch prawn/shrimp fry from the river during the spawning season. Women in southwest Bangladesh catch snails and fish from the *bee*l and its interconnected canals and rivers (Sultana et al., 2001). Ahmed et al. (1999) documented tribal women around the Kaptai reservoir are involved in setting up brush shelters (as fish aggregating devices), collecting fry with push nets, harvesting and retailing fresh fish, and sorting, icing, and drying fish. Women can be seen catching a number of small fish in the districts of Barisal and Rajshahi. As a source of protein for their family, they capture fish with hooks, lines, nets, or traps from various sources such as estuary, canals, *beel*, and rivers (Dubey & Kohli, 2001). Besides, coastal areas residents have been actively involved in cultivating various types of fish for commercial purposes in their own ponds or leased ponds within or near their homes (Ahmed et al., 2012). Thus, the role of women in fisheries encompasses social and economic tasks both within and outside the family to sustain the activities of fishing communities (Ahamed et al., 2012).

Men and women go fishing together in nomadic fishing communities, and women are also engaged in selling fish from door to door in some areas (Islam, 2018). Women equally participate in the hard fishing activities, such as paddling the boat to the fishing grounds, hauling nets from the river, and net mending. Both men and women of nomad fishing society have expert knowledge of fish habitats and the connections between fish availability and seasonal changes, winds, currents, tides, and lunar cycles (Islam, 2018). Nomadic fisherwomen usually work the hardest, and crises usually place greater hardship on women than on other family members (Islam & Chuenpagdee, 2018). The majority of nomad men focus primarily on fishing and selling their catch to make a living while the women are in charge of the remaining duties. They do household chores, care for the family, raise children, and so on, in addition to assisting the men in fishing. In essence, it seems that women are responsible for the entire family.

Problems and challenges

While playing a critical role in Bangladesh's fishery sector, women in the fishing community face a variety of challenges, ranging from male supremacy in the family to a lack of decision-making power, limited empowerment to inadequate wages, social customs to social insecurity, poverty to illiteracy, child marriage to dowry (Islam, 2011). Fisherwomen are frequently deprived of their fundamental human rights and basic livelihood amenities as a result of these severe issues. Fishing is often perceived as a gender-specific occupation in Bangladesh (Islam, 2018), with a heavy division of labour between men and women, similar to the rest of the world (Harper et al., 2020). Women harvesting fish is still culturally taboo in many parts of the country. In addition, the women's movement is limited by the *purdah* tradition (Deb et al., 2015). Fisherwomen face a double workload because they are responsible for both fishing and domestic chores, as in the case of nomadic fishing communities. They are usually deprived of any rest; even during pregnancy, they continue fishing. Most of them are burdened with a workload of more than 12 hours a day ('time poverty'). Some of their work is particularly strenuous. For example, during winter, when saline water intrudes into the river, women have to travel a long-distance overland to collect fresh water for daily use. As a result, the majority of women feel that they look older than their actual age (Islam, 2018).

Poverty disproportionately affects women, especially those who are the sole breadwinners in their households. Owing to a lack of resources for income generation and wage discrimination, women-headed families in fishing societies have the lowest income (Islam & Chuenpagdee, 2013). Even though women claim to do the same physically demanding work as men, in the Sundarbans, women are traditionally paid 70 percent of what men earn (Islam, 2011). The most common acts of violence against fisherwomen include dowry, physical abuse, threats of divorce, polygamy, infidelity, and mental abuse (Parveen, 2007; Islam & Chuenpagdee, 2018). Girls become a family liability as a result of the dowry custom. Almost every family is forced to pay dowry in the form of productive assets like nets and boats and cash and ornaments (Islam, 2018). The cost of a wedding may also put a family in financial distress. As a result, having more daughters in a family raises the vulnerability of the family. Due to dowry and other factors, including childhood marriage, divorce and wife abandonment are on the rise in fishers' communities (Islam & Chuenpagdee, 2013). Early marriage is also common in the nomadic fishing community, with nearly all girls marrying when they are 12 or 13 years old. Early marriage and pregnancy have a long-term effect on women's health (Islam, 2018).

Women in the fishing community have a substantially higher prevalence of diseases than the general population. Water-borne diseases like diarrhea, dysentery, cholera and typhoid are prevalent, indicating poor health and sanitary conditions. For example, in coastal fishing societies, women and children who use drag nets to capture shrimp and prawn post-larvae (PL) must spend five to six hours a day in the water. Water-borne and skin diseases and gynecological problems have been reported in women and young girls who serve as collectors (Islam & Chuenpagdee, 2013). Malnutrition is prevalent in the fishers' community, with malnutrition rates among girls and women being higher. As a result of this situation, the number of active working days and women's life expectancy decreased. Their health problems are further compounded by a lack of access to adequate health care facilities. Typically, they seek medical attention from a nearby quack and traditional healer known as *kabiraj* (Himu et al., 2020).

Women's problems in the fishing community are much too complicated to be solved in a few steps. Since there is still a significant gap between efforts and real needs, a comprehensive and holistic approach is needed to address these challenges. The following crucial measures should be prioritized to assist in the socioeconomic advancement of fisherwomen: offering universal basic education, targeted and need-based training to strengthen their skill and capability, and adequate health care facilities, facilitating credit services from banks and NGOs, and integrating gender issues into all development initiatives. First and foremost, women's formal and informal contributions to the fisheries sector must be acknowledged for these initiatives to succeed. Besides, their access to resources and markets should be increased by establishing self-help groups, voluntary agencies, and social welfare organizations and linking them to financing programs. Integration among government and non-government entities is also very crucial for these initiatives to succeed. Last but not least, social awareness of violence against women should be increased through campaigns, advertisements, and workshops, among other strategies.

Conclusion

The direct and indirect contributions made by women to small-scale fisheries of Bangladesh are often overlooked in fisheries planning and management and policy decisions. Although there are plenty of evidence that women play a vital role in the small-scale fisheries, ranging from catching and processing fish to sales and other financial aspects, there are still gender gaps in this sector. Apart from performing most of the household chores of their family, fisherwomen play a critical role at times of hardship through various measures, including borrowing food and money from neighbors, sacrificing meals, carrying out income-generating activities, and taking loans from banks and NGOs, among other things. Quantifying and ultimately acknowledging this contribution would foster women's empowerment and increase their involvement in the management and stewardship of the fisheries sector. However, they also face a host of challenges such as poverty, illiteracy, lack of access to resources, gender inequality, lack of decision-making power, dowry, child marriage, violence, abuse, etc. To mitigate these issues, governments and non-government organizations must take a systematic and robust approach.

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11. Fisheries Exit and Entry: The Dynamics of Small-Scale Fisheries Engagement in the Chattogram Coast, Bangladesh

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Poor catch often pushes fishers out from small-scale fishing on the Chattogram coast (Photo: Md. Ezazul Bari Chowdhury, 2015).

This chapter provides an explanation for the entry and exit dynamics in small-scale fisheries on the Chattogram coast of Bangladesh. This study was conducted in two communities in the Chattaogram district, Bangladesh. The traditional low-caste small-scale fishers experience various stresses that often result in them wishing to leave the fisheries. Many of them are unhappy with the poor catch, little recognition by the wider society, subjective insecurity due to criminal gangs' activities and long-term debt bondage to middlemen, to mention a few. However, many fishers are firmly anchored in fisheries as a way of life and an indispensable part of their daily life, culture, and faith. Thus, most of them are still strongly attached to their fishing occupations, even though they suffer from different forms of deprivation. The new fishers often see small-scale fisheries as the activity of last resort , when all other livelihood options are lost. The small-scale fisheries also attract investment from fisheries entrepreneurs as highly valued fisheries often 'rhyme with riches.' The study suggests that there is potential to alleviate extreme poverty if small-scale fisheries' riches can be fairly distributed to the fishers through different initiatives and by ensuring basic civil rights. The fisheries value chain needs to support the poor by fair distribution of benefits.

Introduction

Local communities in the coastal areas of Bangladesh are dependent on fisheries and coastal resources for a wide array of fisheries ecosystem services (Islam et al., 2020). Their existence was in harmony with these resources until the market economy and state interventions were enacted. In Bangladesh, coastal small-scale fishers fish in waters of less than 40 m depth, using both motorized and non-motorized boats. The Marine Fisheries Act of 2020 distinguishes between artisanal and industrial fishing. The Act has a 'license' provision for small-scale fishers operating fishing vessels with a capacity of 15 tonnes or less.

Fishing is an ancient and subsistence-based occupation for the people of Bangladesh's coastal areas, floodplains, rivers, and islands. People traditionally engaged in sea or river fishing are known by different terms, '*Jaladas*' being one of them. '*Jal*' means water and '*Das*' means slave or fisher. '*Jaladas*' also stands for people entirely dependent on water for their livelihood. They belong to a scheduled caste (low caste Hinduism) by religion. However, over time and for more practical economic reasons, people from other religions, including Muslims, have become more involved in the fishing occupation. Fishers belonging to different religions are now seen to live together in different parts of the coast. The century-old tradition of these '*Jaladas*' is under continuous pressure of breaking apart. This process started in the mid -the 1960s. Before that, the '*Jaladas*' could control this occupation by themselves, but now they cannot do it for different internal and external stresses (Kabir, 2009). Very few published studies explored the reasons for traditional community engagement or disengagement in small-scale fisheries of Bangladesh (Habib, 2001; Islam, 2012).

This study was conducted in two communities (i.e., Kumira and Halishahar) in the Chattaogram district to understand the dynamics of small-scale fisheries engagement. Specifically, this study explored why some communities are willing to exit the fisheries while other people wish to enter the same fisheries. To understand the drivers of exit and entry into small-scale fisheries of the Chattogram coast, we employed three perspectives: inside to inside, inside to outside, and outside to inside. The findings of this study would help determine policy options (fishery policy) to reduce the pressure on small-scale fisheries, which are already crowded with a large number of unemployed fishers.

The dynamics of small-scale fisheries engagement in the Chattogram coast

To understand entry and exit in small-scale fisheries of the Chattogram coast, we need to analyze the traditional livelihood strategies of fishers and how they have changed over time, adapting to the changes in their asset base and issue of poverty. The following analysis discusses a range of drivers for why fishers lose their interest in the fishing profession and explores the problems relevant to the livelihoods and vulnerabilities that coastal fishers face. Consequently, it is exposing the economic, organizational, and asymmetric relationships among actors located along the different points within the small-scale fisheries. The following findings show drivers of push-and-pull exit in fishery that led to frustration in the fishing communities, and which push fishers to take a decision to leave the fishing profession.

Inside to inside

This section describes how fishing communities see opportunities and constraints within their fishery system that influence their decision on whether to continue their fishing profession or search for opportunities outside the fishery. Many traditional fishers are not happy with their profession and several reasons behind this attitude can be attributed to unhappiness. For example, they feel that fishing occupation receives low level of respect and recognition in the wider society as outsider communities often think of fishing as a low-class profession. Being at the lower ladder of society, fishers have limited access to health, education, and other civic facilities. Many feel fishing occupations are too physically demanding and find working in the same sea environment monotonous. Working hours are not fixed as they change with the tidal cycle, and they have little free time for themselves and their family members. Finally, some feel that there are now too many fishers involved with advanced fishing technology.

With all these hurdles, the catch is poor due to overfishing and pollution.

The majority of small-scale fishers are highly dependent on fishing. Therefore, poor catch makes them susceptible to food, nutrition and livelihood-related vulnerabilities. The availability of fish has significantly reduced for various reasons, such as over-exploitation; pollution of toxic chemicals from different industries in Kumira *ghat,* especially acidic water which destroy the brood and fry fishes; illegal catching of fish using the current *jal,* net *jal;* and shipbreaking activities. With rapid industrialization, different industries have been set up in Kumira because of its geographical suitability. These industries produced different types of effluents, including, among others, dyes and acids. Canals of Kumira are used as a pathway for discharging these effluents into the Bay of Bengal, which pollutes the sea water and destroy the eggs, larva, as well the breeding and nursing ground of fish in the Kumira channel.

The life of coastal fishers is insecure both on land and at sea. Fishers don't have a proper understanding of fishing laws and regulations; thus, they often face police harassment for supposed illegal fishing. Small-scale fishers are also subjected to harassment by coastal authorities by accusations of smuggling since the fishing zone is close to the country's main seaport of Chattogram. While on sea, they are scared of criminal gangs. Most of the fishers complain that piracy is one of the main reasons that make their livelihoods risky and vulnerable. Eventually, these reasons compel them to leave the fishing profession. According to CODEC, from 2005 to 2015, about 1,200 gill nets, 4,000 SBN (estuarine set bag net), 80 engines and 150 boats were pirated from the Kumira *ghat* area. In some cases, criminal gangs kill the fishers. Local administration or leaders are not attempting to protect fishers from the risk of piracy. Insecurity at sea is attributed not only to sea piracy but also to the frequent and capricious stormy weather in the Bay of Bengal. Death of fishers from sea storms or cyclones is common, making fishing on the sea one of the riskiest jobs. It is worth noting that many fishers perceive themselves as being cursed.

Given that fishing income is insufficient and unpredictable, the soaring prices of fuel and raw materials of fishing gears and crafts make it hard to run fishing as a profitable business. Access to the fishing ground in the coastal communities is connected to having productive assets (e.g. boat and gear). The findings in the Kumira and Halishahar research area indicated that many fishers have no access to these essential assets. Small-scale fishers get access to fisheries resources by sharing boats with boat owners (nearest of kin, neighbours or friends in the community) or working as a daily labour. One of the fishing net repairing labourers noted that one new net of *bindi jal* costs BDT 15,000-20,000 (USD 139-185) to be made, which requires a minimum of 15-20 days of work. However, one net is not enough to catch the Hilsa fish which is why fishers need a large investment of funds to catch the fish. Besides, fishing gear often gets damaged during fishing operations. Therefore, fishers take loans from *dadonder* or money lenders before the start of peak season. After all the arrangements, there is no guarantee that fishers can make a good amount of money by fishing for a whole day due to the reduced availability of fish and lowered fish price. The monthly income of a fishers ranges from BDT 5,000-20,000 (USD 46-185). Among them, 60 percent of fishers receive between BDT 5,000-16,000 (USD 46-148), which is not enough to maintain even a small family in the present day. Generally, monthly family (four-six members) cost a minimum of BDT 15,000 to 20,000 (USD 139-185). However, most fishers earn below this amount, and they lead vulnerable lives year-round.

Furthermore, small-scale fishers are trapped in a debt cycle based on the credit support system. Due to their socioeconomic conditions, they are often ineligible to get credit support from banks and other organizations. Before the start of the peak fishing season in Kumira and Halishahar area, fishers take a loan from *dadonder* or money lenders for mending nets and boats or buying accessories like engines or boats. Because the fishers are poor and landless, no microcredit bank will give them loans. As a result, they have no other options than take *dadon* from *mohajon*. This loan system is characterized by high-interest rates, invisible interests, barriers to free market access, and long-term relations with creditors. In Kumira and Halishahar, fishers take loans from BDT 50,000 to 2,00,000 (USD 460-1,845) to mend nets and boats or buy accessories like engines or boats. Despite a deeply rooted sense of unhappiness in the fishing occupations, most low-caste fishers continue their profession. The main reason for continuing the fishing profession is a result of fishing being an entrenched habit and the hope of a good catch in the next season. However, due to widespread illiteracy, many fishers cannot plan, learn, and reorganize, which is necessary for job reorientation. With few alternative skills or a lack of skill/training/knowledge from the outside environment, many are unable to compete in other sectors. Some feel uncomfortable moving to a new job without knowing other people (e.g., lack of relatives in the job sector). Those who want to develop entrepreneurship often have insufficient capital to move. Others do not find expected alternative occupations. Religious beliefs are another strong motivation for staying in the fishing profession by those who believe their profession is connected to their faith.

Inside to outside

This section describes how traditional fishers see outside opportunities that might pull them away from fishing occupation towards alternative occupation. The most important pull factor for leaving the fisheries is to seek a better future for the next generation and obtain a better life by educating their children. Chattogram is the commercial capital of Bangladesh with different industrial factories near the fishing villages. The traditional fishers have limited financial capital, thus are mostly unable to invest in the productive fishing assets. Many poor fishers cannot earn enough from fishing to maintain their family. However, they see that by working in a nearby steel mill factory or industry they can earn BDT 500 (USD 5) per day. They can make between BDT 8,000-10,000 (USD 74-93) per month, whereas the fishing profession cannot guarantee predictable income. Ready-made garment industry in the region also absorbed many labourers, offering a minimum salary of BDT 10,000 (USD 93)/month, without the workers having to have any previous experience or skill. Through these jobs, they can maintain their basic needs and have opportunities to have better health services and educate their children. Again, the work environment in land-based occupations is less exploitative (unlike fishing occupations under *mohajon* or *dadondar*). They can get holidays and bonuses during religious festivals. A section of fishers wants to leave the fisheries due to their inability to lead their life with dignity and safety. As a lower caste profession, catching fish has little or no recognition. Additionally, as an unprivileged member of society, they are easy targets of criminal gangs on the sea. Given this, some fishing families decide to exit the fishing sector after seeing that their relatives and friends improved their lives by engaging in other land-based jobs.

Outside to inside

This section describes the opportunities outsiders see in the Chattogram coast fishery that attracts them to this fishery. The coastal fisheries of Bangladesh are open access and fisheries regulations are not strictly enforced; thus, anyone can easily invest in this sector. In general, hilsa shad fish is at the point of attracting investors outside of fisheries sector. The ownership of a boat, engine, and other fishing equipment is considered the most important productive asset. Most of the coastal poor people do not have these assets. Therefore, outside investors can relatively easily hire these people. Most fishers are illiterate and have little knowledge about the demand and wages for labour outside of fisheries so they end up working as cheap labour in fishing. For investors, it is easy to exploit these people, and investors see small-scale fisheries as an excellent business opportunity as investor themselves don't have to have any specific skills. The cost of labour is cheaper, especially in terms of employing migrant fishers. There is almost no paperwork or bureaucratic process needed and the investments in the fishery are outside the tax regime's influence.

As hilsa and some other marine fish have a good market value, many young people and businessmen invest in the fishery as an additional business, in addition to their primary one. The entrepreneurs are known as *mohajan* (those directly involved in fishing as the owner of fishing assets and a fishing team) and *dadonder* (those providing loans or *dadon*). The entrepreneurs find it easier to operate the business if they can maintain connections with powerful local people. Once an investment is made, profits continue for the long term. Fishing entrepreneurship requires few people to operate the fishing activities.

and it does not require hard physical labour like many other jobs. In some cases, *dadonder* does not interfere with the price of fish products or marketing, but fishers have to pay them an excessive interest rate of 120-240 percent per annum. In other cases, *dadonder* takes the catch at a price much lower than the average market price. Thus, *dadon* is a system of an advance loan through which *dadonder* establishes his right to the fisher's product (Kleih et al., 2003). Many young entrepreneurs opined it is an excellent opportunity to catch fish in the sea as it is an open access and challenging profession. Another reason for involving the young generation in fishing entrepreneurship is the self-employment as there is no boss.

Conclusion

The main objective of this study is to provide an explanation for the entry and exit dynamics in small-scale fisheries on the Chattogram coast. The traditional small-scale fishers experience several stresses that often create a strong desire to leave the fisheries. However, traditional fishers are firmly anchored in fisheries as a way of life with fishing being an indispensable part of their daily life, culture, and faith. Thus, most of them are still strongly attached to their fishing occupations, even though they suffer from different forms of deprivation. The new fishers often see small-scale fisheries as the activity of last resort, when all other livelihood options are lost. The small-scale fisheries also attract investment from fisheries entrepreneurs as highly valued fisheries often 'rhyme with riches.' There is an opportunity to alleviate extreme poverty if small-scale fisheries' riches can be fairly distributed to the fishers through different initiatives. The fisheries value chain needs to support the poor through fair distribution of benefits. The government should provide loan facilities for the lower-caste fishers at low-interest rates and create alternative job opportunities during the off- or ban seasons. The traditional caste-based fishers also demand a special *quota* system for employment in the nearby mills and factories. The government should ensure basic and special education with waivers and scholarships for the children of the lower-caste, socially excluded fishing communities as a means to include them in the mainstream society. A special arrangement of vocational training, for example in transportation as rent-a-car, auto-mechanics, farming of fish, and the dairy system can be adopted, which could alleviate the pressure on the fishing profession and the fisheries resources. Proper use of effluents from the factory plants must be put in place to reduce industrial and shipbreaking pollution. There is also a need to monitor the risk of piracy and invasion of industrial trawlers by increasing coast guard activities and patrolling. Finally, the traditional fishing communities are very assiduous; thus, enabling environment should be developed to utilize their potential combined with an alternative income-generating profession, which will improve their livelihoods and have a beneficial effect on the wider society as well.

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12. Seafood Value Chain: Mud Crab Fishery Exploitation and Marketing in the Noakhali Coast, Bangladesh

Md. Robbel Hossain, Sylhet Agricultural University
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Live crab became an important seafood item in Bangladesh's export trade (Photo: M. Minhazul Islam, 2019).

This chapter analyzes the value chain of mud crab fishery (Scylla spp.) on the Noakhali coast and provides suggestions for possible interventions to improve living conditions and make the value chain more efficient. The main actors involved in the value chain are the crab collectors, fatteners, Aratdars, suppliers, and exporters. In the study sites, more than ninety percent of exportable crabs are collected from natural sources, with the rest being exported after fattening (rearing immature crab of natural sources to full grown) by intermediaries. Generally, collectors sell large-grade crabs to the Aratdars and soft-shell crabs to the fatteners. Then the Aratdars send the crabs directly to Dhaka to the exporters, who export them to foreign markets. Actors in every stage make a profit by increasing the price throughout the value chain. However, the high mortality rate of crab, poor capital, widespread illiteracy, social and religious view, and a lack of government and non-government initiatives negatively affects the profitability of the crab value chain. Stakeholders of the value chain perceived that collectors would benefit more if the value chain could be shortened by direct marketing from collectors to exporters, with the addition of credit facilities for crab collectors being established at the local level.

Introduction

Bangladesh exports large quantities of frozen and live fishery products. Among these, the demand for live mud crab *Scylla spp.* products are increasing, particularly in Southeast Asian countries. The high price of mud crab provides a strong incentive for mud crab fishing and fattening as it is a major source of income for people in some coastal areas of Bangladesh such as, for instance, Noakhali. Presently, mud crab has a good international market (Rahman et al., 2017; Sultana et al. 2019). Despite the huge scope of collecting crab from the coast of Noakhali and suitable agro-ecological conditions for crab fattening, the sector has yet to expand enough to realize its potential. There is a need for expansion of investment in this sector to increase the income of the community of the Noakhali district. The trading pattern of mud crab involves a series of intermediaries, including harvesters, suppliers, exporters, and consumers. Usually, the greater the number of intermediaries, the higher the final price (Zafar & Ahsan, 2006; Rahman et al., 2017).

Considering the increasing demand for mud crab in the local and international markets, it has been gaining a popularity among the coastal communities in the greater Khulna and Chittagong regions (Zafar & Ahsan, 2006; Rahman et al., 2017). The export of mud crabs started in 1977-78 and became a stable business in 1982, ranking third among frozen foods that were exported to earn foreign currency (Ali et al., 2004; Kamal et al. 2013). Farmers initially collected mud crabs from natural sources such as mangrove forests, tidal rivers, canals, ponds, mangrove swamps, and shallow bodies of water. In Bangladesh, crab culture became popular in the 1980s. Generally, two types of culture systems are followed: a grow-out system and a fattening system. In the grow-out system, young crabs are raised and grown until they reach marketing size. This type of culture is generally pond-based. On the other hand, raising soft-shelled mud crabs for a certain period until their exoskeleton harden is known as fattening. As a result, hard-shelled crabs have four to five times more value in the market than soft-shelled mud crabs.

The Sundarbans mangrove region (Satkhira, Khulna, and Barguna) is the main potential area for mud crab culture and fattening. Currently, however, this practice is expanding along the whole region of Bangladesh, with high potential in the Noakhali region. While several studies have been carried out on culture technique and value chain analysis in the Sundarbans region, no such work is available for value chain analysis in the Noakhali region. This study aims at analyzing the value chain of crab products and suggests possible interventions for improving livelihood conditions for the communities involved and making the value chain more efficient.

Habitat, harvest, and catch

Bangladesh's mud crab fishery and fattening depend on the wild catch from swamps, tidal rivers, canals, and tide-fed traditional shrimp known as *ghers* (Azam et al.1998; Ali et al., 2004). Most crab collectors in the study areas collect crabs from the river, *char* (newly accreted riverine islands) areas, and small canals. Different baits, including live frog, eel, and Tilapia fish, are used for crab harvest. More than eighty percent of the crab collectors (85 percent) use traditional hooks made of iron sticks, chimneys made of bamboo sticks, and *chai* (a tubular trap-like) gear for collecting crab. Whereas 11 percent use Tilapia species and 4 percent of collectors use frogs and others as baits. Dingi boats are exclusively used for harvesting crabs from the river.

Generally, fishers go to the river in groups, each consisting of five to seven individuals. Sometimes, it increases to 12-14 members. A trip of five-seven days to collect crab costs about BDT 800-1,100. Some collectors spend almost BDT 100-120 to collect crab per day. In the case of rivers, an individual collector can gather an average of 1 kg of crab daily in summer, 8 kg in the rainy season, and 3 kg in winter. While in group fishing, collectors usually harvest 30 kg in summer, 160 kg in the rainy season, and 80 kg in winter in a single, seven-day trip. The period from August to October is considered the peak season for collecting crabs.

Many factors affect the price of mud crab in domestic and international markets. The supply is affected by the seasonal ban on crab fishing from December to February and May to June to conserve the brood stock and prevent overexploitation. The demand for exported mud crab is reportedly high during Chinese New Year and Christmas when global consumption greatly increases. Meanwhile, local or domestic market demand remains steady throughout the year. Any price increase in the global market ultimately increases the price in the domestic market.

Value chain

The value chain is a series of marketing channels starting with the collectors and ending with the consumers. A series of intermediaries are involved in the value chain of mud crabs in the Noakhali region. In the study area, 71 percent of the crab collectors sell their catches to the *arat* (landing and selling place), about 12 percent sell to *Faria* (middleman), and about 17 percent sell to the local markets. After collecting the crab, the collectors sell crabs to *Faria* when they return from the river. After the collection, crabs are washed with saline water, weighed, and examined through light checking. Different grading systems are involved in the marketing of crabs in Bangladesh. Grading may vary due to sex and domestic and international markets (Table 1). Females weighing more than 120 g and males with more than 200 g are considered suitable for export.

Bamboo-made baskets are mainly used for the transportation of crabs. Besides, jute bags, plastic buckets, and small nets are used. The loading and unloading of crabs into the vehicles is done by hand. In most cases, bicycles are used for local transportation as the most affordable mode. Some also use auto vans for transportation. It usually takes two-three hours to transport from the river to *arat*. Mud crabs are easy to keep alive for several days if they are kept under cool and moist conditions so there is no need for any refrigeration or other sophisticated facilities during transportation. Betel-nut leaf is placed at the bottom to prevent dehydration and keep the temperature low. For export, various containers are used for transportation, usually specified by foreign importers, such as plastic baskets, Styrofoam cartons, and bamboo baskets. The weight of each box varies from 14 to 20 kg of mud crab. To transport from the local market to the Dhaka crab market, the cost varies from 1,000 to 1,200 BDT.

Actors

Crab collectors (fishers) usually spend seven-eight days in the fishing areas during a fishing trip. They come back to shore when they catch enough crab. They go back to their home, sort crabs according to their size, and sell small ones in the local market or to *Faria*. Then, they sell larger-sized crabs in the local *arat*. At local markets, the A*ratdar* buys crabs following the daily price set by the central markets in Dhaka. Among the collectors, there is a leader who works as an agent of the a*ratdar*. He collects all crab catches from the collectors and supplies crab to the *arat*. Often the collectors sell their crab to a *Faria* who sells retail in the local market. These stakeholders play an important role in the value chain for providing value to the product and transport the product from the local level to Dhaka as well as to the international market. In Dhaka, crab is sold according to crab grade in kg, as per international standard size. The grade is usually reduced by at least 10 grams per sale because the animals lose weight by not eating during transportation and from drying out. For instance, If the *Aratdar* bought XL in 400 g, then 10 g is reduced in estimate during the sales in Dhaka, and XL will be considered as the weight of 390 g; other grades of crab are also measured in this way. It takes around 8-12 hours to reach Dhaka from the local *arat*.

Fatteners at the local level collect soft-shell crabs from collectors and rear them until they are full-grown. They stock soft-shell crabs in ponds. These soft-shell crabs are nurtured in the small pond next to the *arat*. After 15 to 20 days, they harvest the crabs from the pond by draining the water. In Subarnachar, suppliers are the main fatteners. Next, the local fatteners send the harvested crabs to the exporters based in Dhaka. These crabs are exported to many countries, including China, Singapore, Hong Kong, Taiwan, Japan, the Philippines, Malaysia, the USA, and Canada. While the size of the Bangladeshi crab is smaller compared to other countries, the demand for it is high, due to their taste.

Another group of actors are retailers. The retailers operate at the local level and collect the under-grade and rejected mud crabs (unfit for export) from different depots and sell them in the local market for domestic consumption, sometimes from door to door. In Subarnachar, about 25 percent of retailers have their fattening ponds. About 60 percent of retailers buy under-grade and rejected mud crab from the depot (*arat*), and 40 percent collect crabs from the depots and fattening ponds.

Table 1. Overall grade and the market price of mud crab from local to international markets.

			Price Range (in BDT)/Kg		
Sex of Crab	**Grade**	**Weight (gm)**	**Collectors to *Aratdar* Level**	***Aratdars* to Exporters Level**	**Exporters to International Market**
	XXL	>500	500-700	620-950	950-1350
	XL	>400	250-500	520-850	750-1050
Male	L	>300	150-300	420-650	650-900
	M	>250	70-150	300-500	550-850
	SM	>200	45-120	300-400	550-800
	SSM	>150	20-80	280-300	450-700
	FF1	>200	500-800	800-1200	1100-1500
	F1	>180	250-600	700-1000	1000-1450
	F2	>180	150-350	600-950	900-1200
Female	F3	>150	75-200	500-800	800-1100
	KS1	>120	60-150	400-700	700-1050
	KS2	>120	45-120	300-650	600-900
	KS3	>100	25-80	60-250	250-400

The value chain of mud crabs in Bangladesh starts from wild crab collectors. It passes through several intermediaries such as collectors, A*ratders*, fatteners, suppliers, local agents from exporters, agents for the exporter, and finally, from the exporter to foreign countries. Among the actors, the exporters play a significant role in elevating the prices and creating an artificial crisis by paying advance money to the A*ratders* so that the latter can provide *dadon* (advanced loan) to the resource-poor crab collectors. Among the actors, the collectors are the most disadvantaged group. About 65 percent of the crab collectors are found to sell their crabs to the *Aratdars*, and 35 percent sell their catch directly to the fatteners due to a verbal agreement with the collectors and the fatteners. For this reason, the crab collectors are often bound to sell their catch to them, which prevents them from getting a fair price. The *Aratdars* buy the crabs from the collectors and sell them to the exporters with a hefty profit. Some suppliers and *Aratdars* also take loans from the exporters with similar contact arrangements. Local agents for the exporters collect crab from small and large depots. About 90 percent of the total supplies from different sources go to Dhaka for export. The final price of the mud crab depended on the whole marketing network. The greater the number of intermediaries, the higher the cost of the crab.

Constraints and recommendations

Different factors in the marketing channel influence the mud crab price and the profit received by the supply chain actors. These factors include poor communication systems, inadequate capital, high mortality rates, social and religious customs, insufficient space and frequency of flights, and inadequate attention from the government and NGOs. The distance between local markets and collection sites is pretty far. The transportation of the collected crabs is not easy as the road infrastructure is not well developed, so they rely on bicycles or go by foot. Sometimes collectors sell crab at a lower price to avoid traveling long distances. Most collectors are non-Muslim, as some Muslims believe that being involved in the crab business opposes their religious ideology. However, the situation is changing as many Muslims are now involved in crab industry.

Crab mortality is the most important constraint of the value chain for each part of the stakeholders. Mishandling and poor transport system are responsible for crab mortality. The lack of saline water in the crab processing area is an important reason for the high mortality of crabs. The exporters complained about the lack of cargo space on the planes, which created uncertainty in the export business. The Bangladesh government restricted crab collection from August to September to protect brood stock. Most collectors highly depend on crab collection for subsistent living. There is no compensation scheme from the government or NGOs for the affected crab collectors.

The most marginalized segment of the coastal population, in particular, landless people, widows, orphans, and children, earn their livelihoods by collecting mud crabs from the wild. Many of these groups have been marginalized by the horizontal expansion of shrimp farming activities in the coastal areas in the recent past. Unfortunately, collectors at local levels earn less compared to the intermediaries. Furthermore, the study revealed that the market structure is entirely demand-driven.

The mud crabs from Bangladesh have a large international market. However, as the value chain analysis revealed, the price gap between the collector and the exporter is far from the added value at the intermediate steps. This is not unlike other export-oriented fisheries products, for instance, shrimp, where most values are added at the exporter (processors) level. The low returns experienced by the poor crab collectors are due to the lack of bargaining power in the supply channel. The demand-driven marketing system often leads to price exploitation. The communities of study areas further suffer from a lack of access to credits that result in indebtedness to middlemen. It is crucial for mud crab collectors to develop a resilient community institution that can withstand the rigors of winning the fight for actual market share. They have access to a loan with flexible credit conditions, and access to *khas* land (government-owned land) for fattening ponds, which can help landless communities set up their enterprise. This will require engagement with local and national governments, and collaboration with relevant stakeholders such as NGOs, and academic and research institutions.

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II

Challenges

13. Climate Change Impacts on Small-Scale Hilsa Shad Fishery in Bangladesh

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Gazi Md Nurul Islam, Universiti Tun Abdul Razak
Mazlan Abd. Ghaffar, Universiti Malaysia Terengganu
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Hilsa species constitute the most important fishery of Bangladesh but are vulnerable to climate change (Photo: Mahmudul Islam, 2019).

Tropical hilsa shad (Tenualosa ilisha) is an anadromous fish migrating from the sea to spawn in a freshwater river. This fishery constitutes an important fishery: it is the largest single-species fishery and contributes more than 10 percent of total fish production in Bangladesh. In recent decades, it appears that climate change impacts negatively affected the fisheries in various ways. Climate change has potential impacts on the internal mechanism of hilsa species that may drive the fishery to shift their habitat, which is reflected in the diverging catch statistics of the hilsa fishery. The hilsa catch has declined in the inland due to the anticipated impact of anthropogenic changes, including climate change, whereas production from marine water is increasing. Apart from increasing fishing efforts, it could be assumed that the hilsa population is moving from the river towards the sea. The climate change-induced habitat change of the hilsa shad fishery has enormous implications for the livelihoods and occupational safety of the fishers. If the climate change impacts continue to aggravate, small-scale fishers are likely to be one of the worst victims because they are heavily dependent on the climate-vulnerable hilsa population. Further, if the hilsa fishery collapses, Bangladesh may face a significant implication for achieving the UN Sustainable Development Goals (SDGs).

Introduction

Marine fisheries and ecosystems provide a crucial foundation for human well-being, particularly in developing countries (Blasiak et al., 2017). In Bangladesh, the hilsa shad (*Tenualosa ilisha)* fishery constitutes the largest single-species fisheries and contributes more than 10 percent of total fish production (Hossain et al., 2019). It has a large market demand and fetches the highest price in the local fish market. The fish is extremely rich in amino acids, minerals and lipids, particularly in essential and polyunsaturated fatty acids. The availability of hilsa fishery in the rivers is lower compared to the marine waters, due to the unplanned water control system, disruption of migration routes, habitat degradation, and increased hilsa fishing effort in nearshore and estuarine waters (Hossain, 2017). However, the catch in both inland and marine waters has been increasing in last few years (Figure 1). This might be the result of successful fisheries adaptive co-management that recently took place in the hilsa fishery in Bangladesh (Rahman et al., 2020).

Over the course of this century, climate change is projected to have an adverse impact as well as the greatest threat to biodiversity (Trew & Maclean, 2021). The fifth report of the Intergovernmental Panel on Climate Change (IPCC) also anticipated that due to climate change, by the mid-21st century and beyond, marine species will redistribute their niches (Pachauri et al., 2014). Bangladesh is very vulnerable to climate change, which is likely to threaten the country's economy, fishery resources and socio-economic condition of coastal fishers (Islam et al., 2020). Bangladesh is ranked 18th in position in terms of national vulnerability to climate change impacts on marine fisheries due to low-lying topography, high population density, climate-sensitive economy, and poor governance (Blasiak et al., 2017). Consequently, marine biodiversity will be reduced, and might impact significantly on fisheries and ecosystem services in Bangladesh. The temperature fluctuations cause marine species' habitat shift, which leads to pressure on fishery stock, habitat loss and other stresses (Pecl et al., 2017). This chapter discusses the potential climate change impacts on inland and marine hilsa fishery, focusing in particular on the impact on small-scale fisheries spawning grounds, and climate change impacts on the internal mechanism of hilsa in Bangladesh coastal areas.

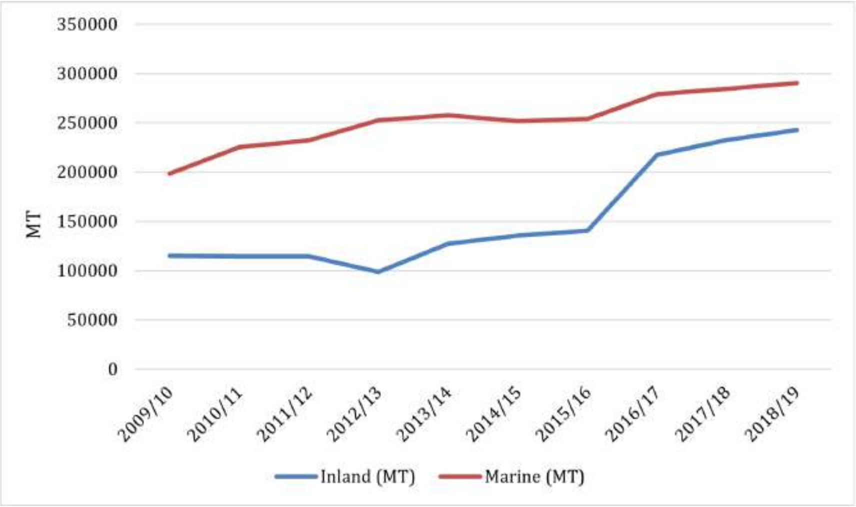

Figure 1. Annual catches (last ten years) of Hilsa in inland and marine waters in Bangladesh. MT=Matric tone (Source: DoF, 2021).

Climate change and environmental degradation issues on the hilsa fishery

The impact of climate change has a huge negative impact on the lifecycle of the hilsa fishery. Temperature rise is one of the major issues and has the highest climate sensitivity, including its impact on primary production on sea surface (Fernandes et al., 2016). The juvenile hilsa catch has declined in the rivers due to climatic change-related distortions, including siltation, closure of migration routes, and habitat degradation (Hossain et al., 2018). Besides, riverine hilsa catch has also declined in Bangladesh waters due to anthropogenic activities such as aquatic pollution, overfishing, and increasing fishing efforts (Dutton et al., 2018). The hilsa fish production is likely to reduce in the exclusive economic zone by 10 percent, and the impact can be worse in potential catch by 2030 and a significant decline (25 percent) by 2060 (Fernandes et al., 2016).

Sea level rise and salinity intrusion have a negative impact on the hilsa fishery in Bangladesh. Hilsa migration and spawning patterns, growth and production are adversely impacted due to increased salinity (Islam et al., 2020). In addition, other oceanographic changes such as ocean acidification and inappropriate water quality also harm the feeding and nursing of the hilsa larvae, thus reducing larval growth and increasing mortality (Islam et al., 2020). El Niño and La Niña have great threats to coastal fisheries resources and to the marine ecosystem in Bangladesh. El Niño and La Niña have a significant impact on the water temperature, hydrology and rainfall in the Bay of Bengal in Bangladesh (Islam & Parvez, 2020).

Bangladesh receives approximately 40 percent of the total impacts of global storm surges due to its geographical location, and the country is turning more prone to severe cyclones, particularly during November and May (Hossain et al., 2018). A number of major adverse climatic conditions, including flood and tidal surge in 1985, devastating cyclone in 1991, flood in 1987, 1998, 2004 and 2007, cyclone *Sidr* in 2007, *Rashmi* in 2008, *Aila, Nargis and Bijli* in 2009, *Mahasen* in 2013 and *Gorki* in 2016, have caused a huge loss in the coastal infrastructure of Bangladesh. In most cases, the adverse impact on the coastal fishing communities has been devastating, destroying their residents and fishing utensils and leading to o illegal fishing to compensate for the loss.

Climate change impact on the internal mechanism of hilsa

Climatic variability such as cyclones, storm surges, sea-level rise, temperature changes, salinity changes, and rainfall changes affect the hilsa fishery's stocks (Islam et al., 2020). Besides, sedimentation increase into the riverbeds, and changes in rainfall pattern (rain is necessary for breeding) also negatively affect the availability of the hilsa population. Hilsa is particularly affected during the life cycle stages of egg, larvae, juvenile, and adult. Therefore, the lifecycle mechanism of hilsa is altered (Figure 2). Consequently, the hilsa population is gradually moving towards the sea, leading to increased marine catches and decreased in inland areas.

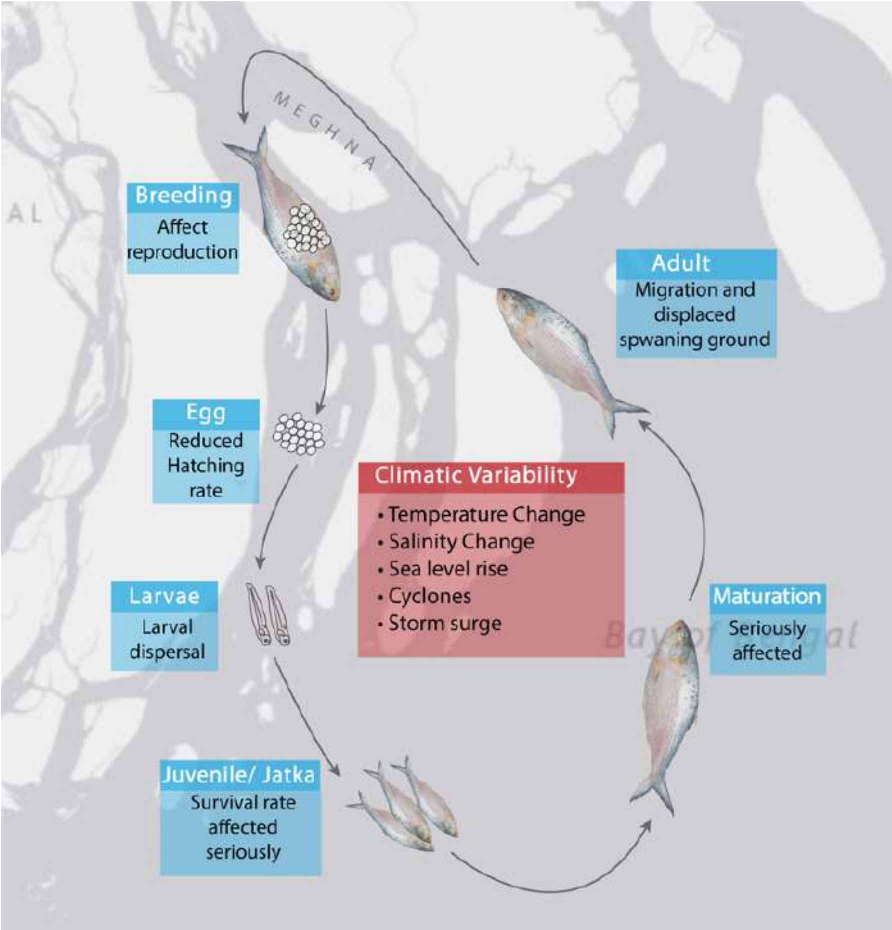

Figure 2. Climate change impacts the internal mechanism of the hilsa population.

Socio-economic impact

The capacity of small-scale fisheries to catch hilsa fish is low compared to large-scale fisheries since they use small-size boats with engines of limited horsepower. Small-scale fishers are not able to chase hilsa fish from the river to the sea. Thus, the change in hilsa fish's availability in the rivers largely affects the income and livelihoods of the small-scale fishers. Bangladesh is one of the countries where most of the coastal fishers are part of small-scale fisheries. The small-scale fishers are the most vulnerable group to the impact of climate change (Islam & Jentoft, 2019). Along with the climate change-related vulnerability, coastal fishing communities are exposed to different uncertainties throughout the year (Islam et al., 2020). The coastal fishing communities are frequently hit by cyclones, flooding, salinity intrusion as well as pollution caused by anthropogenic activities. Poor socio-economic conditions and impacts of climate change negatively impact human wellbeing and surrounding environment. The livelihoods of small-scale fishers greatly depend on hilsa fishery in coastal regions in Bangladesh. Thus, socio-economic conditions, and their livelihoods are tremendously affected by the adverse impacts of climate change.

Natural calamities such as cyclones, strong wind and waves, and current and tidal surges make the livelihood of the fishers more vulnerable. It does a lot of harm to the communities by damaging houses, sanitation systems, fishing instruments, and communication systems and pushes them into the debt cycle of money lenders. Fishers are unable to go fishing during extreme events. On the other hand, the family expenses increase along with increasing pressure of money lenders to pay their loans. The unequal distribution of wealth and power in rural Bangladesh makes it difficult for small-scale fishers, including women, to access fisheries resources (Dickson and Ahmed, 2006). The failure of centralized authorities in managing such resources has been recognized, and delegation of management of small-scale fisheries to the local resource users is now seen to be the only rational way of obtaining effective governance. Metzner (2008) highlighted that there are many examples of limited access to fisheries resources where the stocks have been overfished, over capacitated, and unprofitable. Limiting participation to fisheries and catch is not the solution; there is a need to have a sharing mechanism that determines equitable distribution of benefits.

Climate change impacts often become compound with other issues. Several fishing bans and seasonal closures reduced the number of fishing days by almost a half. The remaining fishing days are also affected by rough weather. Thus, the overall number of fishing days is very limited. As a result, fishers fish indiscriminately without due consideration of conservation regulations. The reports of distant-water bumper catch often appear in the newspapers, implying that nearshore fisheries provide poor catch and that fishers are moving to fish in the deeper waters. Fishing in the deep waters entails several risk factors. Small-scale coastal fishers do not have any technology such as radio communication to receive weather forecasts or navigation during deeper water fishing. They mostly rely on cellphone-based communication to relay messages. However, the cellphone network coverage is weak in the offshore areas. In such situations, small-scale fishers rely on indigenous knowledge and observation to predict and apprehend rough weather situation. Many fishing boats have no lifesaving supports. For example, during the cyclone *Mora* struck the Bangladesh coast in 2017, a government estimate reported that the cyclone killed 53 fishers from Moheshkhali while they were out fishing. Although the government agencies have a system in place to inspect fishing boats to ensure they have the proper safety equipment, the functioning of that system is uncertain.

The vulnerability of small-scale fishers is not all the time related to extreme events; it is also connected to economic conditions and power relations. Small-scale fishers often work as a hired crew in others' fishing boats. In many cases, given the poor socio-economic condition, small-scale fishers are unable to afford their own boat. Instead, they rely on fishing boat owners and have no options but to accept whatever facilities the boat owner provides. The hired crews are likely to have no or little power to negotiate with the boat owner for better protection against extreme weather during fishing. Boat owners often force fishers to continue fishing even during rough weather conditions. Besides, in an extreme case, if any fishers dies during onshore, the boat owners are unlikely to provide any financial support to to the families of deceased fishers. In such a case, the government provides one-time support of BDT 50,000. The participation of small-scale fishers in governing fisheries resources is extremely important in order to achieve the SDGs, particularly goal 13 (taking urgent action to combat climate change and its impacts) and goal 14 (conserve and sustainably use the oceans, seas, and marine resources for sustainable development).

In Bangladesh the co-management project has been successful in encouraging fisher communities to develop alternative income-generating activities by providing micro-credit support through partner NGOs aiming to reduce fishing pressure on waterbodies (Islam et al., 2011). The co-management initiatives play a major role as a safety net during the lean fishing season and have contributed towards improving the livelihoods of fishing households in project areas. The combination of conservation measures, establishment of fish sanctuary and habitat restoration have resulted in upward trends for enhanced fishery management performance, sustaining production and increasing biodiversity. Organized fishing communities generally appear to embrace the concept and perceive significant benefits, but the main issues remain the financial and institutional sustainability of the community-based approach, where further support may be needed for existing community-based organizations.

Conclusion

This chapter discusses the impacts of climate change on the hilsa fishery system within the context of of Bangladesh's coastal region. The study concluded that the hilsa population is moving from the river towards the sea due to various climate change-induced drivers. Climate change has potential impacts on the internal mechanism of hilsa fishery, such as life cycle stages, migration patterns and spawning grounds of hilsa. Furthermore, climate change has an adverse impact on small-scale fisheries and their livelihoods. Small-scale fisheries are heavily dependent on the climate-vulnerable hilsa population, which threatens the livelihoods of fishing communities if the stock collapses. This type of changes in hilsa production and if continue, the impacts on hilsa fishery-based livelihoods that might have significant implications for achieving the UN Sustainable Development Goals (SDGs). Community-based fisheries management approach may help fishers to adapt in situations where government, NGOs, organizations and fishing communities work together to improve the livelihoods of poor fishing communities. The co-management approach is yet to be functional in the coastal fisheries. Still, we can hope that science-based fisheries co-management will be established in the near future to improve the potential hilsa catch from Bangladesh's marine waters. The implementation of a community-based approach and proper poverty reduction strategies would be an effective and viable strategy for the sustainable livelihoods of coastal fishing communities in Bangladesh.

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14. Who Owns the Coast? Fishery-Tourism Interaction in Saint Martin's Island, Bangladesh

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Fisheries and tourism related activities share coastal space of the Saint Martin's Island (Photo: Md. Abdul Baten, 2021).

Saint Martin's Island is the only coral-bearing Island in Bangladesh that has a settlement of traditional small-scale fishers. In recent decades, the island became a tourist hotspot of Bangladesh, leading to competing interests in fisheries and tourism. While the expanding tourism industry helps local fishers in improving their livelihood by creating alternative income opportunities, the negative impacts of unregulated tourism and irresponsible tourist activities are now clearly visible through degradation of coral habitat, environmental pollution, and competition over coastal space between fishers and tourism entrepreneurs. Thus, small-scale fishers face competition in defending the coastal space and surrounding coral ecosystem on which they depend for their livelihoods and well-being. This study calls for restriction measures, such as assessing the carrying capacity of the island and implementing regulations for the protection of islands and surrounding coral ecosystems.

Introduction

Saint Martin, the only coral island of Bangladesh, stands in the Bay of Bengal. Known for its attractive scenic beauty, the island has been declared as one of the country's ecologically critical areas (ECA) (DoZ, 1997). According to the principle of ECAs, several restrictions and prohibitions exist in order to maintain the ecological balance and ensure the conservation of the natural settings of the ecosystems. For example, illegal cutting or collection of trees, hunting or killing of wild animals, harmful fishing practices and other activities that are harmful to aquatic life, industrial establishment, polluting the water by disposing waste, and any other activity that could destroy or change the natural ecosystem are prohibited in ECAs areas of Bangladesh (Sajal, 2018). The co-occurrence of multiple habitats, e.g., coral colonies, seaweed, and seagrass meadow spreads in shallow water areas adjacent to the island, and the mangrove habitat along the frontal line towards the Bay of Bengal contributes to its distinction as one of the more unique ecosystems on Earth (Hasan, 2009). Saint Martin's Island is a resource-rich island that bears multiple coastal and marine resources such as corals (166), mollusks (187), crabs (12), fish (204), marine algae (154), reptiles (27), birds (120), mammals (19) etc. (Tomascik, 1997; Feeroz, 2009; Habib & Islam, 2020). Among the 11 globally endangered marine turtles, 3 species, explicitly Olive ridley turtle (*Lepidochelys olivacea*), Green turtle (*Chelonia mydas*), and Loggerhead turtle (*Caretta caretta*) used Saint Martin's Island as nesting and hatchling ground (Hossain et al., 2004). Sea turtles still use this habitat as their breeding, nesting ground, nevertheless facing multidimensional threats of both natural (e.g., climate change) and anthropogenic origins (e.g., beach lighting, pollution). Saint Martin's Island is considered a social-ecological system as it is an interdependent and interconnected system of people and nature. Since ancient times thousands of people lived on this island, majority of whom are small-scale fishers, used to catching fish in the vicinity of Bay of Bengal. The inhabitants are highly dependent on the wide variety of Saint Martin's Island's ecosystem services. The main livelihood activities of islanders include fishing, tourism, agriculture, seaweed collection, coral harvesting, coconut selling, service sector, day labour, mollusks shell collection, and other petty businesses, all of which are seasonal activities (Afrin et al. 2013; Touhiduzzaman & Rahman, 2017).

Fishing is the most extensive livelihood activity of the 8,500 residents on and around the island. Fishers depend on reefs and adjacent marine waters for subsistence fishing and commercial harvesting (Rani et al.. 2020). The collected fish is sold to local merchants. A substantial amount of fish is sun-dried locally by the five local large fish-drying farms and by individual households, and is afterword supplied to business people in Cox's Bazar and Chittagong (Touhiduzzaman & Rahman, 2017). Another important economy sector is tourism. The island has been used as a tourist destination since 1996-1997 and while, initially, the number of tourists was negligible, the island started gaining interest, especially after the publication of a 2007 Bangla film 'Daruchini Dwip' that covered the unique landscape and local culture on the island (Alam et al., 2015). Recently, the island has become the most popular tourist destination in Bangladesh, with the main tourist season lasting from November to February (Barua et al., 2020). During the peak time, 6-7 ships and local trawlers carry a large number of tourists to this island each day.

Between 4,000 to 6,000 domestic and foreign tourists visit this island, with 60 percent of them staying for 1–4 days on St. Martin's Island (Rani et al., 2020). Unsurprisingly, the island-based tourism industry has had a significant impact on the local economy.

Tourism and local livelihoods

The world's tourism industry is constantly increasing; in 2018, the tourism contributed 10.4 percent to the global Gross Domestic Product (GDP), representing 319 million jobs or 10 percent of the total global employment (World Travel & Tourism Council, 2019). In Bangladesh, the tourism and travel sector has contributed 4.4 percent to the GDP. This is expected to increase by 4.7 percent (World Travel & Tourism Council, 2017) and create employment opportunities for over 1 million people, generating 8.4 million USD on an annual basis (Sarkar et al. 2018). The development of tourism on small tropical islands has several advantages: it improves local livelihoods, conserves fragile coastal and coral ecosystems, promotes small and medium tourism enterprises, ownership and business opportunities, and provides learning experiences (Lechner et al., 2020). Saint Martin's, locally called '*Narikel Jinjira*' is the only tropical coral island of Bangladesh. It is divided into four major administrative units, namely Uttar para, Golachipa, Dakhin para, and Cheradip (Figure 1a). The primary livelihood activities of the majority of islanders are fishing (Figure 1b) and tourism-related services (Figure 1c). Although fishing is the main sources of employment on the island, tourism is one of the primary sources of income, especially during the tourist season. The tourism industry of the island annually provides 19.4 million USD to the national economy (Rani et al., 2020). Approximately 480–500 people are directly connected to tourism activities on Saint Martin's Island, including 34 registered tourist guides and operators (Kamruzzaman, 2018). Many people are also involved in indirect tourism services, such as constructions of hotels, motels, or resorts, running of rent-a-car business, selling umbrella benches, part-time beach-tour operators and guides (mostly students). In addition, many individuals are involved in catching and selling of dry fish to various parts of the country (Uddin et al., 2021). Booming tourism may allow the islanders to have an increasing economy, create alternative job options (part-time, full-time), reduce poverty and hunger levels and improve their living standards. The islanders also agree that the tourism can improve the quality of life (Miah & Mawa, 2019). In recent times, local tourist authorities introduced scuba diving and speedboat sailing so that the tourists can witness the beauty of the corals and its associated biodiversity. There are also plans to bring water skiing and other sporting facilities to the island to attract more tourists (Hasan, 2009). The most southern part of this island, locally known as Chera Dip, is the most famous spot for scuba diving activities (Uddin et al., 2021).

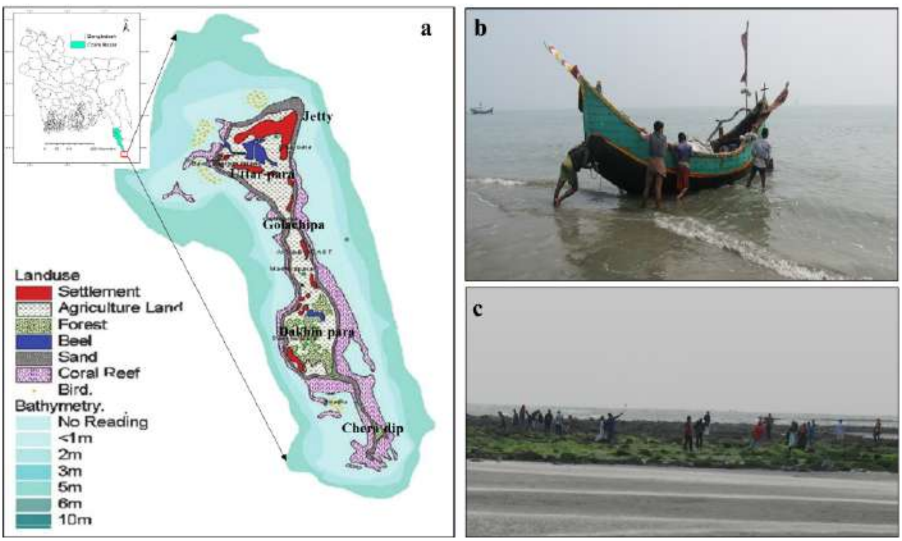

Figure 1. Fishing, tourism, and local livelihoods interactions in Saint Martin's Island (a) land use map of study area (Adapted from Feeroz, 2009); (b) Small-scale fishermen ready to start the fishing trip in the Bay of Bengal area; (c) tourist activities on coral habitat, seaweed, and seagrass bed during low tide. (Photograph b & c taken by Md. Abdul Baten, 2020).

Tourism: The other side of the coin

The positive impact of the tourism industry is well known. However, the negative effects of the tourism are, in a sense, the other side of the coin (Saarinen, 2007). The considerable negative impacts of tourism include traditional clashes such as introduction of bad practices brought by the tourists that hampered local lifestyle, culture, custom and heritage (socio-cultural); seasonal jobs, financial leakages and inflation (economic); construction of infrastructure and contamination of the natural place (environmental) (Bac, 2003). Although the tourism industry in Saint Martin's Island improved the livelihoods and economy of both the local people and the nation, it has had a significant negative effect on the entire ecosystem of the island. One of the most important drawbacks of tourism is the degradation of the coral ecosystem. The destruction of the coral ecosystem was caused mostly by anthropogenic activities such as unplanned and uncontrolled tourism, irresponsible touristic activities, coral extraction for the purpose of selling them as souvenirs, increased sediment load by tourism activities on the coast, oil (diesel) pollution, disposal of single-use plastic, waste from hotels and restaurants, habitat destruction and infrastructure development along shorelines — all of these have caused dramatically adverse impacts on the coral population of Saint Martin's Island (Ahammed et al., 2016; Gazi et al., 2020). To increase tourist accommodation, the land use pattern of Saint Martin's Island has changed dramatically, and the built-up area has increased by 175 percent in the last 14 years (2005–2019) (Ara et al., 2021). The demand for freshwater is ever increasing due to the growing needs of the local population and a large number of tourists, resulting in the drop down of the water table on the island (Barua et al., 2020). The unusual sound produced by hotels, motels, crowding, or even intentional loud music from the tourists is disturbing the calm situation in recent years. The nighttime lighting on the island seriously hampers the natural homeostasis of the marine faunas; for instance, natal homing behavior of sea turtles nesting, latency period of hatching and conservation have been seriously hampered due to beach lighting and anthropogenic pollutants.

Local people collect different types of coral species for lime making, construction work (building and roads), and for selling them to the tourists as a souvenir (Touhiduzzaman & Rahman, 2017; Uddin et al., 2021). At the same time, small-scale fishers on the Saint Martin's Island are facing a series of challenges, including degradation of fish habitat, competition with the industrial fleet, conflict with the fishing fleet of the neighboring countries, water pollution, climate change, and a lack of access to markets. Tourism indirectly impacts the livelihood of small-scale fishers by lowering their income and increasing the price of daily commodities, leading to immeasurable hardship for the locals who have to struggle to fulfill their minimum costs of living (Afrin et al., 2013). According to one key informant, *"Most of the hotel, restaurant, and cottage owners were not residents of this island, but they stay on this island during the entire tourist season with their staff. The local fishermen often sell their land to tourist agencies for their infrastructure development due to economic crisis, thus being displaced from their land".* The land area of Saint Martin's Island is decreasing day by day due to the establishment of new infrastructures and natural causes like sea-level rise. Another key informant said, *"Usually, new land was formed with the accumulation of seaweed, seagrass, and sediment in the coast of Saint Martin's Island. But this has not happened for the last 10 years due to the decline of seaweed and seagrass bed in the coral Island of Bangladesh".* Apart from the natural and anthropogenic threats, global warming and climate change pose a high risk to the biodiversity of the marine ecosystem on St. Martin's Island (The Daily Star, 2009). Notably, sea level rise causes inundation on different parts of the islands during high tides. One key informant NGO official said, *"Literally, the island is sinking due to too many people on a too small-scale space."*

There is also competition regarding the use of coastal spaces. Previously, the local fishers predominantly used coastal space for boat making, repair, net making, or even fish drying. Nowadays, increased tourism infrastructure (e.g.; beach camping, petty shops for tourists needs), or tourist mobility is restricting this space for fishers. Many local fishers are worried that in the near future, the island may be converted into a tourist resort that will restrict fishers' access to coastal spaces and fishing areas or even displace them entirely in the long run. Some respondents even worried that too many tourists in the islands are disrupting their traditional social fabrics.

Conclusion

While tourism improved the standard of livelihood of fishers involved in small-scale fisheries and boosted the national economy, unplanned and unregulated tourism significantly degraded the coral ecosystem on Saint Martin's Island. Since the tourism has created a considerable number of alternative livelihoods for small-scale fishers, putting a stop to the tourism on the island is not a viable option. But perhaps we can introduce ecotourism, where a certain number of tourists can visit and enjoy the scenic beauty of Saint Martin's Island without harming its natural setting. Thus, it is necessary to estimate the carrying capacity of Saint Martin's Island. The study of Hasan et al. (2014) suggested that real carrying capacity (RCC) and adequate carrying capacity (ECC) were 2,913 and 1,835 tourists per day, respectively. The current environmental setting on Saint Martin's Island can hardly cope with 900 tourists a day, but currently more than 6,000 tourists come every day for an overnight stay during the peak tourist season (Rani et al., 2020). This is alarming news. How can a small island cope with a large number of tourists? Clearly, it is necessary to restrict the number of tourists.

Saint Martin's Island is an environmentally protected zone as per the Bangladesh Environment Conservation Act (1995). Based on the act, the government declared the island as an Ecologically Critical Area (ECA). The key aim of conserving ECA is to protect the major environmental features from encroachment by skewered development. Unfortunately, the prohibitive activities such as polluting water by discharging waste or any other activities that could destroy or change the natural characteristics of an ECA continue to unfold unabatedly. Stricter implementation of the ECA rules should be implemented in order to protect the island from the impacts of tourism. Additionally, increasing local awareness through effective education programs that focus on improving the knowledge of ecosystem protection is much needed. Fisheries-based ecotourism can be an option as it can open the door to generating alternative income, without disturbing nature, which is something that may be used to sustain small-scale fishers on Saint Martin's Island. Special policy and managerial attention and transdisciplinary collaborative initiatives are also essential to sustainably maintain the lucrative beauty of this ECA while maintaining the carrying capacities and the homeostasis of its biotas.

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15. Systematic Exclusion of Teesta River's Fishing Communities

Md Shahnawaz Khan Chandan, Jagannath University

Deficient water flows turn major part of the river into a massive char (sand bar), leaving pockets of water body, displacing fishing activities (Photo: Md. Shahnawaz Khan Chandan, 2019).

This chapter depicts how uncontrolled taming of a transboundary river has affected the livelihood of Bangladeshi fishers, who once upon a time led a prosperous life thanks to the river's bounty, but have recently become destitute, landless people. Teesta is one of the 54 transboundary rivers shared by Bangladesh and India. To tap the water resource with its huge hydropower potential, at least 15 hydro-electric power plants are currently being built, and the two largest projects of this kind are already in operation. This damming of the river, coupled with the glacier retreat in the Himalayas, leads to diminishing river flow, resulting in the most disastrous consequences in downstream Bangladesh. The consequences are both the environmental devastation and the livelihoods being put in peril, in particular those of fishing people. Lack of the river water during the main breeding season led to extinction of many species. The release of water from the upstream barrages during monsoons causes a massive deluge in downstream areas where millions of people lose their houses and other properties. Poor catch and lack of arable land are driving the displacement of fishers and is also forcing them to shift to other lower-paying occupation. This study puts forward some recommendations towards sustainable livelihoods for fishing people in the Teesta River basin.

Introduction

Teesta is one of the 54 transboundary rivers shared by Bangladesh and India. The river originates in Himalayas and flows through the Indian state of Sikkim and West Bengal into Bangladesh. The Teesta River basin in Bangladesh spans over 2,037 square kilometers, covering five districts, i.e., Rangpur, Kurigram, Lalmonirhat, Nilphamari, and Gaibandha (Rahaman & Al-Mamun, 2020). In these districts, the river impacts 9,667 square kilometers of agricultural land. According to the last census in 2011, nearly 10 million people live in this region, with a population density of 700 per square kilometer. Around 20-21 million people directly or indirectly depend on the Teesta River for their livelihood (The Asia Foundation, 2013).

However, taming the river upstream has severely affected its flow, which ultimately impacted people's livelihood downstream. The upstream of the river is fast-flowing and has huge hydropower potential. To tap this resource, at least 15 hydro-electric power plants are currently being built currently, and the two largest projects of this kind are already in operation (Rahaman & Al-Mamun, 2020). Although most of these hydro-electric power plants are 'run-of-the-river' projects, which means they are not supposed to hold back water, this dam cannot release water on time due to poor electricity distribution networks in Sikkim and West Bengal (Basu 2017a; 2017b). The diminishing flow of the river is also driven by climate change impacts, as manifested by the glacier retreat in the Himalayas. In 1990, 34 glaciers used to cover an area of 305 square kilometers; in 2004 the glacial cover on the Teesta basin was reduced to only four square kilometers. Consequently, the volume of water flowing down the Teesta has been consistently declining (Basu 2017a; 2017b). This resulted in severe water shortages in downstream regions.

For the Bangladeshi segment of the river, the most disastrous consequence came from the construction of Gajoldoba Barrage in West Bengal. Constructing a barrage on Teesta to facilitate irrigation was conceived as early as 1945 during the British rule. Later, the government of West Bengal planned the Teesta Barrage project at Gajoldoba in 1975/76 as a way to irrigate agricultural lands to supply drinking water in six districts of West Bengal, including Cooch Behar, Jalpaiguri, Darjeeling, North Dinajpur, South Dinajpur, and Malda. The Gajoldoba barrage will also produce 67.50 MW of electricity. Furthermore, India has put in place an inter-basin, water-sharing project linking Teesta, Ganga, and Brahmaputra together, which has diverted most of the water from this river. For these purposes, India keeps the gates of the Gajoldoba barrage closed during the dry season and opens the gates during the monsoon, releasing a massive amount of water at high velocity. Such practice has a devastating impact for the Bangladeshi part of the river, creating bone dry conditions during the dry season and flash floods during the monsoons.

The barrage was constructed without formulating any formal water-sharing treaty between Bangladesh and India. According to an ad-hoc water-sharing agreement made in 1983, Bangladesh should receive 36 percent and India 39 percent of the Teesta water. The remaining 25 percent remained unallocated. In 2011, another water sharing agreement was made between Indian and Bangladesh, with Bangladesh receiving 37.5 percent of the water and India retaining 42.5 percent. However, the agreement could not be turned into a formal treaty due to opposition from Mamata Banerjee, chief minister of West Bengal (Khasru, 2017; Basu, 2017a; 2017b). The government of Bangladesh also constructed a Teesta Barrage barrage at Nilphamari to support agriculture in six northern districts during the dry season. According to the plan, the Teesta barrage project was supposed to be completed in three phases. The first phase of the barrage was supposed to irrigate 50,000 hectares of land during the dry season, and the total command area of the barrage would be 111,406 hectares. Under the second construction phase, the barrage was supposed to irrigate 448,774 hectares of cropland; finally, after the third phase the entire Rangpur, Nilphamari, Lalmonirhat, Dinajpur, Bogura, Joypurhat, and Gaibandha districts would be under its command area (Khasru, 2017).

However, due to acute water scarcity resulting from water diversion by the Gajoldoba barrage, the second phase construction project could not be completed. Even the existing barrage is deemed to be useless due to the water shortage on the Teesta River. According to Bangladesh Water Development Board engineers, the Teesta Barrage requires 40,000 cubic feet per second (cusec) waters to irrigate the croplands thoroughly. However, during winter (December and January), only 5,000 cusec water is released by Gajoldoba barrage, and in February and March, the barrage releases only around 1,000 cusec water (Sarker, 2010; Khasru, 2017). As a result, the Bangladesh side of the river has almost dried up, causing a catastrophic impact on the ecosystem and local agricultural and fishing communities.

Environmental devastation

The dams and barrages upstream of the river led to catastrophic consequences in downstream Bangladesh, where millions of farmers and fishers depend on the river for their livelihoods. The river ecosystem has also changed drastically due to deficient water flow during the dry season and devastating floods during the monsoon. Due to water diversion by the Gajoldoba barrage, the Teesta River in Bangladesh turns into massive *char* (tract of land formed by siltation) during every dry season. These chars are so dry and sandy that almost nothing can be cultivated in these barren lands. The fine grains of sands, carried by the wind, cover the nearby agricultural land, are destroying crops and ruining the fertility of the land (Bari & Haque, 2016). As the Teesta River is drying up, many canals and marshes, which used to be fed by the river, have also disappeared from the region. According to local fishers, these marshes and canals were breeding grounds for many fish species, particularly carps and snakeheads. Now, according to fishers, these fish are no longer found in Teesta. They can only catch some minnows and barbs in the shallow pools in the dried-up riverbed.

The drying of the Teesta River has impacted majority of the hundreds of hereditary fishers who have been living in the river basin for years. The fishers observed that fish breeding mainly occurs during November to December; for this to happen, there needs to be enough water available during this period. However, these days water comes into the river in May-June when the breeding season is already over. This causes serious impacts on the fish population in the river. According to some other account, the Teesta River previously had an abundant fish population for more than six months in a year. But now, fish are available only during the monsoon season. The river used to be a large source of freshwater fish in the region. A study in 2013 recorded 7 species of carps, 9 species of catfish, 4 species of snakeheads, 3 species of eels, 7 species of barbs and minnows, 4 species of perch and 8 miscellaneous species in the river (Khan et al, 2013). The irregular and diminishing flow of water to the Teesta River has severely impacted not only the diversity of the fish, but also the lives of the people who have been dependent on the river for sustenance from time immemorial (Xinhua, 2015). Many well-known species of the river are now on the brink of extinction, as brood can no longer breed due to the lack of water.

When water is released from Gajoldoba barrage during the monsoon season, the dried-up Teesta turns into a ferocious river that destroys everything on its path. Resisted by the silted riverbed, the furious current overflows its banks, destroys cropland, and washes away fish farms. Due to such chronic deluge, large tracts of lands get eroded by the river current, making hundreds of thousands of people homeless and landless every year. Like human beings, livestock also becomes the victim of this annual flood. Due to lack of high grounds and cattle fodder, a large number of livestock perish or become highly sick (Bari & Haque, 2016). Again,during the deluge, the river becomes so furious during the rainy season that, fishing become almost impossible in these parts, according to local fishers and farmers. In 2020, just in Lalmonirhat districts 572 fish farms, 277 hectares of seedbed, 8 hectares of corn, and 10 hectares of peanuts and vegetables had been washed away by the flood (Daily Bangladesh, 2020). Such massive destruction of infrastructure and agriculture severely affects the economic condition of the region. 65-70 percent of the rural population of the Teesta basin districts do not own any cultivable land. A study conducted in 2013 in Lalmonirhat and Kurigram districts revealed that farmers and fishers in these districts are frequently affected by famine and crop loss due to devastating floods and waterless dry seasons. Losing livelihood, these farmers, fishers, and agricultural workers abandon their ancestral homes, sell off their productive assets, and migrate to Dhaka and other cities (Bangladesh Pratidin, 2020; Daily Bangladesh, 2020).

Fishing livelihoods in peril

The field visit from Nilphamari to Lalmonirhat downstream of the Teesta River reveals how hundreds of fishers lost their livelihood due to the withdrawal of water from the river. Fishers in South Kharibari village under Dimla Upazila of Nilphamari district said that nowadays they can hardly catch any fish in the river. However, the elderly fishers in this village can still remember the golden days of Teesta's prosperous fishing community. They talk about a *beel* (large lake-like wetland) called Shutungar Beel adjacent to the river, famous for catching gigantic carp and catfish. Fish like snakeheads, mud eels, and minnows were so abundant that those were mostly used as dog feed. Fishers used to catch only fish of considerable size to sell in the town's market. However, these are stories from the distant past. Today, when the released water floods the river, it brings destruction for these fishers. When the water is released from the Gajoldoba barrage, the homes of the fishers, who mostly live along the riverbanks, are the firsts to be washed away by the deluge. One of the elderly fishers of South Kharibari village reported that he had to move his home 11 times in the last 15 years. According to the village elder around 300 fisher families in South Kharibari and Tepa Kharibari villages depended on the bounty of the Teesta River and Shutungar Beel for their livelihood. As the large wetland fed by Teesta dried up completely, with the river now virtually unsuitable for cultivation and fishing, most of these fishers have migrated to other cities. Some of them have been living on occasional farming and doing menial labour in the urban areas during monsoons.

A different scenario can be found in Doane village located in Hatibandha Upazila of Lalmonirhat district, some 20 kilometers down the Teesta River and on the immediate downstream of Teesta barrage. A narrow stream of the once-mighty Teesta was flowing through the mostly locked sluice gates of the barrage and forming shallow, pond-like stagnant water bodies in the immediate downstream areas of the river. Hundreds of people with boats and fishing nets were busy catching fish in the murky waters of those unclaimed ponds, which are some of the sorry remnants of the mighty Teesta. Some had even set up tents to stay overnight to catch fish: a picture quite the opposite to the one described by the fishers of South Kharibari village who claimed that most of the fishers had already left the area. The many boats anchored along the chars surrounding the shallow water bodies from all sides proved that these fishers had been coming to fish in this area for many days.

In one of the tents, the fisher was found repairing their nets for some night-time fishing. Based on their accounts, all the men catching fish near the barrage were farmers. Due to extensive damming and water diversion, the Teesta River has significantly changed its course in the last ten years. Massive chars have formed on the riverbed, and their expanding sands have engulfed the croplands along the former riverbed. As a result, farmers have abandoned their original profession and are struggling to earn a livelihood by catching small fish in these stagnant pools. According to these farmers turned fishers, the original fishers of these areas belonged to lower caste Hindu communities who left this area a long time ago.

One of them said that he alone lost 35 bighas of cropland to the growing chars of Teesta. These farmers said that only the farmers on the upstream side of the Teesta barrage can benefit from a small amount of water retained by the barrage. These people are also aware of how Gajoldoba barrage has affected the river and the livelihood on the other side of the border.

Based on the accounts of one of these fishers, some 20 years ago, Teesta used to flow at least 30-35 miles eastwards and take a meandering course in reaching the barrage. All along the river were fertile croplands and waters teeming with fish. Due to water diversion from the Gajaldoba barrage and consequent siltation, the course of the river has changed, and wetlands and croplands have disappeared. Once prosperous farming villages along the downstream of the Teesta River have now turned into poor fishing villages. These poor subsistence fishers are catching Mud Eel, barbs, Bengal loach, Gangetic Mystus, Spotted snakehead etc. They sell a portion of their catch at the local market and keep some of it for their consumption. They also receive occasional charity from local NGOs and welfare organizations. Some of them tried their luck in the cities but had to return to the village empty-handed as cities like Dhaka could not offer them a better job and better accommodation in congested slums. According to these fishers, the original fishers of the Teesta River had moved further downstream. In Lalmonirhat district's Teesta Upazila, the recently built Daspara and Modiram villages are two villages where 200 Hindu fisher families settled recently after shifting their homes from the villages of the upstream side of the Teesta barrage. They had also formed an association of fishers to help each other.

Some 60 kilometers downstream from the Teesta barrage near Diaspora village, Teesta's riverbed becomes a massive char dotted with shallow waterholes. After walking for several hours through the char, a once narrow stream has become the main course of the river. There, a couple of men were found still fishing on the river with boats and nets. One of them, a sexagenarian fisher from Diaspora village, shared his story of struggle. He has moved houses eight times so far — sometimes due to river erosion and sometimes due to unavailability of fish caused by the changing course of the river. Many of his neighbors have moved a lot more than him. When asked why they have settled here, he said that as there is no more fish in the river, they settle in places where there are private fish culture ponds on the river. Through their association, they get a contract to harvest the ponds. However, the number of ponds is also shrinking due to the drying up of the river, and most of the fishers are not lucky enough to get such contracts due to brutal competition. Local influential people often threaten them not to bid for the contracts. By convincing local politicians, they take the contracts. Many a day these fishers cannot catch anything. In those days, they and their family members are starving. According to them, they don't get any help from the government. If the river does not favour these people in the monsoon, they shift their house again in search of private fishing ponds. They don't know what will happen to them with things getting progressively worse. With the demise of the Teesta River, all means of their survival are vanishing day by day.

Due to the intensifying scarcity of water, the number of destitute fishers is increasing. Destitute farmers — victims of river erosion — are also becoming dependent on fishing, adding to the pressure on the poor fishers and their shrinking supply of fish. When they can no longer withstand the suffering, they have to move in search of a better place for fishing. As a result, a once busy, thriving fishing community is now being forced to lead a semi-nomadic life. One of these fishers said that due to a shortage of fish, he and some of his neighbors had migrated to Chattogram to try their luck in deep-sea fishing. However, after spending seven years doing that and earning around Tk 50,000, he decided to return home as he felt that deep-sea fishing was too risky for him.

Conclusion and recommendations

Diverting the water from Teesta by constructing barrages and dams has severely affected millions of people's livelihood in Bangladesh. Severe water shortage and a long spell of the extremely dry conditions have created a desert-like environment along the Bangladeshi part of the river. On the other hand, chronic deluge during monsoon due to the release of water from upstream barrages destroys a huge amount of agricultural assets and infrastructure in Bangladesh. The fishing peoples are the worst affected as the river remains dry throughout the fish-breeding season, leading to extinction of many fish species. The situation is forcing many fishers to shift to farming, through there is a considerable lack of arable land in this semi-desert landscape. Many fishers don't have skills and experience for alternative occupations. In conclusion, the researcher would like to put forward some recommendations to sustainably solve the issue of increasing poverty in Teesta's adjacent areas:

1. Unenforced Teesta water-sharing agreement must be formulated into a bilateral water-sharing treaty between India and Bangladesh and the treaty must be respected by both parties;
2. Subsistence fishers and farmers affected by the drying up of the Teesta River should be brought under the Bangladesh government's social security programs;
3. The government should provide an accurate forecast of the monsoons to these fishers and farmers;
4. There should be an information-sharing platform between the Bangladesh government and the Indian government so that the Bangladesh government can inform local people about the accurate timing of the release of water from the upstream barrages;
5. The government must ensure that farmers and fishers living in remote areas access agricultural information and weather forecasting;
6. For this purpose, cell phone-based SMS services can be utilized. With the help of NGOs, the government can train farmers and fishers on using cell phones to get agricultural and weather-related information;

7. Gradually, through such training programs, these farmers and fishers can have accessibility to the internet and smartphones. Furthermore, the government and NGOs can provide interest-free small loans to these farmers, besides training to make smartphones and the internet available;

8. Education is of paramount importance to reduce poverty. Unfortunately, a large number of school buildings get destroyed or severely damaged by river erosion during the deluge. Schools can be set up in portable or easily transferable buildings so that the entire structure can be shifted during monsoon deluge;

9. Children of affected fishers and farmers should be provided with stipend and scholarships to avoid drop-out; and

10. A large number of affected people migrate to different cities where children of these families may not have access to education. A comprehensive database of the affected population should be prepared so that these people can be tracked even after migration and these children are enrolled in the educational institutions with support from the government.

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16. Does Occupational Safety and Health (OSH) Concern Small-Scale Fishers in Bangladesh?

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The onboard working conditions of small-scale fishers on an artisanal fishing boat (Photo: Md. Sazedul Hoque, 2022).

Estimated global figures put fishing as one of the most dangerous types of employment. This situation is exacerbated in Bangladesh, where safety standards and facilities are poor and safety training is virtually non-existent in artisanal and commercial fishing sectors. This chapter discussed the safety and health status of small-scale fishers based on survey data sets conducted in the coastal villages Alipur, Mahipur of Patuakhali, and Pathorghata of Barguna district of Bangladesh. The study results provide original baseline information on the natural, social, and health safety hazards faced by artisanal fishers on land and sea. Data about the fishing vessels and fishing practices also identified several areas where safety should be concerned. This chapter also explores the respondents' suggestions and recommendations for a better safety environment on board. These recommendations could help save lives and reduce the devastating impact on the families and communities in instances when a fisher and primary income earner's life is lost at sea.

Introduction

Bangladesh's geographical position and hydrography are highly conducive to the fishing industry and are important to its economy and food security (Shamsuzzaman et al., 2017; 2020). This applies to inland fisheries coastal and marine fisheries within the country's Exclusive Economic Zone (EEZ) and outside this region. Millions of people in Bangladesh rely heavily on the fishing industry for their work and income, with 11 percent of the population being employed within the sector (DoF, 2018). Hilsa shad (*Tenualosa ilisha*) is a primary sea catch in the Bay of Bengal, designated as one of Bangladesh's Geographical Indicators (GIs). Hilsa is primarily caught by small-scale artisanal fishers, with approximately 0.5 million fishers directly depending on this catch for their livelihoods (DoF, 2017). Safety concerns for fishers and their families are severe during the hilsa fishing ban periods due to a lack of income, increased food insecurities, and health risks experienced by artisanal fishers (Sarker et al., 2019).

Artisanal fishing makes up 82 percent of the total marine fishing (DoF, 2018). Artisanal fishing refers to non-commercial, small-scale, and local fishing, operated by small fishing vessels, generally in coastal and shallow waters (FAO, 2020a). The safety of artisanal fishers is a major concern in Bangladesh as they are exposed to various hazards, both natural and man-made, each time they are out fishing in the sea and rivers. The artisanal fishing vessels are often small, <24 m, and as such are not included in the International Maritime Organization (IMO) 2012 Cape Town Agreement (PEW, 2018). Vessels are often ill-equipped without basic safety equipment and encounter little to no enforcement of safety guidelines. The crew's accommodation is usually cramped and noisy, and there is limited space on board for people to work and move around safely (Zakaria et al., 2022). Lack of space also implies less storage for the tools and equipment required for safe fishing operations. Supplies such as ice, fresh water to drink, fuel, and food must also be accommodated on board, leaving very little space for the crew to live and work safely. Fishing is identified as the most dangerous occupation in the world (International Labour Organization, 2016). It is responsible for an estimated 32,000 related deaths per year, according to the Food and Agricultural Organization of the United Nations (FAO) (FAO, 2020b), which is clearly an additional risk that small-scale fishers encounter. The lack of adequate training points to a safety risk for small-scale fishers (FAO, 2016a).

Other safety concerns for fishers are the extreme weather conditions in Bangladesh and its surrounding waters, which are regularly encountered. Weather in Bangladesh can be broadly defined by four seasons: summer, rainy season, autumn, and winter. Seasonal cyclones tend to occur in the summer and late rainy or autumn seasons and often have a devastating impact on small-scale fisheries, with yearly loss of life at sea. Piracy is another concern that small-scale fishers face. The acts of piracy include petty theft, hostage-taking, torture, and cases of murder (Safety4Sea, 2020).

Fishing safety in Bangladesh, particularly within small-scale fisheries, is an under-researched area. The records relating to the impacts of the lack of safety measures and equipment for these fishers, such as the total annual number of deaths and life-changing injuries, are likely to be conservative estimates due to insufficient and unreliable reporting mechanisms and the ambition to preserve the national reputation. The lack of enforceable regulations exacerbates the various existing hazards facing small-scale fishers. The Bangladesh Merchant Shipping Ordinance 1983 requires essential life-saving equipment to be on board all sea-going fishing vessels, but in practice, most of the vessels hardly meet these requirements. Thus, this regulation was updated in the Bangladesh Marine Fisheries Act 2020. The Department of Fisheries recently launched 'The Sustainable Coastal and Marine Fisheries Project of Bangladesh,' which covers fishers' safety equipment, relevant training, and plans against Illegal, Unreported, and Unregulated (IUU) fishing, along with other fisheries issues. However, this is unlikely to meet the guidelines relevant to the international codes and regulations regarding safety at sea. Bangladesh has also yet to ratify ILO's Work in the Fishing Convention 2007, C 188, which is an international convention setting out rules for some of the safety hazards endured in smaller-scale fisheries (ILO, 2017). However, the draft of the FAO-supported national plan of action to prevent, deter and eliminate IUU fishing refers to plans for Bangladesh to ratify the C188 by 2022 (FAO, 2001).

Acknowledging the many dangers that small-scale fishers face in the coastal area of Bangladesh, this chapter sets out to gather and discuss precise information concerning the main occupational safety and health issues often encountered by small-scale fisheries in Bangladesh. The study explores the natural, social (including health), and anthropogenic dangers of hilsa fishers. It also provides the necessary recommendations to mitigate these safety issues and improve the lives of artisanal fishing communities and their families.

Socio-demographics of small-scale fishers

The small-scale fishers are usually between the ages of 20-50 with the majority being between 40-50 years old. Small-scale fishers are mainly divided into three groups, i.e., fishers (labour), skippers, and boat owners. The boat and net owners pay for the net, boat, and other necessities like fuel and food during fishing. The fishers (locally called *jele*), refers to the crew members involved with setting and hauling of nets, catching and sorting fish, and preserving them in ice. The fishing boat skippers (locally known *majhi*) and their assistants are the driving force onboard. In addition, some crew members are involved in cooking and maintaining the vessel engine. These different roles and responsibilities within the fishing industry led to differences in remuneration for various activities and safety investments. For example, the boat owner is likely to invest a large portion of his income into the fishing boat and net making. They are also responsible for ensuring the basic safety standards are met onboard to obtain boat and fishing licenses. However, basic safety standards are not always maintained once the license is obtained. The skipper is the master of the boat and usually takes a double share of the catch profits over the rest of the crew onboard. The skipper is the one responsible for the crew's safety while onboard. Labour fishers receive a minimal share of the catch profits, barely covering their subsistence.

Most fishers (>75 percent) are employed full-time and have more than 20 years of fishing experience. The remaining are part-time fishers with less than five years of experience. Those working as full-time fishers are more likely to encounter occupational hazards at sea. Any accident or serious injury during fishing negatively affects the respective fishing families as the alternative income sources are limited. The new fishers usually start to learn their trade with a more senior family member or a neighbour. The knowledge-sharing related to fishing is intergenerational with no formal training taking place. The new fishing member usually starts a fishing trip in winter when the seas are calmer and fewer storm or cyclone events occur.

In Bangladesh, small-scale fishers mainly target hilsa (75 percent) for their income and livelihoods (DoF, 2018). Shrimp is another high-value species that fishers target. Species such as tuna, mackerel, sardine, squid, and other are mostly caught as by-catch. During the hilsa bans, the government provides 40 kg of rice for each fishing family (those who have ID cards) under the Vulnerable Group Feeding (VGF) program. During the hilsa fishing bans, as Alternative Income Generating Activity (AIGA), fishers tend to take bike rides for transport and work in agricultural fields such as small-scale poultry and cattle farming. They may also participate in net mending, boat repairs, and possibly boat making (Sarker et al., 2019).

Fishing information about small-scale fishers

Bangladesh's small-scale marine fishing is characterized by a large variation in terms of fishing demographic regarding boat size, fishing duration, depth and distance from shore, total number of crew members onboard, storage capacity, safety, and navigation devices for. The boat sizes vary from small medium and larger. The small boats are less than 10 meters long and usually operate during daytime in near-shore waters, with fishing trips starting in the early morning and ending in the evening. The medium size boat is between 10-15 meters in length; fishing trips on these boats lasts around three to six days and the number of crew members ranges between five to seven. On the other hand, a boat of more than 20 meters in length is considered as large that operates in deep sea (out of EEZ) for 12-15 days with 15-20 crew members onboard (See Table 1). The factors such as the size of fishing crew, holding/storage capacity, engine capacity, and fishing distance/depth are all usually dependent on the boat size. For fishing distance and depth measurement, the fishers rely on their indigenous knowledge/technique; for distance, the skipper operates the boat at a specific speed (e.g., 15-20 km/hr) in a particular direction (N/S/E/W) for a specific period (hr). Water depth for fishing operations is estimated at a maximum of 80-100 *bam* or more (approximately 5 feet that are calculated by horizontally extended two arms of an adult man). Few life jackets and buoys, largely present for demonstrative purposes only, as well as FM radio, mobile, and GPS are commonly used for safety and navigation. Meanwhile, there are no radar or sonar-like modern navigating devices on the boats. In an emergency situation, fishers use fishing net floats, water, fuel carriage plastic gallons or drums to survive a capsizing caused by a natural cyclone or other causes.

Table 1. Information about small-scale artisanal fishing in the Bay of Bengal.

Parameter	Category	Respondent (%)
Types and size (m) of a fishing boat	Large size (15-20m)	20
	Medium size (10-15m)	30
	Small size (<10m)	50
Crew number (Total person onboard)	<5	12
	9	32
	14	19
	15-20	37
Fishing seasons	Summer	12
	Rainy	28
	Winter	10
	All year	50
Trip duration (days)	5	30
	10	50
	15	20
Fishing depth (ft)	<200 (Less than 40 bam)	65
	200-300 (40 - 60 bam*)	18
	300-400 (61 - 80 bam*)	10
	400-500 (More than 80 bam*)	7
Fishing distance (km) from shore	<100	42
	100-200	32
	200-300	12
	300-400	9
	>400	5
Storage capacity (Metric Ton)	5	60
	10	23
	>10	17
Engine capacity (HP)	50 -100	43
	100-150	32
	150-200	25
Engine preference	Japanese	13
	Chinese	48
	Indian	39
Having license	Yes	70
	No	30
Communication/Navigation devices used	FM Radio	95
	Compass	60
	GPS	11
	Radar	0

Note: Crew number, storage capacity, trip duration-depth, and engine power are *interlinked with the size/type of boat.*

Safety and health issues of small-scale fishers

The hazards that small-scale fishers face during fishing can be life-threatening. These hazards and health outcomes are categorized into three main areas focusing on social, environmental, and health-related issues.

Social factors

Diverse social factors contribute to the fishers' exposure to safety and health hazards. Most people in the coastal areas of Bangladesh live under the poverty line. They fight for basic survival needs like food, nutrition, health, household materials, water supply, and sanitation (FAO, 1994; Hoque et al. 2021; Jakaria et al. 2022). In many cases, this poverty has left the coastal fishers with no alternative income opportunities other than fishing. They fish even in rough weather conditions and during fishing ban periods without a proper safety equipment. Bangladesh's coastal fishers have deficient financial, social, and educational status (FAO, 1994; Hoque et al. 2021; Jakaria et al. 2022). Illiteracy and a lack of access to information make small-scale fishers unaware of weather signals and basic safety rules during fishing in the sea. Fishers and boat owners are willing to go fishing even in rough weather. As mentioned above, fishing is a kind of intergenerational profession for small-scale fishers and the new family members usually get involved in fishing following their senior family members. Given the socioeconomic conditions, children of a fishing family prioritize going fishing rather than staying in education or looking for other jobs. As more people in the community go fishing and learn from each other, this becomes an informal education for them. Thus, fishers do not care much about taking basic safety training and safety fishing rules that need to be followed. It's not uncommon for fishing trips to end in fatalities. One fisher summed up his concerns by saying:

"Go[ing] for fishing at sea [is the] same as go[ing] for war - not sure we may or may not return."

The safety hazards facing fishers can affect the whole community, and often, a fatalistic acceptance and belief in Allah (God) is taken to the lack of adequate provision of safety equipment and measures taken on board, as indicated by the quotes from fishers below:

"For our safety, we go with nothing (no life jackets or buoys...) but the Allah/God only. Allah/God gives us safety".

Another social safety concern are the piracy attacks on the artisanal fishers during fishing at sea. The risk of the artisanal fishers being attacked by pirates is concerning, with new cases still being reported during the study period (Prothom Alo, 2019). The FAO also noted that the marine fisheries sector of Bangladesh has problems with robbery in the deep sea (FAO, 1994c; Jakaria et al. 2022). The act of piracy that fishers encounter includes theft of personal items, fish, and fishing gear from the vessel. Besides, fishers are sometimes taken hostage in order to collect a ransom (from around 500-5,000+ USD equivalent in BDT) for their safe release. While incident of physical torture is the most common, fishers are sometimes killed by the pirates. Piracy has posed a safety threat for fishers in Bangladesh and neighbouring waters (Rahman, 2013; Dastider, 2017). However, the government has taken different initiatives recently, which have helped decrease pirate attacks. The low-cost alternative technological approach investigated emergency locating the fishing boat during a piracy attack or any other adverse situation for sea fishers in Bangladesh (Munshi et al., 2014).

Environmental factors

Globally, Bangladesh is considered as one of the most vulnerable and disaster-prone countries to climate change (Climate Change Cell, 2007). Bangladesh is one of the top most country that was affected by the ten deadliest cyclones on earth over the past century (Wikipedia, 2021). Higher intensity of natural hazards like cyclones and sea-borne depressions (caused by lower atmospheric pressure) resulted in risky fishing operations, limited fishing, and shortened fishing trips (Islam and Jentoft, 2017). Natural hazards caused by extreme weather conditions can make fishing very difficult and unsafe. The fishers mostly encounter heavy rains, cyclones, lower atmospheric pressure (depression), and hot weather. Heavy rains cause poor sea visibility and increase the likelihood of slipping on the deck. Sea-borne depression and cyclones have been encountered by most fishers and generate an annual loss of life and substantial financial loss (Islam & Jentoft, 2017). Tropical depression and cyclone during summer and rainy season originating in the Bay of Bengal have stopped fishing for a week. Fishers disobey the weather warning and continue fishing with no or minimum safety practices to meet their food security and livelihoods, which can lead to fatalities and morbidities of fishers (Islam & Jentoft, 2017). A death of a fisher due to unsafe fishing practices could pull the entire family into extreme poverty and prolonged suffering. Cyclones are highly dangerous and can get worse due to the limited safety facilities and a lack of safety culture that would promote safe practices onboard. The fishers noted that during hot weather conditions, they may get sunburn and sunstroke. The lack of sunglasses and sunscreen availability means that sun exposure is a particular hazard. In May of 2019, a fisher in Kalapara Patuakhali lost his life during the summer cyclone *Foni* (May 2019). In late Autumn of the same year cyclone *Bulbul* caused the loss of 25 fishers. A summer cyclone *Amphan* in May 2020 caused the loss of 3 fishers in the Mahipur area of Patuakahli.

Health issues during fishing

The small-scale fishers suffer from different health hazards during their fishing trip. The longer they spend time at sea, the more likely they are to experience physical health hazards. The common hazards include diarrhea, vomiting, dizziness, and fever. Besides, eye and skin problems, abdominal pain, peptic ulcer disease, lack of appetite, and dehydration are frequently reported. Fishers also noted heart problems, allergies, and cases of asthma at sea. The high incidence of diarrhoea indicates unhygienic drinking water conditions on board. Drinking water is carried from shore and stored on the boat in a plastic drum for the duration of the trip. Vomiting is caused by seasickness or indicates other health problems. Intense workloads and the manual handling of heavy fishing gear and nets, often operated in direct sunlight or wet saltwater conditions, can cause skin and eye problems. Engine noise, smoke fumes, and confined sleeping areas can also contribute to physical health issues. Allergies and asthma tend to occur more onboard commercial fishing vessels where processing facilities are available (Lucas et al., 2010; 2016). However, small-scale artisanal fishing vessels do not have processing facilities and therefore encounter fewer occurrences of such problems.

After fishing, some fishers suffered from several short- and long-term physical health problems. Operating at sea in an exposed, wet, and constantly moving environment under cramped conditions varies significantly from most working environments on shore, which can have severe long-term physical consequences on the body if not adequately protected. The fishers also suffer from long-term physical problems cardiovascular diseases, hearing loss, visibility health issues, musculoskeletal disorders like tendonitis and cervical neuropathy, and also short-term fevers, colds, coughs, skin problems, and headaches. The findings indicate that many fishers directly experience serious health issues resulting from their occupation (Mandal et al., 2017; Zakaria et al., 2022). Given the importance of small-scale fisheries, providing adequate health and safety support is crucial for maintaining healthy and sustainable fishing communities (Woodhead et al., 2018).

Conclusions and recommendations

The study highlights social, natural and health-related factors that make small-scale fishers susceptible to occupational health and safety hazards. The situation is exacerbated by inadequate regulation, governance, and enforcement of basic safety requirements. Small-scale fishers and their families suffer the most in instances of fishing-related accidents or deaths.

By highlighting the main safety hazards encountered by the small-scale fishers, this chapter provides the following recommendations and safety interventions for the fishers, boat owners, and the Bangladesh government that can contribute to safer fishing practices:

- The fishers should be provided with a full spectrum of essential safety equipment on board. Boat owners and fishers also need a light post near shore to direct proper navigation.
- The fishers and boat owners need to be provided with financial support through low-interest bank loans, which they could use to buy fishing boats and nets and purchase new engines. Therefore, a dedicated, fair banking system (fishers' bank) is explicitly needed to support fishers like '*Krishi bank*' for agricultural support.
- Life insurance for fishers and skippers and boat insurance for boat owners should be provided.
- Improving onboard weather forecasting devices and their availability and strictly following the weather signals could minimize the fatalities caused by natural weather factors.
- During the hilsa ban periods, timely and sufficient support is recommended for the fishers through the Alternative Income Generating Activity (AIGA), which could significantly improve their security (food and financial) and safety when they cannot be at sea.
- An easy and accessible process (under the same ministerial office, either Ministry of Fisheries and Livestock, or Ministry of Shipping) for obtaining a new boat and fishing license or renewing one should be accomplished so that the fishers and boat owners can be motivated to apply for the licenses.
- Establish an effective Monitoring Control and Surveillance (MCS), Automatic Identification System (AIS), and Vessel Monitoring System (VMS) that will allow suitable vessel tracking and enable a fast and effective search and rescue system when necessary.

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17. Fishing at the Frontier: Lived Experiences from a Riverine Fishing Community at the Bangladesh-India Border

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A fisher standing hopelessly on the erosion site, losing all of his properties in the womb of the mighty Padma River (Photo: Jaman Ahmed Udoy, 2021).

This chapter reveals how riverine fisheries serve as a livelihood option for vulnerable fishing communities and identifies the major challenges and stressors these communities face at the Bangladesh-India border. Riverine fishery plays a significant role in livelihood, food, nutritional security, employment, and culture for the local fishing communities; however, this community is continuously shrinking and displaced due to various natural and man-made reasons, particularly by a barrage in the upstream. The 'Farakka Barrage' extremely disrupted the natural riverine production systems, especially fisheries, through noticeably changing natural flow patterns and hindering migrations of fish. Most importantly, riverbank erosion threatens fishers' livelihoods, leading to a devastating loss of homestead land while also changing border boundaries at the frontier. To shield the geophysical and socioeconomic vulnerability of fishers, the unprotected settlement should be safeguarded by efficient and environment-friendly embankments, and their livelihoods should be protected under existing social safety net programs.

Introduction

Bangladesh is situated in the world's largest delta, the Bengal delta. The country is crisscrossed by rivers of varying size and length that primarily originate from three major river basins: the Ganges, the Brahmaputra, and the Meghna. There are 406 flowing rivers in Bangladesh, of which 57 are transboundary rivers, 53 of which originate in India and three in Myanmar (BWDB, 2021). For millennia, rivers played a significant role in the development of human civilizations worldwide as humans relied on rivers and floodplains for their livelihoods, culture, and food (Ahmed and Sinha, 2014). In Bangladesh, people living in the rural areas along the rivers harvest fish almost all year round. Perhaps more than in any other nation, they catch fish without any prior or little investment as part of a subsistence fishery or as professional fishers. A large section of the population relies on riverine fisheries for food and employment. Apart from directly fishing, many people rely on other fishery-related practices such as fish marketing and trading, craft, and gear repairing activities to make a living. For many people, fishing is a seasonal activity, mainly during the rainy season. But for traditional fishing families, it is the primary and, in some instances, the only source of income (Rahman et al., 2002). In addition, each year, many people join fisheries-related activities since they have lost other livelihood options as a consequence of natural disasters such as cyclones or riverbank erosion. Thus, riverine fisheries often serve as the 'activity of last resort' or 'safety valve' for the impoverished section of the society (Islam, 2012).

Riverine fisheries were once well-known for their rich biodiversity and are still cherished for the exotic taste and texture of the fish. However, due to the water withdrawal activities in the upstream countries, barrages, dams, canals, and tunnels have dramatically altered the waterflow — to the point that several long stretches of even those larger rivers stay dry for most of the year (Ahmed & Sinha, 2014). Overexploitation of the fisheries resources, degradation of the natural habitats, siltation due to reduced water supply, construction of sluice gates are all major threats and stressors to the sustainability of the riverine fisheries and the livelihoods of those who depend on them (IFC, 2012). However, challenges to river-based fisheries are multi-faceted and new challenges are continuously evolving. This chapter presents how riverine fisheries serve as a livelihood option for the people living on the border areas of Bangladesh and the challenges they regularly face.

The Padma River, anthropogenic changes, and affected livelihoods

The Padma, as a transboundary river, is known as the River Ganges in India. It is a symbol of faith, hope, culture, sanity and a source of livelihood for millions. The river is the center of social and religious tradition in the Indian sub-continent and most sacred in Hinduism, known as *Ma Ganga* (Mother Ganga) as a living Goddess. By supporting agriculture, animal husbandry, fisheries, tourism, trade and transport, the river contributes significantly to the livelihood, food, and nutritional security of about one-third of Indian and two-thirds of the Bangladeshi population (Kumar, 2017). It is also a center of cultural heritage and has long been a source of fishery-based livelihoods. The biography of the Padma fishermen and boatmen, their joys and sorrows of life, the laughter and the tears, the lack of grievances — which are inherently an integral part of that way of life — are portrayed in Manik Bandopadhyay's classic Bengali novel *Podda Nodir Majhi* (Boatman of the Padma).

The Padma River in northwestern Bangladesh is vital to riverine fish species as a feeding and breeding ground. The most famous fishery species is Hilsa (*Tenualosa ilisha*), locally called 'Padma Ilish'. The species of Padma is the tastiest of all Hilsa — rich in fat and flavor. The Padma River in Bangladesh holds immense importance for supplying water for irrigation, trade and business, transportation, conservation of wildlife, and daily household use of riverbank inhabitants (FAO, 2011). However, the free-flowing Ganges River faced its first barrier in 1974, when the Farakka barrage was built by the Indian governments near the Bangladesh border. The dam is situated 17 kilometers from the border with Bangladesh, and was built to withdraw water from the river, which immediately caused severe socioeconomic and ecological consequences in Bangladesh. The withdrawal of water causes serious ramifications to the riverine fisheries of the Padma River. Following the operation of Farakka barrage, the flow of the Ganges in Bangladesh reduced significantly in the dry season. It was estimated that the average pre-Farakka flow (1934–1975) was 2,340 m^3 /sec, whereas during post-Farakka, the average flow was recorded to be only 1,236 m^3/sec (1975–1995) at Hardinge Bridge point in Bangladesh (Rahman, 2006). At the same time, the discharge of water is increased during monsoons, causing flash floods. The fluctuation of Ganges flow significantly degraded the total ecological system by disrupting fisheries resources, agriculture, navigation, and has led to a growing salinity intrusion from the coast (Mirza, 1997; Giupponi, 2014). River navigation, which is called the heart of Bangladesh's transport network, was also significantly affected. The country already lost about 15,600 km of inland navigational route, and another 3,300 km has become risky for navigation due to the upstream withdrawal of water in India (Ahmed, 2006). Moreover, many fishers, boatmen, businessmen, and farmers have changed their livelihood patterns during the post-Farakka period (Hossain, 2009).

Characterization of small-scale fisheries in the Padma River

The fishing communities presented in this case study live on a *char* (riverine silted island), known as Char Khidirpur. The char is located at the Bangladesh-India border on the bank of the Padma River. 120 fishing households were surveyed through face-to-face semi-structured interviews. In addition, five focus group discussions were conducted to gather empirical data. The age of the active fishers ranges from 14 to 76 with an average age of 46. The majority of people are born in the char while the rest are migrants who came to the village after losing their lands due to river erosion. Most of the fishers' families were composed of four to five members (54.16 percent), two to three members (31.66 percent), and more than five members (14.16 percent). Almost half of the fishers are illiterate, and the rest attended five to ten years of schooling. There is only one government-run primary school in the village. More than half of the fishers (58 percent) send their children to primary school, and the rest employ their children in income-generating activities, mainly in fishing. The instances of child labour are high. Around 65 percent of children study and work besides to supplement the family income. Almost 100 percent of women are housewives, and some of them help their husbands in agricultural work. About 45.65 percent of people are involved in fishing as their primary occupation. The rest do fishing alongside other activities i.e., agricultural work, day labouring, petty business etc. About 55.61 percent of fishermen have an average monthly income that ranges from BDT 8,001-10,000, 19.09 percent of fisherman earned BDT 6,001-8,000, while only 11.62 percent earned more than BDT 10,000 (1 USD=85 BDT). For the majority of the year, the fishers are hardly able to save any money after meeting all the expenses, and the majority live from hand to mouth. However, during the peak season, when they catch a lot of fish, they could save money to cover the expenses during the lean period of the year. About 80 percent of fishers have no additional land except their homestead. The overall characteristics of the fisheries systems are presented in Table 1.

The physiographic condition of the char is precarious and prone to erosion. The fishers have to move from one place to another if they lost their land due to river erosion. Thus, the majority of the residents are found to be living in temporary huts made of mud and roofed with a kind of weed leaves, locally called 'Kash Bone'(*Saccharum sponfaneum*) collected from the riverside. Another smaller group of fishers live in a tin shed surrounded by tin house. Some relatively wealthy fishers live in tin-roofed brick houses. Fortunately, the overwhelming majority have access to safe drinking water from the tube-well while only a few households drink river water. Due to its remoteness, the char is not connected to the national grid of electricity. However, almost everyone has access to solar power-generated electricity. The island is poorly connected to divisional headquarter Rajshahi, the major city in the region. For modern treatment facilities, fishers have to cross the river to go to Rajshahi. Due to poor connectivity, in many cases, the dying patients fail to reach the hospital in time.

Fishing as a livelihood strategy

Almost all the fishers are hereditary fishers, and they want to continue this professional tradition into the future. Despite the adversities and hard-working environment, the fishers find peace and solace in their forefather's profession. They believe that there is a spiritual connection between this river and their occupation. For this reason, they cannot leave this profession even in an unfavourable environment, and they are proud to introduce themselves as fishers. They are highly skilled and professional, and they don't have convertible skills to do other jobs, so fishing is their only hope. But, again, to start agricultural farming or petty business, they would require adequate capital, which they cannot manage. Thus, they entirely depend on the riverine fishery for their livelihoods. Fishers use a variety of fishing gears and crafts for fishing. The majority (68 percent) of the fishers have their own fishing craft; the rest of the fishers hire fishing boats from other fellow fishers or the *dadondar* (local private money lenders and investors in the fishing business).

Table 1. Characterization of small-scale fisheries in the Padma River.

Key features	Explanation
Use of boat	Fishers use boats for fishing at a short distance from the bank or in a distant river.
Types of boat & size	Both engine operated boats and Dingi (non-mechanized simple boat) are used. Usually, small & medium size boats were used in the study area (mostly between 5-15 meters), with a few small trawlers for deep river fishing.
Power of boat engine	Mostly 5HP to 20HP
Materials of boat	Mainly by wood from Mango tree (*Mangifera indica),* Jambul tree *(Syzygium cumini),* Lebbek tree *(Albizia lebbeck),* Shishu tree (*Dalbergia sissoo*) and plain sheet.
Boat production cost	Small to medium size: approximately 40-60 thousand BDT. Large size: different price ranges according to variations; generally costs more than 1 lakh BDT.
Use of fishing gear	Gill net, Seine net, Cast net monofilament, Gill net, Push net, Scoop net, Fishing trap, Hooks & lines, Set bag net and Wounding
Number of people required for gear operation	Usually 3-5 members
Major target fish species	Hilsa shad, *Aspidoparia spp.*, Flying barb, Giant river prawn, *Tengara mystus,* Tank goby, Ticto barb, *Mola carplet*, *Garua Bachcha*, Humped featherback, Bronze featherback, Long-whiskered catfish, Wallago catfish, Stinging catfish, Rohu carp, Catla, Silver carp, Indian river shad, Ganges river sprat, Striped spiny eel, Himalayan glassy perchlet, pama, Corsula, Black rohu, Pangas catfish, Rita, Spotted snakehead, Striped snakehead, Great snakehead, Climbing perch, Giant gourami
Fishing area	Fishers have the right to fish throughout the river. Fishing areas range from short distance of 2-3 km to longer distance of 20-25 km. With the water flow changes of river, fishers also change their fishing areas.
Monthly income	6,000-10,000 BDT
Fishing season	Year-round
Occupational mobility	Only fishing; Fishing plus other employment (e.g., agriculture, day laboring, petty business etc.).
Main purpose of fishing	Mainly for both sale and household consumption or either for sale or consumption.
Disposition of catch	Direct sales to town market or local market, sales to middleman, and retailers.
Processing of catch	Sold fresh for human consumption.
Fishing restrictions	Fishing nets with mesh above 4.5 cm. Two ban periods for hilsa shad fishing. 22- day fishing ban to protect brood hilsa shad in October each year. 8-month fishing ban to protect juvenile hilsa shad (November to June each year).

Both engine-operated boats and non-mechanized traditional boats (*Dingi*) are used by fishers, which are usually small to medium in size. The size of these boats varies between 5-15 meters. Engine boats are used for fishing in distant part of the river, while *Dingi* is used for fishing in short-range distant fishing. A few small trawlers were also used for deep river fishing. Engine power of the mechanized boat mostly range from 5HP to 20 HP. Boats are mainly made of wood from the Mango tree (*Mangifera indica*), Jambul tree (*Syzygium cumini*), Lebbek Tree (*Albizia lebbeck*), Shishu tree (*Dalbergia sissoo*), and plain sheet. The production cost of *Dingi* boats range from BDT 20,000 to 25,000 while medium-size, engine-operated boats cost between BDT 40,000-60,000. Production cost of large size engine-operated boats depended on various factors, including wood quality, engine power, and other variations; the cost of these boats is generally over BDT 100,000.

The fishers employ a range of fishing gears, including *Fash Jal* (Gill net), *Ber Jal* (Seine net), *Khepla Jal/Jhaki Jal* (Cast net*), Current Jal* (Gill net), *Thela Jal* (Push net), *Chekna Jal* (Scoop net), *Ayngta ber* (Fishing Trap), *Barshi* (Hook & line), Behundi Jal (Set bag net), *Ungta* (Wounding gear) as well as some traditional gears such as *Koch,Vair doar, Gang Dohar* etc. Usually, fishers go fishing in groups. In most cases, each team has three to five members. Operating a *Ber Jal* (seine net) requires 15-20 team members. Although fishing activities mainly take place at night, some fishers also go fishing in the early morning. The fishing trips usually last for 12 hours. The total fish catch greatly varies, and the average fish catch per fisher, per day, was about 8-10 kg during the peak season and 1-2 kg during the off-season. The catch rate also varies depending on the height of the water column in the river. The majority of the fishers perceived that they usually get the highest fish catch when floodwater started to recede at the end of the monsoon period. Another group of fishers perceived that the highest yield happened during the monsoon periods. The differences in opinion may be connected to the fishing gears they use. However, all fishers agreed that fish catch is becoming low during the winter season (December-February).

A major part of the catch is sold to the middleman. The retailers buy some catch and a smaller portion of it is directly sold to the consumers in local markets. On top of that, some high-valued fish are destined to city markets in Rajshahi. All fishers experienced a decrease in the amount of catch in comparison to the previous years. Several types of fish species that they caught 10-15 years ago are now almost extinct or rare. The fishers thought several anthropogenic factors to be responsible for fishery decline in the Padma River. According to the fishers' perceptions, several man-made causes such as the use of destructive fishing gears, catching of brood fish, over-fishing, sand mining in the river, river pollution, building embankment on river flow, reduction of water due to the Farakka barrage, and siltation are behind the decline of the fishery. Due to the extreme disturbance of the river's ecological environment, fishery species are losing their feeding, breeding, and spawning ground.

Fishers' lived experiences at the frontier

According to the Mujib-Indira Border Treaty (1974), midstream of border (transboundary) rivers define the boundaries of Bangladesh and India. As the lower riparian state Bangladesh faces a greater risk of riverbank erosion on its side. The erosion of border riverbanks creates problems in border demarcation as the border pillars are sometimes washed away by erosion. This fluid border boundary often triggers conflicts between India and Bangladesh. Both countries will then engage in action to take over the new land (Mia, 2012). This case study on fishers portrays an example of how riverine communities face untold miseries as they live near an unstable river boundary. Due to the riverbank erosion, the border demarcation is changed, and the Border Security Force (BSF) of India has established a surveillance in those places where the border pillars of Bangladesh have been eroded. This situation creates a barrier for movement to mainland Bangladesh, as fishers must pass through Indian surveillance posts to go to mainland Bangladesh. Due to the conflict between the border security forces in the riverbank eroded areas, fishers often need to postpone the fishing activities. Sometimes Indian border security forces block fishers from going fishing in the rivers. The river-based ferry communication with Rajshahi also frequently faces obstruction. Communication with Rajshahi city is becoming very difficult, and fishers had to go through many split journeys to reach the city, which frightens them due to a perceived sense of insecurity. There have been instances of fishers being robbed on the river during their trips. The transportation ferry to Rajshahi operates only at a specific time in the day which hampers the transportation of fish that is caught at different time schedules. Thus, fishers must sometimes hire a boat, paying a high price to transport small amounts of fish, which creates additional financial pressures. In this situation, fishers are forced to sell the fish at a lower price on the local markets. The fishing communities also face multifaceted challenges due to weak governance system. Some influential people use illegal gear for catching fish during the ban periods, but they are never brought in front of the law because of their connections to local politicians. As a result, genuine fishers cannot find enough fish even after working hard all day. At times, local fishers also employ illegal fishing gear to catch a higher number of fish; they often get imprisonment and fined, which burdens the family. The family often had to face financial trouble for continuing legal procedures, resulting in extensive hunger and poverty.

Overall, the livelihood outcomes of these fishers at the frontiers are dismal. Instead of catching fish in their nets, the fishers themselves have been caught up in a complex tangle of poverty, insecurity, and deprivation. The life of the fishers is trapped in *dadan's* net of moneylenders. This debt is hard to escape, leading to endless crises. From generation to generation, the chain of poverty is a constant obstacle in their lives. In sustaining their livelihood, they have to take loans at a high interest rate from moneylenders. As almost all the hard-earned income of fishers goes to the moneylenders to repay the loan, the condition of the fishing family remains unchanged. Even if they had thousand dreams, they cannot build even the smallest fortune.

Hazardous spaces and displacement

Living in a hazardous environment, fishers constantly face the risk of displacement from their settlement due to erosion (Figure 1). The fishing village is under an ongoing process of erosion. There were four villages on the char but within fifteen years, three villages were completely eroded. As a result, the land area of the char is decreased: from 4,000 hectares to only 40 hectares with only one remaining village. The population has also decreased: from about 10,000-12,000 to 3,500. Riverbank erosion forced the fishing communities in the village to move their home from one place to another like nomads. They shared their thoughts of looming fears, afraid that when they are out fishing on the river, their house might be lost in the womb of the river. During the rainy season, many of them will lose their houses and will need to build new ones in other places. In a sudden event of released water from the barrage, they may lose their home with all their belongings. About half of the fishers reported losing their home 5-6 times due to erosion; the rest had to move even more frequently — about 8-10 times in their lifetimes. While the local authorities often attempt to control the erosion, these attempts are primarily short-termed and inadequate to protect the land during the monsoon season. Thus, riverbank erosion is likely to continue with the risk of changing border river boundaries.

Figure 1: (Left): Part of the fisher's home just near the bank of the river, thus prone to riverbank erosion (Photo: G. M. Mehedi Hossain). (Right) A fisher standing hopelessly on the erosion site losing all of his properties in the womb of the mighty Padma River (Photo: Jaman Ahmed Udoy).

According to fishers' statements, when the banks of the river collapsed, and the Bangladeshi villages disappeared, the Indian Border Security Forces (BSF) established the surveillance post in these parts of river water. When the river water recedes in winter, the course of the river changes. To go to Rajshahi, the nearest economic hub and divisional headquarters, the fishers need to cross over the river to where the new Indian surveillance post is. In these cases, they have to rely mostly on the whims of the Indian Border Forces to allow passage. Unsurprisingly, they are terrified of fishing and moving across the border region. According to the fishers, due to smugglers' involvement in the smuggling activities on both sides, innocent fishers face various problems. There have been several allegations of Bangladeshi fishers being detained and tortured by Indian border guards. It was also reported that the fishers from another side of the border often fish illegally in Bangladesh's water territory with highly efficient and destructive fishing gears. This type of action sometimes causes skirmishes between the two countries' border guards, and these fishing communities often bear the brunt of the consequences.

The fishers have blamed Farakka Barrage for the hazardous riverscape. Due to the construction of Farakka Barrage upstream, the flow of water in the Padma is significantly reduced during the dry season. As a result, fish biodiversity in the river has lessened, and agricultural works are at risk due to insufficient water. Notably, in the monsoon, all gates of Farakka Barrage remain opened to release floodwaters. Consequently, the water level of the river Padma in Bangladesh reaches dangerously high levels, inundating surrounding households and intensifying riverbank erosion. Excessive sedimentation, river depth declination, change in thalweg and water flow direction are the adverse effects of the Farakka Barrage. These changes together are the main factors behind the riverbank erosion. The number of fishers is decreasing in these Charlands as their lives are getting more complex day after day. According to one estimation, about 1,500 fishers have migrated over the last five years, relocating to other places, a process which is continuing to date. They mostly settle in the shanti areas of Rajshahi city, working as a day labourer, rickshaw pullers, masons, or sand miners. Some of them even migrate to longer distances, leaving no trace of their previous life in the char.

Conclusion

This study illustrated the deficient standard of living of the fishing families that are far behind in fulfilling their fundamental rights and sustainable livelihoods. Indeed, there has been a lot of progress done in the fisheries sector of Bangladesh lately. Still, without achieving a sustainable standard of living for small-scale fishers, this progress is not expected to last as small-scale fishers are the lifeblood of the fishing sector. The fishing communities in question are undoubtedly vulnerable, both in geophysical and socioeconomic terms. Efficient and environment-friendly embankments should safeguard the unprotected settlement and their livelihoods should be protected by the existing social safety-net programs. In broader context, both the government and non-government organizations must focus on the sustainable development of these vulnerable communities by improving their quality of life and building capacity.

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18. Important and Over-exploited: A Case Study of Baor Fisheries Management of Bangladesh

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Community-based fisheries management has long been practiced in baor fisheries (Photo: Md. Monzurul Islam, 2019).

Oxbow lakes, locally known as baor, have formed during the decades-long process in which dead sections of rivers altered their course while keeping in a considerable amount of water. This chapter discusses the historical evolution of baor management regimes, different management systems, resource status, and users. The findings suggest that the baor resources are being governed by Jolmohal Management Policy (2009) under three management categories: the first category, initially started in 1978, falls under the Oxbow Lakes Fishery Project OLP I and is directed by the Department of Fisheries; the second category, started in 1989, falls under Oxbow Lakes Small-Scale Fishermen Project OLP II within the community-based fisheries management system; third category governs the lease of the baor resources to genuine fisher association. This chapter highlights the limitations of management regulations and discusses fishers' rights, hazards, and livelihoods, concluding that the second management approach category is the best. Based on field observations and stakeholders' input, the chapter provides recommendations on overcoming challenges and ways to improve the management and sustainability of resources.

Introduction

Baors, globally known as oxbow lakes, are a particular type of water bodies found in the southwest region of Bangladesh. These water bodies are semicircular, dead sections of rivers that have been altering their courses for decades, keeping in a considerable amount of water. The arc size may vary in length, ranging from 10 to 95 percent of a circle, never completing a full circle. *Baor* is typically a semi-closed water body that is still part of the river floodplain, connected by its inlets and outlets. It is considered a natural habitat and breeding ground for different indigenous fish and has a huge potential for fish culture. A unique characteristic of a *baor* is that both aquaculture and capture fisheries are practiced without installing any specialized system/structure. *Baors* are located in the southwestern districts of Bangladesh: Jashore, Jhenaidah, Chuadanga, Kushtia, Bagerhat, Magura, Meherpur Satkhira, Faridpur, Gopalganj, Madaripur and Rajbari. These are important ecosystems for the country's inland small-scale fisheries and are common property resources for the local people (DoF, 2019). About 600 *baors* are occupying 5,671 hectares (ha). The area of each *baor* ranges between 10-500 ha, and there are typically one to seven villages located on its shores. Historically, *baors* were considered rich in fisheries resources. The total fish production in *the baor* ecosystem is 10,343.00 metric tonnes (MT), and the average production is 1,824.00 kg/ha, with an annual growth of 28.13 percent in the financial year 2018-2019 (DoF, 2019). Though these *baors* are mostly semi-closed, they are rich in biodiversity. In most of the *baors*, there are two types of fisheries population: stocked (hatchery-reared fish fry is released into *baor* for stock enhancement) and non-stocked (indigenous to *baor* ecosystem).

Over the years, *baor* ecosystems have been facing pressures from natural and anthropogenic threats and risks, including increasing population, siltation, low water flow from the upstream, unplanned Flood Control and Drainage (FCD) and Flood Control Drainage and Irrigation (FCDI) programmes, turning roads in open water bodies, alteration/disappearance of aquatic habitats, loss of river *beel* connection, myopic government agriculture and water leasing policies, and global environmental change, that have led to a loss of breeding and nursery grounds as well as an overall decrease in fisheries productivity (Alam et al., 2017). Most of the *baors* are silted up, resulting in reduced water volume available for fisheries productivity and other benefits due to intensive agricultural farming in their catchment area. To address these challenges, the development of responsible *baor* management and proper use of its resources should be a priority.

History and evolution of baor management regimes

According to the 'Jalmahal Management Policy 2009', *Jalmahal* is a body of water in which the water stays occasionally or remains throughout the year. *Jalmahal* is also known under the following terms: *haor*, *baor*, *beel*, *jheel*, pond, ditch, lake, *dighi*, *khal*, river, and sea. *Jalmahal* can be a closed or an open water body. Fishers' access to these *Jalamahals* has a long history. Before the British colonial regime (1757), fishers had traditional rights over open water bodies, including rivers, floodplains, wetlands, lakes, and oxbow lakes. At that time, fisheries resources were treated as common property and managed by the local fishing community. Fishers held this right up to the early stages of the British colonial regime. To generate revenue for the colonial government, the Permanent Settlement Act was passed in 1793, and these rights over the *Jalmahal* shifted to the *Zamindars* (landlords). At that time, the *Jalmahals* and the surrounding land were sub-divided among *jotedars,* who gave them to *ijaradars* through a lease system. *Ijaradars* collected a toll (tax) from the fishers for fishing on behalf of the particular *jotedar*. Most of these leaseholders were non-fishers. Low caste Hindus were fishers and some rural low-status holder Muslims became fish traders. This system continued till the division of India in 1947.

Afterwords, the new Pakistan government abolished the *Zamindar* system. The *Jalmahal* became government property through a land settlement act (Section 3, The East Bengal State Acquisition and Tenancy Act, 1950). The responsibilities of *Jalmahal* (except reserved forest area) went to the revenue department. An open-auction leasing system was practiced from 1950 to 1965 and during this time the right to use *Jalmahal* was given to the highest bidder. From 1965, preference was given to the fishers' co-operative societies registered at the co-operative department in order to help the poor fishing communities. In independent Bangladesh, during 1973-74, the preference was given to the registered fishers' co-operative society to agree to the highest bid value. However, this system was unsuccessful. Because the leasing system was introduced by the previous leaseholders taking the co-operatives façades and arranging a sub-leasing system also having an effective control, all *Jalmahal* including *baors* have started to be transferred from the Ministry of Land to the Ministry of Fisheries and Livestock (MoFL) with an attempt to change these from revenue-earning to sustainability by a presidential order during 1974-84 (Ahmed et al., 1996; UK Essays, 2018; Mamun and Brook, 2015). During 1984-86, *Jalmahal* were leased out through an open auction system within the fishers' co-operative societies that replaced the negotiation system, which was ultimately changed to a sealed-envelope tender system

(UK Essays, 2018).

The New Fisheries Management Policy (NFMP) was launched in 1986 to emphasize ecological management of selected *Jalmahal*. Under this rule, a licensing system was introduced to protect fishers' rights over the water body. Due to its failure, this policy ended in 1995 (UK Essays, 2018). During 1995- 1996, the Open Access Policy was launched, abolishing the lease system of flowing rivers. Under this policy, license-free fishing was made available for all except for fishers using mechanized boats. In 2005, the Water Body Management Policy was passed to ensure poor fishers get access to *Jalmahal*. In 2009, Jalmahal Management Policy was adopted when the government approved some changes in Water Body Management Policy 2005 (UK Essays, 2018). With the evolution and changes of *Jalmahal* management over hundreds of years, the *baor* management also faces transformation. After Bangladesh achieved independence in 1971, several projects were undertaken for different *baor* ecosystems. To demonstrate the possibilities of a major increase in fisheries production, a pilot project called Oxbow Lakes Fishery Project (OLP I) was launched during 1978–1986 with financial assistance from World Bank/IDA (Ahmed D, 1998). Through the OLP I project, six *baors* were brought under culture-based fisheries management during 1978-1986. Under this system, the *baors* are directly managed by the Department of Fisheries (DoF) and fishers enjoy their rights to *baor* resources on a catch share basis. After completing the project, the government was inspired to undertake Oxbow Lakes Small-Scale Fishermen Project OLP II (1989 – 1997). The OLP II was introduced in 1989 to establish the rights of poor fishers by ensuring their participation in the management process. The project was implemented in 23 *baors* by the DoF and the Bangladesh Rural Advancement Committee (BRAC) with technical assistance from the Danish International Development Assistance (DANIDA) and funded by the International Fund for Agricultural Development (IFAD) and DANIDA (Middendorp et al., 1996). Under the OLP II, *baors* are being managed through Community Based Fisheries Management (CBFM) with the supervision of DoF. Although both projects have been completed, currently, these 28 *baors* are being cultured and managed like "OLP I programme (6 *baors*)" and "OLP II programme (22

Baors)" for enhancing overall productivity of these *baors* and to uplift the socioeconomic condition of the fishing communities. The rest of the *baors* are leased out to private bidders under the '*Jalmahal* Management Policy 2009' by the district *Jalmahal* committee on behalf of the Ministry of Land. This policy ensures that only genuine fishers can get a lease of *baors* by creating an officially registered fishers' association or co-operative. However, the reality is that the powerful local individuals had convinced the poor fishers to form an association to get the lease of the *baors*. At the same time, the rural elite became the de-facto owner of the lease.

Types of baor resource management

Over the years, three different types of management practice have evolved in *baors* enforced by three different types of controlling bodies. Thus, the *baors* are historically categorized under three categories based on their management.

In the first category, the *baors* are managed under the OLP I programme; the government provides necessary technical and administrative management such as fingerling stocking that is managed and supervised by *the baor* manager and assistant hatchery officer. The DoF provides the fishing license to lakeside fishers. Members of *Matsajibi Samiti* (fishers' organization) receive the license for the non-stocked fish catch. However, some selected fishers get licenses to harvest cultured and non-stocked fish. Non-stocked fish can be harvested freely, around the year, using different gears, while cultured fish is harvested twice a year. Fishers get a 40 percent share of the total catch, and 60 percent goes to the government. Of the 60 percent, the DoF receives 35 percent, and the Ministry of Land (MoL) gets 25 percent of the revenues.

In the second category, *baors* are managed under the OLP II programme, where the fishing communities are the main governing body. The government provides technical support through the local fisheries office. The Lake Management Group (LMG) implements the CBFM. The LMG is an elected body voted by the local fishers' association members. The committee of LMG is comprised of a chairperson, a secretary, a cashier, and the fishing group leaders. A fishing group consists of fourteen to sixteen members. Each LMG consists of a Lake Fishing Team (LFT) and a Fish Farming Group (FFG) (Middendorp et al., 1996). LFT members are men, while women belong to FFG. FFG members are only involved in fish farming in the *baor* fishponds.

Unfortunately, a conflicting relationship exists between the two groups. The main reasons behind the conflict include: (i) objection from LFTs and the wider community regarding the participation of women in fisheries activity; (ii) both groups claim their demands on *baor* fishponds; (iii) dispute over the share of fish harvest during the floodwater inundation of *baor* fishponds; and (iv) inability of women to directly partake in fishing. However, communities developed some management rules focusing on sharing benefits, access to the common resource pool, conflict prevention, and keeping the ecosystem healthy. As part of successful management, they unified the two groups (LFT and FFG) as part of which men from fish farmers' households take part in *baor* fishing activities on behalf of women. Fish is harvested (both stocked and non-stocked) at least thrice a year. Net income is equally distributed among the fishers. However, the level of success is not the same for all lakes under this management category. For example, only a few *baors* have sanctuary because all fishers need to agree on establishing a sanctuary. Still, this category is the best of the three management systems.

Under the third category (in a leased *baor*), resources are managed by a lease holding fishers' association. The leaseholders have full control over the water body and access to both the stocked (culture) and non-stocked (capture) fisheries. The leasing policy itself restricts many fishers from benefiting from the *baor*. Despite several local fishers' associations, only one association can get the lease, which creates conflicts between fishers' associations. A small mesh-sized net is used to harvest both stocked and non-stocked fish. Some leaseholders allow local fishers to catch non-stocked fish in small quantities, although this is not permitted in most cases. The high cost of leases motivates the leaseholders to cultivate fast-growing fish in high density, hampering the natural balance of the water body, which eventually affects the overall biodiversity. For example, small indigenous species in these *baors* are on the verge of extinction.

Fishers' livelihoods

The majority of the fishers in *baor* areas have been fishing for, on average, 20-30 years. Most of them are lower caste Hindus for whom *baor* fisheries is a traditional occupation. The total number of fishers of a particular *baor* is divided into sub-groups of fourteen to sixteen members, each led by a group leader. Each group operates their fishing net separately from others near the *komor* (bush shelter), which is selected for them during stocked fisheries harvesting time. Most fishers have 3-4 pieces of *komor* and *kochal jal,* which they join together during operation. In addition, most fishers have their fishing craft (*dingi nouka*) by which they can catch non-stocked fish round the year. Women don't participate in harvesting activities, but they are involved in mending nets and fish sorting alongside their husbands.

Before introducing cultivated fisheries, *baor* resources used to be open for all fishers. After the aquaculture was introduced, a section of fishers was left out. However, some interventions were beneficial, such as marketing activities, improving transportation modes, new trading opportunities, and crop production increment. Altogether, these transformed the effect of oxbow lakes, contributing to the well-being of the people living around the catchment area. Specifically, the project helped part-time and full-time fishers (those with landholdings of 2.5 acres or less) by providing employment opportunities. In this way, the project activities helped different landless people boost their income and increased the productivity of the oxbow lakes and their adjacent water bodies. At the same time, the intervention led to some fishers losing their fishing opportunity as they are not selected as project beneficiaries. As a result, the fishers' human rights and *de facto* rights have been violated since they traditionally utilize *baor* resources. Consequently, they are forced to adopt various new livelihood strategies, including working in agricultural and non-agricultural activities.

During the lean times and fishing ban periods, the livelihood of fishers is tough. As they have limited alternative income options, most of them take loans from middlemen or NGOs at a high-interest rate, making them further vulnerable to poverty. In coping with such a situation, some adopt different strategies, including working as day labourers and reducing the daily meal intake in terms of number, size, and quality of meals at the household level. Moreover, they take their kids back from school and employ them to work to supplement the family income. Additionally, overexploitation of common-pool resources and other environmental degradation undermine the community's adaptive capacity to a severe level. Food insecurity, malnutrition, and human causality are the typical consequences of such disasters.

Obstructions to baor fisheries management

The barriers to managing *baor* fisheries are multi-dimensional, caused by different management, natural, economic, and social factors in *baors* that are managed under different regulating bodies (Ahamed *et al.*, 2019). These challenges and their likely causes and effects on *baor* fisheries management are shown in Table 1.

Table 1. Challenges in baor fisheries management with their likely causes and effects.

Key challenge	Type of *baor* management category	Likely Cause	Impacts
Flawed leasing system	ABC	*Jalmahals* belong to the Ministry of Land, and beneficiaries must lease these water bodies for a particular period without any time-length guarantee.	DoF/fishers/leaseholders must follow top-down decisions by the Ministry of Land that may create unfavorable conditions in the fish population.
Absence of sanctuaries	BC	Lack of agreement among fishers when it comes to establishing a sanctuary and lack of incentives from the authorities.	Decreased species diversity of non-stocked fish species.
Insufficient fry release	A	Lack of attention and care of the *baor* management authority.	Targeted production of fish not being achieved.
Poaching	A	Insufficient monitoring and lack of attention of *baor* management authority.	Poaching of fish that causes a decline in fish production.
Pollution from agricultural waste	ABC	Fertilizers and pesticide run into *baors* through rainwater from the catchment area.	Deteriorated water quality that causes fish mortality.
Jute retting	AB	Local communities use *baor* water as the primary source for the jute retting process.	Water quality deterioration affects fish production and domestic use of water.
Aquatic weeds	A	The growth of weeds is stimulated by the runoff of nitrogenous fertilizer from the catchment area.	Declined water suitability and decreased water depth for fisheries habitat.
Insufficient rainfall during monsoon	ABC	Seasonal disturbance due to climate change effect.	Hampered recruitment in the population of non-stocked indigenous fish.
Decreasing water depth	ABC	Siltation and lack of excavation	Decreased fish stock abundance in *baor*
Decreasing water area	ABC	*Baor* periphery is more silted due to jute retting and crop cultivation, and the *baor* area is being squeezed.	Decreased fish stock abundance in *baor*
Heavy rainfall and floods	ABC	Climate change anomalies, surface runoff, and siltation caused floods in the *baors*.	Overflowing water from a lake causes fish to escape.
Poverty	AB	Income from *baor* remains low	Fishers face trouble in securing the money needed for investments in fishing.
Poor interest in secondary occupation	A	Fishers entirely depend on *baor* resources and consider it as a traditional occupation.	Vulnerable livelihoods
Exploitive loan system	ABC	High-interest rate and difficulties in securing loans from banks and NGO.	Unable to make investments that would improve livelihoods and help in coping with shocks.
Poaching	AB	Insufficient guard and livelihood vulnerability drives local people (mainly those who don't have the membership) to poach.	The decline of fish production and fishers' income
Ignorance of local fishers	ABC	The fishers lack awareness of good governance practices and resource stewardship.	Unsustainable fish production

A: Baors managed by the DoF, B: Baors managed by CBFM, C: Baors managed by the leaseholders

Conclusion

In southwestern Bangladesh, a considerable portion of the population depends on *baor* fisheries resources for their livelihood and well-being. While once *baor*s were rich with fisheries resources, environmental changes have been gradually slowing down the free-flow of these open waters. However, these changes made many *baors* suitable for aquaculture. Now *baor* fisheries in Bangladesh are mostly filled with extensive culture systems. A proper management strategy and introduction to modern aquaculture practices, such as semi-intensive and intensive practices, can improve production. The CBFM based management has been identified as the best among the three existing management systems in *baor.* However, even under this management scheme, the diversity and abundance of small indigenous fish species is declining due to natural habitat degradation. The majority of *baors* have no fish sanctuaries to protect fish species from overexploitation. The government should take the necessary steps to establish at least one permanent sanctuary for each *baor* with regular monitoring through the Department of Fisheries. Additionally, ecosystem-based *baor* management should be practiced. It is also urgent to introduce a fair leasing system, developed specifically for poor fishers. The government should implement a monitoring system. Credit facilities that are mortgage-free and with low interest rates should be available to fishers. Finally, technical measures such as excavating silted lakes and establishing no-take fish sanctuary should be properly managed in each *baor*.

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19. Degradation of Fish Habitats and Conservation Issues of Chalan Beel Fisheries of Bangladesh

Md. Abu Sayed Jewel & Md. Ayenuddin Haque
University of Rajshahi

Sanctuaries in Chalan Beel result in higher fish catches and better daily incomes for fishing communities (Photo: Md. Abu Sayed Jewel, 2020).

Wild fish stocks of Chalan Beel, a significant wetland of Bangladesh, are of enormous importance to the economy, livelihoods, and food security of Bangladesh. However, loss of fish biodiversity due to the degradation of aquatic habitat hampers the sustainability of this vital ecosystem. This chapter addresses the causes of biodiversity degradation, the likely failure of existing fish sanctuaries to conserve fish diversity, and a practical management approach to address these conservational drawbacks. The study identified a wide range of threats and stressors that caused the transformation in once productive fishery in the Chalan Beel ecosystem into a degraded fisheries habitat. The study recommended: (1) structural improvements (ring pipe, hexapods, and tree branches) in the construction of sanctuaries, (2) the formation of community groups and awareness building on conservation needs, (3) a ban on fishing during a breeding period, (4) promotion of an alternative livelihoods approach during the ban period, and (5) prioritizing an ecosystem-based management approach for improving overall ecological condition of the beel.

Introduction

Chalan Beel is the largest beel in Bangladesh, with an enormous environmental and socioeconomic importance (Hossain et al., 2009; Alam & Hossain 2012). A *beel* is a comparatively large and lentic lake-like perennial natural wetland that stores surface run-off water from flowing water bodies such as rivers and canals (Alam & Hossain, 2012). This large depression of water mass is mainly formed by the amalgamation of former courses of Atrai river, Karatoya river, and the tributaries of the mighty Brahmaputra river. Chalan Beel is consisted of a series of depressions interconnected by many channels to form one continuous area of water bodies during rainy season (July–November), and it covers an area of about 368 km^2 and extends over four adjacent districts — Rajshahi, Pabna, Sirajganj and Natore (Alam & Hossain, 2012). Currently, the beel ecosystem covers a 9,164 ha area, including 93 internal beels during rainy season and 2,227 ha in the dry season (Khanam et al., 2023). There are 16 rivers and 22 canals that pass through the beel. During dry winter and summer, water area of the beel ecosystem decreases down to 52 - 78 km^2, which looks like a cluster of smaller *beel*s of varying sizes. This ecosystem offers an excellent alluvial cropland along with biodiversity rich during post-monsoon season (Alam & Hossain, 2012; Sayeed et al., 2014).

The unique ecosystem of Chalan Beel offers sites for fishing, agriculture, aquaculture, livestock farming, integrated farming, and a place for recreation and tourism. Most importantly, this ecosystem harbours a huge number of different fish species. It supplies highly-prized fish varieties to local and national markets and serves as a livelihood option for about 100,000 fishers (Hossain et al., 2009). These fish catches are for both subsistence/consuming at home and for sale. The majority of them are less educated with limited skills needed for alternative livelihoods.

However, in recent decades, Chalan Beel became one of Bangladesh's most endangered fishery ecosystems due to different anthropogenic and natural disturbances. Although the beel is a static water body, once there was a strong water flow across Chalan beel. In Bengali, '*chalan*' means moving and it is believed that the name of the wetland refers to its original water flow. Presently, the beel has turned into a dead one and the fisheries habitat has been destroyed. About 22 rivers have dried up over time due to various pressures. Consequently, indigenous fish species diversity that significantly contributed to the livelihoods and economy of local people are threatened or extinct.

This chapter assesses the different anthropogenic disturbances the Chalan Beel fisheries face. The findings reveals how the environment of Chalan Beel transformed from a highly productive fishery to the current degraded situation and the drivers which caused this degradation. The study collected primary data by interviewing stakeholders of fish sanctuaries established in different smaller beels in different locations of the ecosystem. In addition, secondary literature was reviewed to validate the perceptions shared by the study participants.

Chalan Beel fishery: Threats and stressors

Historically, the Chalan Beel was well recognized for its of rich fisheries resources that supported the livelihoods of many people living around this beel. In addition to the lower levels of education and very limited choice for livelihood alternatives in the area, the fishers dependent on the beel fishery are economically deprived. According to the respondents, the most commonly used fishing gear in Chalan Beel are push nets, cast nets, lift nets, and hooks. Among these, catch per unit effort is the highest in lift nets. The average daily fish catch of the beel is around 3.25 kg. The fishers have become more vulnerable with the change in the ecosystem from high productivity to low. A respondent stated, *"Once there was a huge production of indigenous fishes from the beel which have now disappeared'*, emphasizing the historical state of the beel fishery.

Respondents were asked to identify and describe the problems which led Chalan Beel to its present drastic situation. The findings showed that five anthropogenic stressors along with one natural factor have contributed to the decline of fish production (Figure 1).

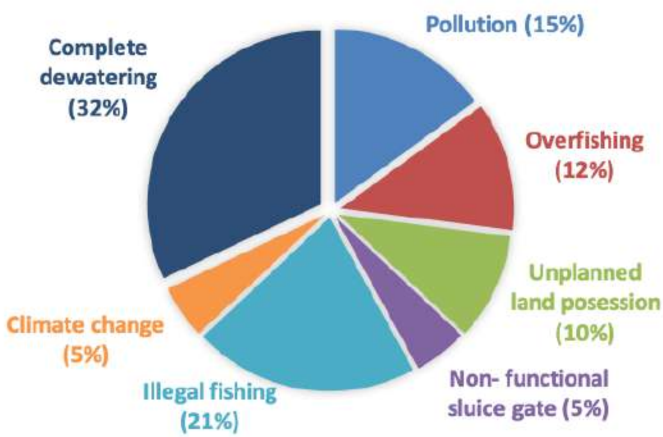

Figure 1.Threats and stressors to the Chalan Beel fishery in Bangladesh.

Overfishing

Overfishing is acknowledged as a big problem to Chalan Beel fishery as described by 12 percent of the participants. Some fishers catch fish with bamboo-made '*Banas*' that act as fish-passing obstacles. These are placed at the mouths of canals and small rivers when water levels are low before the seasonal floods. Although mature fish are known to spawn in floodwater, they are caught before spawning. All kinds of fish, crabs, snails and other aquatic organisms are also harvested uncontrollably causing rapid destruction of the biodiversity.

Unplanned land use development

Ten percent of the respondents claimed that massive infrastructure such as roads, embankments, highways, unplanned barriers, bridges, culverts, and housing projects have blocked many water bodies (e.g., Ishwardi-Sirajgonj railway, the Flood Control and Drainage (FCD) infrastructure). These constructions have caused a gradual decrease in the volume of Chalan Beel water body. The sediments stored along both sides has almost stopped the water flow. In additions, the rise of chars in the rivers has diverted the water flow and caused contraction of areas (Nasim, 2020). As a result, indigenous fish species have lost habitats and migratory routes, which has adversely affected their breeding, spawning, and migration.

Non-functional sluice gate

Approximately 5 percent of respondents thought that rivers were dead because the sluice gate constructions are non-functional and block the water flow along rivers, including the Baral river, a large river which is referred to as the "heart of Chalan Beel". Baral river fed most small rivers, canals, and smaller beels in the region. However, its normal course was interrupted due to the construction of several sluice gates around its mouth causing the river to disappear for about 30 km during the period of 1985 and 1996 (Azom et al., 2021). As a result, the Baral river and its beels, and creeks have all dried up since then. Without this perennial water source, there is no water for eight months of the year and water remain only four months during the rainy season. Moreover, the water body is turned into a cropland when it dries up. During the dry season, therefore, Chalan Beel has a significant water scarcity that significantly impact both agricultural and fish productivity.

Illegal fishing

Another problem confronting the fishery is illegal fishing as was identified by 21 percent of respondents. Despite the prohibited use of fishing gears such as the monofilament gillnet (*jal*), fishers continue to employ these gears targeting brood fish and recently spawned fry of many indigenous species. Though the Fish Act of 1950 forbids catching of juvenile fish, many fishers continue to use various nets and traps at the start of the rainy season. Thus, the spawn and fry of many native species are caught in nets and traps, leading to their demise. *Gher* (e.g. The modification of rice field surrounded by high and wide dikes with canal dug at the inner periphery) fishing is very common at Manda Upazila in Naogaon along the Atrai River targeting the fish caught in fallen bamboo and tree branches along the banks and in the deep river. To draw in more fish, the *gher* is heavily fed with supplementary feed before being covered with a net although the Fish Act of 1950 restricts this kind of harvesting. The biodiversity of the beel is severely harmed by this destructive fishing.

Pollution

Pollution was cited as a concern for the Chalan Beel fishery by 15 percent of participants in the study. These pollutants include pesticides and fertilizers overused in agriculture and aquaculture. This leads to harmful contamination of water bodies resulting in the extinction of native freshwater fish species.

Climate change

Only 5 percent of participants expressed their concerns about impact of climate change on Chalan Beel fishery. According to them, the rainy season is getting shorter while the dry season gets longer over time. This results in shorter fishing seasons. Moreover, late rainy season causes disturbance to spawn of fish resulting in low fish production.

Complete dewatering

Complete dewatering, as identified by most study respondents (3 percent), is the most serious cause contributing to the loss of biodiversity in Chalan Beel. They claimed that during the dry season, only deep beel regions (depressions) have water left behind, and that individuals utilize pumping or mechanical dewatering to catch the remaining fish altogether, including the breeding stock. The collapse of the breeding stock prevents natural recovery of endangered species causing loss of biodiversity.

Management actions as responses

Older fishers of the region can clearly remember that the beel was abundant with various fish species several decades ago. Yet, fisheries resources have decreased over the recent past due to different threats and stressors. This situation worsens during the dry season when water levels drastically reduce leaving several shallow pockets of stagnant water causing less refuge for the remaining fishes. During this time, fish are exposed to greater predation and increased susceptibility to capture, which causes a disproportionate reduction in the brood fish stock and poses a serious risk of depleting species to below recoverable levels.

To address the present situation, protection of brood-stock and juvenile species would be the most effective action towards ensuring the sustainability of fisheries resources of Chalan Beel. As a, establishment of a fish sanctuary is considered the most promising tool in managing and conserving depleted fisheries resources. In fact, several fish sanctuaries have been introduced by different government and non-government organizations in different parts of the beel. This approach is also recognized as the practically easiest to implement in Chalan Beel compared to other potential measures such as fishing gear restriction, implementation of ban during spawning period. Between 2006 and 2017, a total of 40 sanctuaries were established in the beel by the Department of Fisheries (DoF), including both seasonal and permanent conservation areas. According to the study respondents, these sanctuaries have positively contributed to fish productivity, biodiversity conservation, and improvement in socioeconomic status of local communities. Fish sanctuaries are increasingly gaining recognition as the most effective approach to protect, conserve, and manage fish diversity throughout the country.

Establishment of sanctuaries: A way forward?

Although it has been recognized that fish sanctuaries are an effective approach to preserve the diversity of fish in a body of water and, in some situations, to prevent the habitat from being destroyed (Siddique et al. 2020), there was a lack of research about the performance of Chalan Beel's sanctuaries. The respondents interviewed in this study stated that the existing sanctuaries play a significant role towards their socioeconomic improvement through increased fish cached and a higher daily incomes. This finding was also consistent with a recent study by Khanom et al. (2023), who discovered that a significant rise in total catch and the biodiversity index suggests a steady habitat restoration although the recovery of species may have been less. They concluded that the fish sanctuary's effects may have contributed to a rise in biodiversity index and overall catch.

Despite the contributions of sanctuaries towards sustaining fish stocks and socioeconomic improvements, the effectiveness of sanctuary establishment is debateable. Among the 40 sanctuaries evaluated in the present study in different parts of Chalan Beel showed that only 16 are well-managed whereas 24 are mismanaged. When participants were asked to acknowledge the factors impeding the effectiveness of sanctuary, they identified several factors (Figure

2). The lack of monitoring and renovation (36 percent), lack of improved structure (17 percent), illegal fishing (18 percent) were the factors mostly identified followed by management conflicts (10 percent), overfishing (7 percent), pollution (8 percent) and siltation (4 percent).

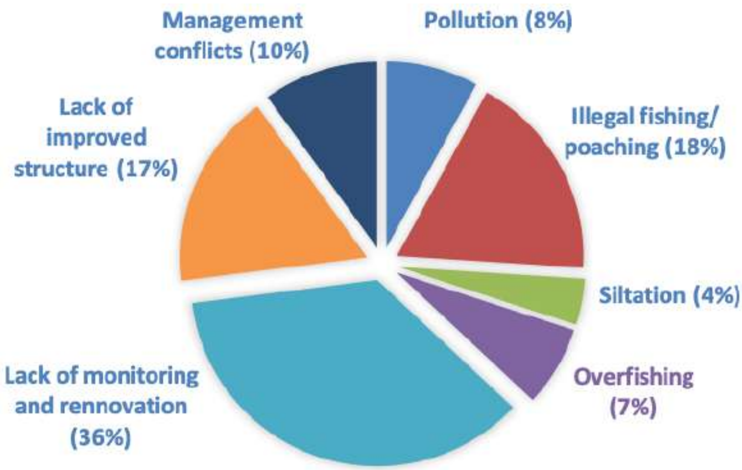

Figure 2. Causes of the failure of existing sanctuaries in Chalan Beel.

As shown in case of Halti Beel tank sanctuary in Chalan Beel by Siddique et al. (2020), a proper management of sanctuary results in an increase fish production and socioeconomic development of the dependent community. Factors such sanctuary type, location, sanctuary structure, and other technical and social issues should be considered in establishing fish sanctuaries to ensure efficient management. There should also be some comparative measures to evaluate the ecological and social improvement of sanctuary-dependent areas should also be evaluated in comparison to the communities without any sanctuaries to evaluate its efficiency as a management tool.

Community's active participation can also result in better outcomes in managing a sanctuary (Islam et al., 2016). For example, community-based fisheries management in Ashura Beel in Dinajpur (Mustafa et al.,

2012) was effective as they focused on local interests and involved the community in the establishment of the sanctuary. The present study on Chalan Beel recommends: (1) structural improvements in constructing sanctuaries using ring pipes, hexapods, and tree branches, (2) formation of community groups and building their awareness on management needs, (3) imposing a ban on fishing during a specific breeding/spawning period, (4) introducing alternative livelihood approaches during the ban period to ensure biodiversity conservation, and (5) implementing an ecosystem-based management approach to improve the overall ecological condition of the Chalan Beel ecosystem.

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20. Fish Diversity Decline Threatens Small-Scale Fisheries in the Haor Basin of Bangladesh

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The establishment of sanctuaries is a response to the governance system of the haor ecosystem (Photo: Debasish Pandit, 2019).

The haor basin ecosystem in northeastern Bangladesh is a natural hotspot of inland fish diversity, which significantly contributes to country's small-scale fisheries. Small-scale fisheries provide food security and employment for the millions of fishers in the haor region. However, the decline in fish diversity has become a major concern in the basin due to several natural, social, and governance-related drivers. Using the I-ADApT framework as the analytical lens, this chapter assesses fish species diversity and responsible stressors impacting the natural, social, and governing systems. The chapter concludes with a presentation of major problems accountable for declining small-scale fisheries production of the basin with possible conservation measures. The consolidated information of this chapter might be helpful to drive effective national policies and programs for safeguarding the haor fish diversity and small-scale fisheries of Bangladesh.

Introduction

In physical terms, *haors* are saucer-like or bowl-shaped, shallow marshy wetland ecosystems covering almost one-fourth (25 percent) of northeastern Bangladesh (Alam et al., 2015; Pandit et al., 2015; DoF, 2019). The *haor* basin is a natural combination of low-lying wetland habitats comprising rivers, streams, large areas of seasonal floodplains, irrigation canals, and hundreds of interconnected *beels* (CEGIS, 2012; Pandit et al., 2021). About 411 *haors,* comprising more than 8,000 km2, are distributed over seven districts: Sylhet, Sunamganj, Moulvibazar, Habiganj, Kishoreganj, Brahmanbaria, and Netrakona (Pandit et al., 2015; Sunny et al., 2020). During monsoon season, the *haor* basin receives massive discharges from various rivers streaming down from Assam and Meghalaya's hills, transforming it into a vast inland sea.

The *haor* basin of Bangladesh is enriched with many potential fisheries resources and provides feeding, breeding, nursing, and overwintering grounds for numerous resident and migratory fish species (Sunny et al., 2020). However, the *haor* ecosystems are threatened due to several anthropogenic and naturally induced causes (Pandit et al., 2015, 2021). Destruction of fish habitat caused by roads, embankments, drainage, flood control, pollution, aquaculture, siltation along with overfishing, dewatering of certain vital areas, use of unauthorized and destructive gears, and climate change are some of the main causes leading to a reduction of fish and other aquatic resources (CEGIS, 2012; Alam et al., 2015; Aziz et al., 2021). These activities contribute to the disappearance of many fish from the natural waters, leading to genetic erosion and a threat to indigenous fish species (Alam et al., 2015).

The I-ADApT framework (Assessment based on Description and responses and Appraisal for a Typology) was used to identify the natural, social, and governance aspects and select suitable responses for sustainability (Bundy et al., 2016). Using the I-ADApT framework, we worked on the main issue, stressors and their impacts, vulnerabilities, responses, and appraisal, where the decline in fish diversity affects small-scale fisheries that link the natural properties of the *haor* ecosystem with the social and governance systems. The present status of the natural, social and governance systems, factors or stressors affecting these systems, and their impacts on natural resources are discussed in this chapter.

Description of the drivers and their impacts

Natural system

The *haor* ecosystem is unique due to its vast wetlands, wide river-fed floodplains, ample amounts of rainfall, and suitable temperature, all of which make it most suitable for supporting high fish diversity. A total of 154 indigenous fish species from 35 families and 12 orders inhabit these areas, with Cyprinidae and Cypriniformes being the dominant family and order, respectively (Table 1). The most dominant species include *Puntius sophore, Mystus tengara, Chanda nama, Parambassis ranga, and Esomus danrica*. Among the identified fish species, 35 percent are threatened, of which 16 percent are endangered, 14 percent are vulnerable, and 5 percent are critically endangered. The remaining 65 percent of species is comprised of near threatened (16 percent), least concern (44 percent), and data deficient (5 percent). Cypriniformes is the most vulnerable order with a maximum number of threatened fish species (27), representing half of the *haor* basin's total number of threatened species.

Table 1. The present status of fish in the haor basin.

Sl. no.	Name of orders	No. of families	No. of species	Threatened species (by numbers)			Non-threatened species (by numbers)			
				CR	EN	VU	NT	LC	DD	NE
1	Anguilliformes	2	2			1		1		
2	Beloniformes	3	4					3	1	
3	Channiformes	1	5	1	1			3		
4	Clupeiformes	3	7		1	2		4		
5	Cypriniformes	3	65	4	13	10	12	23	3	
6	Cyprinodontiformes	1	1					1		
7	Mugiliformes	1	2			1		1		
8	Perciformes	7	17				5	12		
9	Siluriformes	10	42	3	8	4	6	18	3	
10	Synbranchiformes	2	6		1	2	1	1	1	
11	Syngnathiformes	1	2			2				
12	Tetraodontifomes	1	1					1		
	Total	35	154	8	24	22	24	68	8	

Status code: *CR- Critically Endangered, EN- Endangered, VU- Vulnerable, NT- Near Threatened, LC- Least Concern, DD- Data Deficient, NE- Not Evaluated.*

Small-scale fishers often claim that overfishing is the main threat to fish diversity in the *haor* basin. According to the experienced fishers, the main issues of concern include increased fishing frequency, a higher number of fishers, an increased number of destructive fishing gears, and a rise in the usage of small mesh-sized nets. Additionally, the connecting channels between the *beels* and rivers are blocked by constructing flood control embankments, roads, and dams. As a result, the migratory routes for the fry/fingerlings and brood fish become blocked (Pandit et al., 2015; Talukder et al., 2021). On the other hand, the construction of sluice gates, bridges, and culverts facilitates fish migration. These structures also help fishers to catch more fish by fencing and setting traps within gates or bridges, leading to reduced biodiversity (Sunny et al., 2020). Further, irrigation in agricultural fields adversely affects *haor* ecology and fisheries resources in the winter season (Aziz et al., 2021).

Aquatic plants and reeds provide necessary feeding, breeding, and nursery grounds for fish and other aquatic organisms in *haor* basin. De-weeding and deforestation are mainly practiced for fishing, navigational, and fuel collection purposes. For example, about 61 percent of people of the Tanguar Haor area in Sunamganj argue that the destruction of swamp forests led to the depletion of fish and other resources (Haque & Kazal, 2008). Likewise, an absence of aquatic plants in the Hakaluki Haor caused fish biodiversity reduction (Islam et al., 2011). In this way, unsustainable use and destruction of swamp forests and reeds negatively affect fisheries resources (Alam et al., 2015).

Haor basin faces water and sediment pollution as it repeatedly receives discharges from untreated sewage, industrial run-off, agricultural run-off, stone crushing waste, polyethylene, and plastics. Poison fishing, agrochemicals, navigation, and tourism directly impact water quality, affecting the aquatic ecosystem. Fish and other aquatic resources have been depleted due to agrochemicals used in the agricultural fields adjacent to the *beels* (Islam et al., 2011, 2013). In addition, thousands of mechanized boats pollute the aquatic environment through the noise, oil spills, and open dumping into the *haors* (Alam et al., 2015). Water pollution in the *haor* basin also occurs due to the storage and transportation of coal (Alam et al., 2015) and coal mine drainage from the upstream via transboundary rivers such as Jadukata, Someshwari, and Shari-Goyain (Talukder et al., 2021). Moreover, the soil texture of the *haor* bottom has been gradually degrading due to the deposition of chemical fertilizers, pesticides, polyethylene, plastics, and other contaminants.

In recent years, climate change has become one of the biggest threats to the *haor* ecosystem of Bangladesh (Sunny et al., 2020; Aziz et al., 2021; Pandit et al., 2021). Temperature fluctuation, the erratic patterns of rainfall, droughts or prolonged dry spells, and frequent flash floods are commonly observed in the *haor* basin (Majumder et al., 2013). All these factors significantly affect ecological and physiological processes *viz.* feeding, breeding, disease outbreak, etc., of fish, which might accelerate the loss of fish species diversity in the *haor* basin (Aziz et al., 2021). Furthermore, during the breeding season, the erratic behavior of rainfall leads to failure in fish reproduction due to insufficient water supply in the rivers and *beels* of the *haor* basin. Although some small indigenous fish species can breed in such extreme environmental conditions, larval development is hampered due to water scarcity (Aziz et al., 2021).

Due to heavy rainfall, frequent flash floods in the *haor* basin are responsible for increase in bank erosion, water turbidity, siltation and sedimentation, as well as changes in sediment texture and reduction in water depth. Generally, water depth changes seasonally, but the depth of the wetlands in some places of the *haor* basin has been permanently reduced through deposition of silt and sediment. Therefore, the upper basin of the *haors* becomes dry during winter. Most of the *haor* region (except some deepest parts, known as *beels*) remains dry from January to March every year. This is one of the significant threats to fish biodiversity. For example, the water covering the area of the Hakaluki Haor has been remarkably reduced due to siltation (Aziz et al., 2021). In addition, an increase in water turbidity affects herbivore and planktivore fish in their search for food.

Social system

In the *haor* basin, small-scale fishing was one of the main occupations for many households, followed by agricultural farming, day labour, fish trading, fish farming, boating, fishing gear making, and boat making. Population increase, unemployment, poverty, illiteracy, and lack of alternate income sources, directly and indirectly, impact fisheries' status. The demand for indigenous fish harvested from the inland open waters like *haors, beels*, rivers, and canals is generally higher than farm-produced fish. However, small-scale fishers are deprived of receiving a fair price for fish due to exploitative marketing systems, which forces them to harvest more fish to support their minimum income for subsistence living. Small-scale fishers are further marginalized through the lack of modern fishing equipment, fishing restrictions put in place by the leaseholders, and the competition with non-traditional part-time fishers who possess modern equipment. In addition, because of the high lease value in revenue-oriented management regimes, poor fishers hardly get the right of access to the waters, though only valid fishers have the right to obtain a lease of the *jalmohals* (government-owned water bodies in Bangladesh). To seize the lease of the *jalmohal* from actual traditional fishers, powerful leaseholders often organize a dummy association of fishers from different villages adjacent to *jalmohal*. Thus, wealthy, influential individuals or local elites (e.g., politicians) become leaseholders under the guise of fishers. About 96 percent of fishers in the Hakaluki Haor cannot access the *jalmohals* in the present leasing system. Some fishers only get the chance to work in these leased *beels* as day labourers (Islam et al., 2011). The leaseholders harvest all the fish by completely dewatering the wetlands during the dry season. Since most of the leaseholders are influential elites preoccupied with securing a profit, they hardly consider the value of conserving and restoring fisheries resources in the *haor* ecosystem.

In 1996, the Bangladesh government decided to transfer management responsibility of smaller and closed *beel* to the local administration. It started the transfer of smaller water bodies (up to 20 acres) to the Ministry of Youth and Sports to create employment for the youth in the rural area. However, the local youth societies did not use this government initiative; rather, some other vested groups formed so-called youth societies and took possession of all smaller water bodies (Haque & Kazal, 2008). Thus, local young fishers have no access right to the *jalmohals*. This phenomenon creates social conflicts, which sometimes lead to bloody violence. To survive, poor local fishers are compelled to extract non-fish resources such as aquatic vegetation, snails, mussels, and birds indiscriminately. As a result, aquatic and terrestrial ecosystems of the *haor* basin have drastically degraded.

Wetlands of *the haor* basin are losing their water area on an ongoing basis due to the conversion of open water wetlands to agricultural lands, fish farms, cattle grazing grounds, and human settlements. Simultaneously, fish habitat destruction and fragmentation have occurred due to urbanization, development of unplanned infrastructures (i.e., construction of dams, embankments, roads, sluice gates), sand mining, stone mining, irrigation, deforestation, and overexploitation of swamp forests, riverbank erosion, and siltation. Furthermore, changing the traditional crops to high-yielding varieties has drastically altered the land use pattern in *haor* catchment, ultimately affecting the breeding of small indigenous species of fish (Islam et al., 2013). Besides, using different chemicals in crop fields to control pests, insects, aquatic weeds/vegetation, and other plant disease-producing agents has had direct and indirect effects on fish diversity. Acute toxicity resulting from using these poisons leads to fish mortality. In addition, insectivore fish have been deprived of a portion of their food when insecticides are applied. Fish eggs may also be damaged by the toxicity of poisons, whereas soil fertility can be decreased.

Years ago, very few people lived in the *haor* areas. Nowadays, many people from different parts of the country permanently reside here. New villages have been developed by filling in marshy lands, swamps, ponds, and *beels*. As a result, the production and ecological function of the Hakaluki Haor is threatened by an expansion in human settlement, resulting in serious degradation of the country's rich, distinctive ecosystem (Islam et al., 2011).

Governing system

A hierarchical management system governs the *haor* ecosystem. The Department of Fisheries practices top-down management of the wetlands where local fishers have minimal or no involvement. Bangladesh Haor and Wetland Development Board manages and regulates wetlands and *haors* in

Bangladesh. The Department of Bangladesh Haor and Wetlands Development is also responsible for managing the aquatic resources of the *haor* basin. The goal of these institutions is to establish an effective management system for the aquatic biodiversity of the *haor* basin (i.e., fishes, crustaceans, and mollusks), safeguard vulnerable species, and promote sustainable exploitation of fisheries resources. Besides, the Local Government Engineering Department also works to promote sustainable fisheries activities, biodiversity conservation, and improvement of the socioeconomic standard of fishers in the *haor* area by implementing community-based fisheries management programs, including rehabilitation and construction works.

To facilitate breeding of species, a seasonal ban on the exploitation of some commercially important fish species has been imposed. A policy that restricts catches during the breeding season prohibits fine-meshed gears and the harvesting of brood fish. All fixed gears that obstruct water flow or fish migration are permanently banned. Many fish sanctuaries have been established in the *haor* wetlands, but fishers hardly care about these regulations in most cases. Indeed, a dewatering technique for fishing activities practiced in the Hakaluki Haor led to the extinction of the fish population (Islam et al., 2011). Despite the size and species, any fish that accumulates in the *katha* (a fish aggregating device) is caught by fencing and seining during the dry season (Pandit et al., 2015; 2021). Fishing by bamboo fencing (*bana*) or nets with fixed fishing gears across sluice gates, canals, rivers, or other waters is common during the post-monsoon season when water flows down to the deepest parts. Researchers found that Hakaluki Haor was losing nearly 32 out of 107 fish species because of overfishing done by the lessee compounded with other drivers (Islam et al., 2011; Aziz et al., 2021). Thus, introducing a revenue-based *jalmohal* leasing system, i.e., non-compliance with fishery laws and regulations of Bangladesh and *jalmohal* policy, has become one of the most severe threats to fish diversity and the fishing community in the *haor* wetlands (Sunny et al., 2020).

Finally, a top-down planning approach to technical assistance and a lack of local participation in management activities are also significant problems for *haor* ecosystem. Most of the *jalmohals* in the *haor* basin are affected by random changes in policy. For this reason, actual traditional fishers are not satisfied with the government. Interdisciplinary coordination problems and weak linkages among various government disciplines, reluctance and weak enforcement of fisheries laws and regulations, weakness in leasing system management and lack of regular monitoring of *haors* were recorded as major problems (Islam et al., 2011).

Vulnerability

Haor basin is situated in a fertile, low-lying region characterized by high vulnerability to floods, tropical storms, earthquakes, and climate change impacts. Alteration of environmental conditions can affect natural fish migration reproduction of populations, reduce the nursery and feeding grounds for juvenile fish, and ultimately prevent stocks from spawning. The *haor* region was nearly free from exotic fish species about three decades ago. Exotic fish species can harm native fish species diversity, leading to extinction and disrupting natural ecosystems (Pandit et al., 2021). However, ten non-native fish species, including *Aristichthys nobilis*, *Barbonymus gonionotus*, *Ctenopharyngodon idella*, *Cyprinus carpio* (var. communis & specularis), *Clarias gariepinus, Hypophthalmichthys molitrix, Mylopharyngodon pisceus, Oreochromis niloticus*, *Oreochromis mossambicus,* and *Pangasionodon hypophthalmus,* have been recorded to date. These species are present in these wetlands either because they escaped from aquaculture during heavy flooding or through intentional stocking. Exotic fish species threaten indigenous fish species by competing for food and ecological niche.

Fishery-dependent households in the northeastern *haor* region are one of the most vulnerable communities in Bangladesh because of a lack of education, low assets, weak social networks, food scarcity, and restricted access to common property resources. Frequent flooding is one of the leading causes of livelihood vulnerabilities, which directly worsen the socioeconomic condition of the small-scale or marginal fishers and social development in the *haor* region of Bangladesh. The extreme, unpredictable characteristics of the rivers and high rainfall, especially in comparison to other parts of the country, cause frequent flash floods in the area (CEGIS, 2012). Frequent flash flood causes loss of physical assets, including houses, loss of crops, loss of income and livelihoods, the devastation of the local educational institutions, damage of transportation facilities, food shortage, and malnutrition, among other things. Thus, flash flood poses severe threats to the occupation and income of the poor peoples and forces them to change their occupations. During natural disasters, fishers take shelter in swamp forests to protect themselves from colossal loss. However, the percentage of swamp tree-covered areas is rapidly decreasing. Landslides result in the migration of many inhabitants and the development of new villages, which causes enormous economic losses. Additionally, some fishers work as day labour in the agricultural fields, but seasonal fluctuations in demand for agricultural labour sometimes descend abruptly due to flash-flooding and other causes. The wage rate (per day) varies from USD 3 to USD 5, but women get a lower wage rate than their male counterparts for the same amount of work. Other significant problems include extortion by the local brokers, inadequate credit facilities, lack of marketing facilities, insufficient fishing knowledge, lack of appropriate gear, and disturbances by criminal gangs and local people.

Responses of the systems

Social system

Due to a decline in fish diversity and limited access to the leased *jalmahals* (available only in the monsoon season), many fishers have to catch fish from distant places with open access to wetlands. As fish production decreased, many fishers switched their profession (e.g., day labourer, working at agricultural farms, etc.). Fishers who still fish have reduced the amount of purchased food and compromised their food consumption by having fewer meals per day. Other responses include eating less quality food, foraging natural foods in the swamp forest to supplement typical diets, using any savings they have to fulfill their needs, and borrowing money from NGOs and money lenders. Even though community responses were primarily local, their implications were seen at the regional and national levels.

Governing system

For addressing the current challenges of *haor* capture fishery, different ministries of the Government of Bangladesh, especially the Ministry of Fisheries and Livestock, Department of Fisheries (DoF), and different non-government organizations (NGOs), are actively involved in reducing overexploitation of fisheries resources. They create public awareness, provide training on aquaculture, handicraft, and sewing machine operation, and involve fishers in alternative income-generating activities. Along with these, various unique programs aimed at increasing productivity have been introduced in the recent past. These include community-based fisheries management, restoration of fish habitats to facilitate breeding and migration, establishment and management of *beel* nurseries, stocking of fingerlings, establishment and maintenance of sanctuaries for the conservation of biodiversity, expansion of cage and pen fish farming in feasible water areas, issuing of fishers' identity card, ensuring access right of fishers to the *jalmohals*, and adoption of climate-smart technologies (CEGIS, 2012; DoF, 2019; Talukder et al., 2021). The governing system responses are designed to improve the *haor* basin's social and natural system resilience.

Different collaborations between NGOs and DoF show that NGOs can organize effective participatory institutions of fishers for collective management, which leads to a flexible community-based approach. Consequently, in collaboration between DoF and the WorldFish, the Community Based Fisheries Management-1 (CBFM-1) played a vital role in inland small-scale fisheries management in Bangladesh. The CBFM-1 began in late 1995 and ran until July 1999 to empower fishing communities and ensure an equal distribution of benefits. The CBFM-1 has been shown to be effective in promoting participatory fisheries management and equitable benefit distribution. However, questions about the community groups' long-term viability and coordination over vast inland floodplains and acceptable social and environmental models remain unaddressed. The CBFM-2 was developed with financing from the Department of International Development (DFID) in response to these lessons, needs, and policy challenges. The CBFM-2 project aimed to improve the livelihoods of poor fishers who rely on inland fisheries resources by evaluating and testing user-based (community-based) fisheries management arrangements across a wide range of inland fisheries in Bangladesh and informing and facilitating appropriate policy changes. Hundreds of CBOs (community-based organizations) were formed to manage the wetlands. DoF, WorldFish, and 11 non-government organizations collaborated to develop the CBFM-2.

Appraisal: Evaluating the responses

Natural system

In the case of short-term response, there is a positive impact on the natural system. Due to some project activities, natural habitats were somewhat restored, several red-listed indigenous fish species were revived, and fish production was increased (DoF, 2019). Law enforcement, enabling policy, government funding, and intensive monitoring are the factors that contributed to the successful short-term result. However, in the long run, projects found the CBO's to be a failure due to overexploitation of natural resources after completion of the project, resulting in a decline in fish diversity, thus reversing the initial gains. Overall, increased fish production from the *haor* ecosystem (DoF, 2019) and decreased fish diversity (Aziz et al., 2021) seem contradictory, but this is the practical situation of the *haor* region of Bangladesh. Due to *beel* nursery and other stocking programs, fries of carps and other fishes are released in the *haor* wetlands, distributed to all adjacent waters, increasing the fish production. The establishment of fish sanctuaries showed positive and effective impacts on the conservation of fish species and turtles in the *jalmahals*. Local fishers stated that some indigenous species had reappeared in the water body due to better management (van Brakel et al., 2021).

Social system

A series of community development initiatives, particularly rural infrastructure and flood protection measures are implemented by different government departments. These infrastructure projects had a positive impact on people and livelihoods. Therefore, people who participated in the project experienced the benefits. However, after project completion, the failure of CBOs occurred due to a lack of social cohesion or increased social conflicts (van Brakel et al., 2021). Furthermore, illiteracy, the dominance of influential and political misconduct, lack of thoughtful and transparent local leadership, minimal community participation in discussion and decision-making, lack of efficiency for managing risks and conflict resolution accelerated the risk of sustainable management of these ecologically sensitive *haor* wetlands (Sunny et al., 2020). Ecological benefits far outweighed the costs because they enhance long-term ecosystem services to the communities. Few attempts of livelihood improvement projects have diversified their livelihood activities at a medium level. However, the level of success in livelihood diversification and improvement varied based on the age of fishers, access to credit and savings, mode of land ownership, distance from the nearest market, and value of household assets. Some training provided to women and men offering alternative livelihood activities, including rearing poultry and cattle, also improved their livelihood status at a certain level.

Governing system

The responses of the governing system are inadequate for enhancing the resilience of the social and natural systems. Poor governance with top-down policy implications, inter conflict over ownerships, non-transparent sociopolitical representation of managerial roles among Ministry of Land, Ministry of Environment, Forests and Climate Change, Department of Forest, Department of Environment, DoF, Bangladesh Water Development Board, Local Government Engineering Department (LGED), Department of *Haor* and Wetland Development, legislative bindings of district public administration, and poor linkages with lack of collaborative efforts, make the scenario more complex (Sunny et al., 2020). Nevertheless, the impacts and outcomes associated with fisheries co-management implemented in *the haor* region are generally positive across a range of social, ecological, and governance measures. Because co-management arrangements for fisheries are widespread, diverse, dynamic, and supported by various institutional structures and organizations.

There is no specific management measure for aquatic ecosystem conservation and restoration except fish sanctuary establishment and management (Talukder et al., 2021). Notably, sanctuaries are not adequately monitored or governed as permanently protected areas. WorldFish, International Union for Conservation of Nature (IUCN), Center for Natural Resource Studies (CNRS), Bangladesh Fisheries Research Institute (BFRI), different public and private universities, several national and international NGOs, and other international organizations are still working to improve the current situation. Still, their efforts have not been very successful due to limited funds, short-term operation period, weaknesses of the operational system, and/or lack of coordination among NGOs and between NGOs and Govt. for efficient use of these funds.

Conclusion

The decline is fish diversity has become a significant issue in the *haor* basin, which threatens small-scale fisheries of the basin. Several natural, social, and governance drivers are responsible for this situation. The main problems of *haor* small-scale fisheries include the lack of access to the *jalmohals*, overexploitation of resources, fish habitat destruction, and weak governance. In this situation, ecosystem-based fisheries management with active community participation, fishing gear maintenance, the establishment of sanctuary and its management, proper implementation of fish acts and regulations, and raising public awareness can play a great role in conserving fish diversity in the *haor* basin. In addition, creating alternate livelihood options for fishers, dredging of canals and *beels,* stocking of indigenous fishes in the *haor* basin, seed production of small indigenous species (SIS) and release in the *haor* waters through pen culture techniques can be effective to conserve aquatic biodiversity and enhance small-scale fisheries production in the *haor* region of Bangladesh.

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21. Illegal and Widespread: Use of Destructive Fishing Gear as Barriers to Hilsa Sanctuaries Management

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Fishers use bamboo-made traps (chai) to catch fingerlings of pangas species, which is destructive to fisheries biodiversity (Photo: Mahmudul Islam, 2022).

This chapter describes how small-scale fishers use different types of destructive gears which violate the rules of fisheries regulations, of which monofilament gillnet (current jal) is the most widely used. Fishers use current jal because it is cheaper than conventional gears, easy to operate, and has a higher catch per unit, to mention a few advantages. The study identified some factors, such as socioeconomic (e.g., poverty), political (e.g., corruption), and environmental (e.g., river bank erosion) that are responsible for the unabated continuation of destructive fishing gear use in the Meghna River estuary. This study suggests effective restrictions on destructive gears production and use, a comprehensive incentive program for all affected fishers during fishing closures, and a co-management mechanism for sharing the responsibility and benefits of fisheries management in the Meghna River estuary of Bangladesh.

Introduction

The hilsa shad (*Tenualosa ilisha*) fishery is the largest estuarine fishery in the world in terms of catch (Blaber, 2000). It constitutes a long-standing economic activity in the Meghna River basin in Bangladesh. A large number of fishing crafts and gears are used in the Meghna estuary for the commercial exploitation of fishery resources The traditional fishing gears used in Bangladesh include fishing nets, fishing traps, hooks and lines, wounding gears, and fish aggregation devices (Hasan et al., 2016). Fishers usually use drift gill nets (locally known as *gultijal, konajal*), monofilament gill nets (*current jal*) and seine nets (*berjal*) to catch hilsa. The Government of Bangladesh (GoB) has declared six sanctuaries in the rivers of Meghna and Padma and their associated tributaries to protect the fishery from overfishing and habitat degradation. In addition, the Department of Fisheries (DoF), in cooperation with law enforcement agencies and local government administration, initiated a countrywide ban for eight months from November to June every year on catching, carrying, and selling of *jatka* (juvenile hilsa less than 25 cm in size). Another restriction is placed on the catching of brood (mature and about to spawn) hilsa for 22 days during the peak breeding season in October (Rahman et al., 2012; Islam, 2021). Furthermore, the government initiated a compensation scheme for the affected fishers. During the 2019–2020 financial year, of the 505,787 households involved in *jatka* fishing, 280,963 (the poorest) were allocated support of food grains under a compensations scheme (Islam, 2021). Although different regulations have been imposed to manage this important fishery, non-compliance and intrusion by the destructive gears are common. This results in overfishing, resource depletion, habitat degradation, and social and economic conflicts among the fishers.

The use of destructive and illegal fishing gear is a significant concern in fisheries management worldwide. It is not only an issue on the high seas but is also a matter of great concern to estuarine and coastal areas, where small-scale fisheries operate (Luomba et al., 2016). Destructive fishing gear can degrade habitat, capture high proportions of juvenile and small fish, and ultimately lead to reduced production (Cinner, 2009). There are many reasons why fishers use these gears. Of them, poverty is vital, and it pushes for overexploitation of coastal fisheries resources and the use of destructive fishing gear in tropical developing countries (Cinner, 2009). The poor fishers primarily use them. It is also found that household food insecurity may contribute to using destructive fishing gear (Silva, 2006). Other reasons for using destructive fishing gear include the high cost of legal gear, good returns from small-fishing gears, inadequate regulation measures, lack of local knowledge integration in making policy, corruption, and insufficient penalties (Luomba et al., 2016). Poor socioeconomic conditions and management issues are likely to contribute to non-compliance with fishing rules and regulations (Cinner, 2009).

The Government of Bangladesh regulates the fishery sector through licensing, gear restriction schemes, and seasonal closures. In most cases, a significant non-compliance with regulations is observed in the fisheries of Bangladesh (Islam et al., 2017). It is important to investigate the causes of management failure in the coastal area for proper management. One of the prerequisites for a sound management system is to measure the factors responsible for weak management. For proper management, factors responsible for using destructive fishing gear need to be identified and understood for appropriate decisions. So far, very little research has been conducted on the management challenges of illegal and destructive fishing gear in the Bangladesh context. Therefore, this chapter aims to identify factors that cause the continuous use of destructive fishing gear in the hilsa sanctuaries. These findings will be beneficial for formulating improved programs for fishery management.

Destructive fishing gears and their drivers of use

Fishers in the Meghna River estuary use different fishing gear, but not all fishing gears are legal. In the legal framework of the Bangladesh fisheries, there is no clearly defined destructive fishing gears list. Some destructive gears are as follows: monofilament gill net (*current jal*), estuarine set bag net, marine set bag net, fish traps and mosquito nets. Monofilament gill nets (*current jal*) are the most widely used. As presented in Table 1, small-scale fishers explained several benefits of using *current jal,* including that they are easy to operate, less costly, and usually catch more fish than conventional gear. The fishing operation by *current jal* also requires less time and minimum manpower and lasts longer in terms of durability. The use of *current jal* during the off-season helps fishers continue their fishing. The net is easy to operate, so even child labourers can handle the fishing operation.

Table 1. Fishers' preference for using current jal.

Why *current jal*?	
Less body strength required for operating the net (for child labour)	Not easily degraded
Fish is caught even during the off-season	Cheaper than legal gear
Fish can be caught even with a torn net, thus saving the cost of repairing	Easy to operate
Requires minimum manpower for fishing operation	Higher catch
No fixed fishing space is required	Short fishing time

Socioeconomic factors

Poverty is perceived as the main livelihood problem of the fishers. The decline in fish catch is the most crucial factor for the increasing level of poverty and food insecurity in fishing communities. Some fishers cannot afford to buy expensive, efficient legal gear so, instead, they invest their small capital in gear that can ensure at least some catch to support their livelihoods. In these circumstances, buying a *current jal* is an obvious choice for most fishers. The lower fish harvest and increased poverty level push fishers to exploit fisheries resources by any means possible, typically by using destructive fishing gear.

The majority of fishers are illiterate and are unaware of different rules of fisheries regulation, particularly about illegal gears and regulations regarding appropriate mesh size. For instance, one fisher noted that he had an understanding that the *current jal* was banned for fishing ban season only, whereas in fact, the use of *current jal* is completely prohibited throughout the year. Most of them have little idea about the destructive nature of illegal fishing gear. Ignorance about the law has been identified as the major factor in breaking the regulations of fisheries low in Bangladesh (Kuperan & Jahan, 2010).

A large portion of fishers have no alternative income source, so during the ban season of fishing, they take loans from middlemen and or microcredit organizations. After the end of the ban season, fishers must pay back their loan, which forces them to go for a higher fish catch, using destructive fishing gear. Many fishers depend only on fishing income as they hardly have the skills required for other available job alternatives. Many of the fishers alleged that without creating scope for an alternative income source, it is unfair and unjust for the government to impose any fishing regulation.

Political factors

Some wealthy fishers are involved in local partisan politics. These fishers use their connections to local power-holders and use different restricted fishing gear or do fishing during ban periods. To compensate for the loss of income during the ban seasons, the Government of Bangladesh provides 40 kg of rice as a part of a compensation scheme. Although the government has a compensation scheme for the fishers affected by the ban, almost half of the affected fishers do not get their allocated support (rice grains) during ban periods. There are allegations that local government administration, e.g., members and chairman of the Union Council (the third and lowest tier of the local government), misappropriate the schemes by allocating the rice for their party people or relatives, even though they are not true fishers. Hence, due to a lack of support from the compensation scheme, fishers are forced to use *current jal* and other destructive fishing gear. And while all types of fishing are banned in the six sanctuary areas for a specific period, the incentives are only provided to the hilsa fishers. Non-hilsa fishers feel this discriminates against them when they, too, suffer from the bans. Consequently, the deprived fishers are not motivated to conserve fisheries by not using destructive gear. Further, the amount of assistance that the government provides is not enough because it only provides 40 kg of rice, which is insufficient for covering the needs of fishers' families. Some fishers also disputed the government's restriction on some gears, as they think these gear are not harmful. For example, many fishers indicated that if they follow the government's specification of mesh size, then there will be no fish in their net. The fishers' complaints may be exaggerated, but it is essential to regularly revise the laws to pay heed to the concerns of the fishing communities. There are complaints that during the ban periods, the government prohibits catching other fish species with legal gears, which creates hardship for fishers. When policy-makers or parliament make a draft of a law, they hardly consult with small-scale fishers and do not consider the fishers' problems and constraints. Therefore, the regulations eventually result in non-compliance and poor implementation. The governing bodies related to controlling illegal fishing are arguably not attentive or are incapable of doing their work due to higher authority indifference or limited logistic support. The weak enforcement has led to the perception among most fishers that if they violate the law, the chances are that they will not be charged (Kuperan & Jahan, 2010).

Environmental factors

Riverbank erosion is a principal contributor to the region's natural hazards, contributing to making people poor (Islam et al., 2020) as the river erosion destroys agricultural land and washes away households' assets. As a result, people affected by erosion fall into extreme poverty. Moreover, most fishers reported that siltation is a significant problem in the river. Due to siltation, many places are now unsuitable for fish movement; thus, fishable areas are reducing. In addition, siltation causes the reduced velocity of water current. Since hilsa is a fast-moving species that needs a stronger current for movement, fewer fish are caught in conventional gear. People in these situations enter the fishing profession when they cannot meet their basic needs. As *current jal* is cheaper to buy than conventional fishing gear and fishing with it brings good income, they mostly use destructive fishing gear to catch more.

Discussion

Poverty is often believed to be a driving force in exploiting marine resources in tropical developing countries, although relationships are complicated and poorly understood (Silva, 2006; Cinner et al., 2009; Islam et al., 2017). The findings suggests that destructive gear users tend to be poorer are broadly consistent with the poverty trap concept (Barrett et al., 2006). Poverty traps are situations where the poor cannot acquire the income required to overcome low-income problems. In this way, the fishers are involved in behaviour that may reinforce their poverty (Dasgupta, 1997; Miah et al., 2022). Ignorance of the law has been identified as the primary factor for using destructive gear with regulations in Bangladesh. Some studies indicate that a higher probability of detection and conviction arising from enforcement activities is likely to discourage people from committing illegal activities (Sutinen & Anderson, 1985). The findings support the argument that in the Western Indian Ocean region cultural factors are important in influencing the use of destructive gears (De la Torre-Castro & Lindström, 2010). Munyi

(2009) suggests that it is difficult for most fishers to adopt alternative legal fishing gears as most fishers are poor and dependent on money lenders, thus having limited capital to buy legal but expensive gear.

The hilsa fishery suffers from serious recruitment overfishing (indiscriminate catching of *jatka*) and growth overfishing (indiscriminate killing of gravid brood). This degradation of the hilsa fishery is mainly attributed to using *current jal* that captures hilsa species of all lengths. Several studies have hypothesized that destructive fishing gears can degrade habitat, capture high proportions of small fish and ultimately lead to reduced yields (Cinner, 2009). In this way, fishers cannot acquire good catch. Destructive fishing gears also cause other biodiversity loss. For example, river dolphins are some of the world's most threatened aquatic mammals and their numbers are greatly reduced, mostly due to the by-catch of various types of illegal fishing (Islam, 2021). The use of destructive fishing gear, especially *current jal* has a great negative impact on the fishing communities. When they use *current jal*, the coast guard, police, or navy seize and destroy the net. Due to gear loss, fishers fall into a great economic problem and are obliged to take loans with high interest from different NGOs. Therefore, fishers cannot minimize their financial problem because they have to repay the installment of microcredit after family expenses. To overcome the crises, fishers start using *current jal* although they face the risk of being captured by law enforcers. Thus, the use of destructive fishing gear negatively affects both the environment and the fishing communities.

For proper management, the Department of Fisheries often conducts a raid against illegal gear, particularly *current jal*. However, confiscating destructive fishing gear and imprisonment of fishers further deepen the vulnerability of fishers. To address this vulnerability, they continue fishing with destructive fishing gears to obtain higher catch and income. The fishing communities and the government authority must grapple with this complex trade-off. Effective implementation of a ban on destructive fishing gears will make the dependent fishers poor but will be beneficial for the ecosystem. On the other hand, if they continue using destructive fishing gear, fishers will get more income in the short term. However, in the long run, resources will be degraded, which is likely to negatively affect the future generation. In this context, finding a win-win situation is necessary. Developing a co-management mechanism for addressing the livelihood needs of fishers and hilsa sanctuary management could be a solution.

As described above, the vulnerability of small-scale fishers to various stressors and risks may undermine incentives to act as resource stewards, even if they are empowered through adaptive co-management. According to discounting theory, in which future rewards are regarded as less valuable than rewards gained today, the high degree of risk exposure and vulnerability of fishers results in high discount rates and limited incentives for participation in managing a fishery, despite their dependence on it. Thus, vulnerability undermines participatory fishery management (Barratt & Allison, 2014: Kolding et al., 2014). Enabling environment could help local fishery management organizations to broaden their role to include concern for the fishing community's well-being by addressing both their wider vulnerabilities and aspirations, which may help to address some of the current disincentives of fishing people to participate in long-term stewardship by more compliance and enhancing support for fisheries management (Barratt & Allison, 2014).

Conclusion

With an overarching aim to contribute to better management of the economically important Hilsa fishery of the Meghna River estuary, this study was conducted to identify the reasons and factors responsible for destructive fishing practices in the estuary. The study also unpacked the trade-offs between using destructive fishing gear and management effectiveness. Widespread poverty, never-ending debt to middlemen and reliance on microcredit, lack of awareness and alternative occupations, inadequate and inappropriate distribution of government assistance, political interference by influential local people, corruption, and limited capacity of the management bodies are some factors for the expansion and continuation of destructive fishing practices. Some elements are also related to environmental changes in the region, such as siltation. The use of destructive fishing gears created concerns for fishers and management bodies since it could undermine the sustainability of the fisheries resources of the estuary. More importantly, a trade-off is created where fisheries conservation and livelihood development seem mutually exclusive. Therefore, a co-management partnership among private and public agencies, fisheries experts, and civil society may be necessary for hilsa sanctuaries management.

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22. The Footprint on Fragile Ecosystem: Sustainability of Mud Crab Production Practices in Coastal Bangladesh

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Participation of women in crab marketing positively improves their decision-making capabilities (Photo: Zannatul Ferdoushi, 2015).

As an export commodity and luxury seafood, there has been increasing interest in crab harvest and crab farming in Bangladesh. The mud crab farming and fishing sector are playing a significant role in the national economy of Bangladesh through foreign exchange earning, increasing employment opportunities, and by improving the livelihood of the rural communities in the coastal region. While crab farming systems are often considered more resilient to environmental stressors and disease than shrimp farming, crab farming in Bangladesh is underdeveloped. Given that the farming depends on the wild seed stock, the existing crab stock in the wild (i.e., in the Sundarbans mangrove areas) is already at risk and over-exploited. Depletion of wild mud crab stock could lead to ecosystem imbalances. Further, low socioeconomic capitals are observed in the crab fishing and farmer communities. Any disruption in international markets creates tremendous negative impacts on the income of marginal crab fishers and farmers, as evident in the COVID-19 situation. Therefore, the sectors warrant appropriate planning and policy supports for sustainable development. Considering its strong potential aspect in the international market, suitable environmental conditions in the southwest part of the country, and cheap labour cost, a short-term technology like crab fattening could be developed more through proper management.

Introduction

Seafood is considered the most traded food commodity globally (Watson et al., 2017), of which crab products occupy an important position. According to FAO (2016), the world crab fishery production (primarily comprised of *Scylla serrate* (Forsskål, 1775), *Scylla olivacea* (Herbst, 1796), *Portunus pelagicus* (Linnaeus, 1758), and *Callinectes sapidus* (Rathbun, 1896)) has increased from 343 thousand t in 1990, to more than 951,000 t in 2015. Crab is a member of phylum Arthropoda, belonging to the suborder Brachyura of order Decapoda under the class of Crustacea with broad carapace, living in marine, brackish, or freshwaters. They differ from species to species in size, shape, colour and structure (Penn et al., 2018). Among them, Indo-pacific mud crab, swimming crab, Chinese mitten crab, King crab, and spider crab have become an important source of income for export and local consumption in many countries. Several species of *Scylla* are collectively known as mud crab, Indo-pacific swamp crab, or mangrove crab. Keenan et al. (1998) identified four distinct species of *Scylla; S. serrata, S. tranquebarica*, *S. olivacea* and *S. paramamosain*. It inhabits muddy bottoms, mangrove marshes, and river mouths in estuarine environments (Motoh, 1979), and occurs widely throughout the Indo-West Pacific Ocean and Australia, as well as in Japan, the Philippines, Indonesia, East and South Africa, and the Red Sea (Eldredge & Smith, 2001). There is an increasing trend in the production of mud crab in many Asian regions, propelled by faster growth rate. Wider distribution and high fecundity are other characteristics that are likely to contribute to the positive trend.

Crab aquaculture was firstly developed in China about 100 years ago. Now China, USA, Japan, Korea, and Thailand are ranked as the top five biggest crab consumers (Breinl & Miles, 1994). China, USA and Canada together contribute to 70 percent of the world's crab production. Gravid female crabs play an important role in marketing, particularly in Asian countries; Japan, Taiwan, Hong Kong, and Singapore (Agbayani, 2001). In Bangladesh, mud crab is the second most important seafood after shrimp and prawn in export earnings (Rahman et al., 2017). Compared to other aquaculture practices, crab fattening requires less space and time, with higher profitability that plays an important role in the recent expansion of this practice (Ferdousi, 2013). Thus, wild-caught mud crab and fattening practice of juvenile mud crab are now playing a significant role in the local and national economy through local employment and foreign exchanged earning. These practices are also improving the livelihood of the rural communities by creating alternative livelihood opportunities in the coastal region of Bangladesh. This chapter discusses sustainability issues related to mud crab fattening practices in the coastal area of Bangladesh.

History of crab farming practice

For the last few decades, shrimp farming is one of the most important economic activities in coastal Bangladesh. However, shrimp farming faces serious challenges such as converting mangroves into shrimp farms, destroying other biodiversity during wild seed collection, releasing pollutants into aquatic environments, etc. Again, with the continued expansion of shrimp culture worldwide, market prices have dropped, profit margins have been squeezed, and there has been an outbreak of viral diseases that affected shrimp farming in Bangladesh. In Bangladesh, traditional shrimp culture is done simply by 'trapping, holding and growing' the wild shrimp fry gathered from tidal waters. During this type of traditional shrimp farming, mud crab larvae also enter the ponds and the tidal waters. However, the farmers consider these species a nuisance and do not take any special care of them. There are complaints that crabs make holes in the dykes, which drains out the water.

Using the experience of shrimp culture, some professional crab catchers became interested in crab culture. Juvenile mud crabs are released into the pond, and trash fish is used as supplementary feed. After four-five months of culture, the first crop is harvested and the next crop is started. This type of grow-out culture practice of crab at first started in the south east and south west part of Bangladesh. The mud crab fattening system was introduced in Bangladesh in the early 1990s. Adult female crabs are reared for gonadal development for two–three weeks in earthen ponds or bamboo-made cages (Hasanuzzaman et al., 2014). Both grow-out and fattening culture systems depend entirely on wild-caught of sub-adult or juvenile crab from natural sources. After harvesting crab from the wild, the small-scale fishers sell the crabs to depots where crabs (gravid female and male crabs with all appendages) are packed live for international markets. Damaged and weak crabs are sold on local markets. Healthy, non-gravid and juvenile crabs are stocked in grow-out and fattening systems. In the absence of any hatcheries, small-scale fishers are the only supplier of crablings to the grow-out and fattening culture systems. The southeast part of Bangladesh can establish hatcheries to provide a continuous supply of seed (Salam & Ross, 2000). There are two seasons for crab fattening in Bangladesh: the dry or peak season (October to May), and the lean or wet season (June to September). According to one estimate, about half a million people in Bangladesh are involved in crab production, and a million others are involved across the carb industry. The export value of crab products was 7.6 million USD in 2015, which skyrocketed to nearly 43 million USD in 2018-19 (Savage, 2021). About 90 percent of crab exports are destined to China.

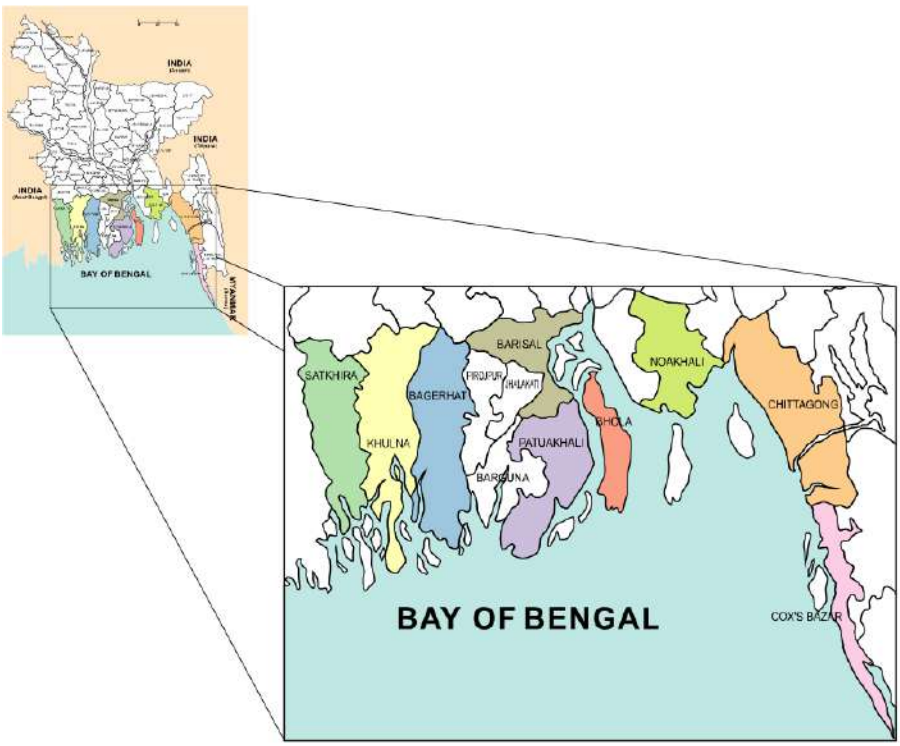

Figure 1. Crab farming and fishing area in Bangladesh.

Sustainability of mud crab production

FAO (1995) defined sustainability as the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such sustainable development that conserves land, water, plants, and animal genetic resources is environmentally non-degradable, technically appropriate, economically viable, and socially acceptable. According to Tisdell (1999), aquaculture development should regard its environmental consequences and the sustainability of aquaculture. Production technology, social and economic aspects, and environmental aspects — these three interrelated aspects are the main flow of sustainability (Figure 2).

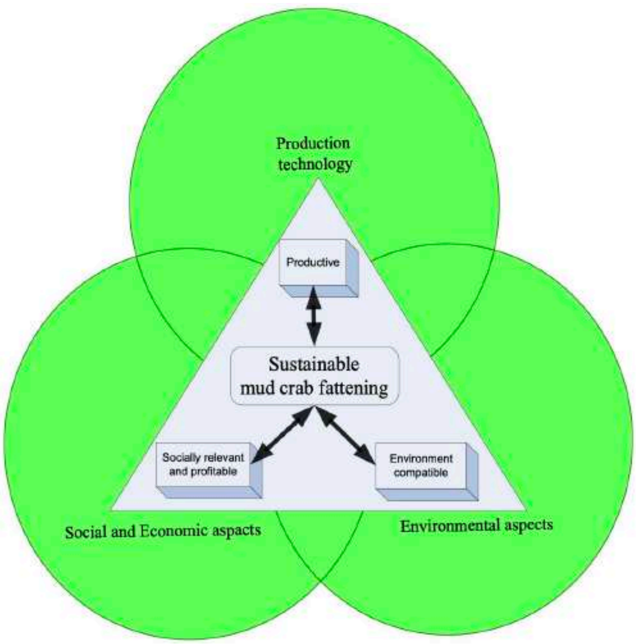

Figure 2. The three inter-related aspects of the sustainability of mud crab fattening in Bangladesh (Adapted from Edwards 1998).

Production aspects

Culture species, culture facility, and husbandry, are the three main aspects of production technology (Edwards, 1998). Culture species influences husbandry during various stages of production. Culture facilities should be diverse as static or running water ponds, cages, and pens. At the same time, husbandry may involve various stock management methods, use of different feeds, management of substrate, water quality management, disease prevention, and therapy (Edwards, 1998). The mud crab fattening in Bangladesh has great potential. Farming in pens and cages in mangrove swamps could be successfully established as an alternative livelihood for the people in the coastal region in Bangladesh (Zafar & Hossain, 2009). While grow-out and fattening systems are practiced more widely, soft-shell farming is also introduced in Bangladesh. While crab farming systems are often considered more resilient to environmental factors and disease than shrimp farming, crab farming in Bangladesh has also experienced a boom-and-bust cycle. The capture mud crab fisheries are a year-round coastal fishery, particularly in the mangrove habitats of Bangladesh. The harvesters use a variety of fishing methods that include long metal hooks, split bamboo trap, rope line, cast net, setbag net, or even fish by hand. In the Sundarbans mangrove forest, non-mechanized country boats are used to operate these gears, which are controlled by one to three fishers, often by family members, including women and children. The crab farmers usually buy juvenile crab from the small-scale fishers at Tk 10 per species, which are then reared in pond and gher (enclosure) for three months. It is estimated that after spending BDT 45 per crab, the farmer can sell it at Tk 250 (BBS, 2020). Earlier fishers were able to collect 4-5 kg crabs; after five years, the amount lowered to 2-3 kg. The size of crabs has also reduced from 250-350 g to 100-150 g. For better catch, crab fishers must roam a longer distance in the forest (Rahman et al., 2017). Over-exploitation, harvesting small and brood crabs, destruction of breeding and nursery habitats, environmental pollution, have all led to a decline of natural stocks of crab fishery (Rahman et al., 2017).

Environmental aspects

The external environment includes the natural resources used for aquaculture development such as land, water, nutrients, and biological diversity. The internal environment of the aquaculture system is considered as husbandry part of the production technology (Edwards, 1998). However, like any other aquaculture practice, brackish water mud crab fattening can also negatively impact the environment. The most important one is the overexploitation of crab in the mangrove region, increased soil salinity that could raise the social conflict between agriculture and fisheries. Moreover, unplanned construction of ponds or other structures would also reduce biodiversity. The farming depends on the wild seed stock. The harvesting pressure could decrease the wild stock, and the uncontrolled fishing of brood may threaten the natural populations, ultimately affecting fishers' livelihoods. Despite all negative impacts, mud crab farming in pens in mangrove swamps can enhance the soil quality by increasing the organic carbon (Zafar & Hossian, 2009). In addition, the practice has offered an opportunity for increasing farmer's incomes. However, the overall balance between resource use and impact needs to be more widely assessed.

Unfortunately, crab farming resulted in several adverse environmental effects on estuarine ecosystems. Figure 3 is showing the direct and indirect environmental impacts of crab farming. Coastal farming could directly or indirectly alter the aquatic and terrestrial environment and bring changes in the physical environment through its negative environmental impacts. All of those changes can ultimately destruct the local ecosystem, including the livelihood of the coastal people (Figure 3).

Figure 3. Direct and indirect environmental impact of mud crab fattening.

There is a number of drivers behind the recent expansion of mud crab fattening in Bangladesh. The species has a high tolerance to environmental stress and disease occurrence. It has a shorter crop cycle; thus, the economic return is high; culture systems are diverse with low to moderate to high inputs, and the culture technique is simple. Therefore, this activity became a viable alternative livelihood option. Plus, the species has a lucrative international market. All these factors make crab fattening a popular farming practice (Rahman et al., 2020). However, this practice has a footprint on the coastal ecosystem, particularly on the Sundarbans mangrove ecosystem. Due to the unavailability of hatchery-produced crab seeds, the farmer is dependent on wild-caught juveniles (Ferdoushi & Xiang-Guo, 2013) for the fattening practices. Again, wild sources also serve as the source of mature crab. The harvesting of wild stock seems unsustainable as berried crab is often harvested during breeding, bypassing the annual banned period in January-February. Unfortunately, it has been speculated that the existing crab stock in the wild, primarily in the Sundarbans mangrove areas, is already at risk and possibly over-exploited (Chantarasri, 1994). Indiscriminate harvesting, harvesting freely during the breeding season, and destruction of natural habitats, including breeding, feeding, and crab nursery grounds, have been reported more recently (Rahman et al., 2017). Depleting wild mud crab stock may lead to ecosystem imbalances resulting in ecological deterioration of water and soil, along with loss of biodiversity in the Sundarbans mangrove forests and other areas experiencing high fishing pressure (Rahman et al., 2020).

Socioeconomic aspects

The social and economic aspects are getting attention nowadays and there is a significant concern for livelihoods of connected communities (Ruddle, 1993; Edward, 1998). In the coastal region of Bangladesh, particularly in the southeast and southwest part, mud crab fattening is widely practiced and socially accepted due to its greater contribution to the livelihood of the coastal people. The practice could be varied in regions with different social characteristics like age, religion, family size, and production, and total income from fattening. In the rural area, the farmer's access to vital social services like education and training is poor (personal communication). While some commercial enterprises are involved in crab farming, most of the farmers and all harvesters are small-scale. The industry employs nearly 500,000 farmers, most of them with very small landholdings who are living below the poverty line (Roy, 2020). A survey of the farmers involved in mud crab fattening shows that the majority of farmers involved in mud crab fattening are between 26-35 years of age. Very few farmers (only 5 percent) had more than a secondary school certificate education. About 36 percent of the total farmers have a household with five to six people. The larger size of the family may make it difficult to invest in farming due to financial constraints. It is revealed that 63 percent of interviewed farmers took on crab fattening as their primary occupation (Ferdousi, 2013). There is a low adoption rate of this improved technology because of the incremental cost implications, which the farmers cannot afford and because of inappropriate extension methods and unfavourable weather conditions during the wet season. Moreover, lack of training programs could be another barrier in this sector.

Similar low socioeconomic capitals are also observed in the small-scale fishing communities that collect crabs from the Sundarbans. Besides traditional fishers, many poor people who lost other livelihood options on land, as well as deserted or widowed women are also involved in crab harvest. As the crab market is export-oriented with very low local demand, any disruption in international markets creates tremendous negative impacts on the income of marginal fishers and farmers. Particularly, closures of global markets during COVID-19 created a dire situation characterized by huge income loss, food insecurity, and poverty.

Conclusion

The above discussion reveals that the introduction of crab fattening in Bangladesh can bring substantial social and economic benefits to marginal segments of society. However, the insufficient resources, poor institutional support, lack of extension services, vulnerability to interruption of global markets can be considered as the major constraints for long-term sustainability and sustainable livelihoods for crab farmers. However, unlike shrimp and prawn, crab farming in Bangladesh has not developed as fast as expected. It is still in the primitive stage, constrained by inadequate research focus with respect to both the mud crab fishery and species biology. Therefore, the industry warrants appropriate planning and policy support for sustainable development. The income of crab farmers could be significantly higher if culture methods were intensified. Considering its strong potential aspect in international market and suitable environmental conditions in the southwest part of the country, cheap labour cost and short-term technology like fattening could be better developed through proper management. Both the private and public sectors can play a significant role in developing this export-oriented species. Proper institutional and administrative support and extension services like training, providing precise message during the needed time would positively affect the livelihoods of the poor. It also observed that the participation of women in crab fattening could positively improve their decision-making capabilities. However, it is urgently needed to have more support from national and international organizations. More research and knowledge, and extension services are needed for sustainable livelihoods through crab farming. Overexploitation of wild crab fishery is another major concern. Therefore, it is essential to immediately improve the technology and management with proper stocking density assessment, and establish a resilient environment by reducing stress through sustainable water management practices. The government should take necessary steps to stop the current rate of mangrove habitat destruction to allow suitable living conditions for the restocked mud crab larvae into the mangrove region. Government should also pay attention to the alternative income-generating option for poor fishers in the mangrove region during the closed season.

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About the author

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23. Anatomy of Disasters: How Hazards Became Disasters for Small-Scale Coastal Fishers in Bangladesh

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Small-scale fishers work and live in fragile physical conditions such as riverbank erosion (Photo: Atiqur Rahman Sunny, 2017).

Using the Pressure and Release (PAR) model, this chapter explores the mechanism of disaster vulnerabilities that impinges on small-scale coastal fishers in the Patuakhali region, Bangladesh, due to extreme events and socioeconomic context. This study also identifies small-scale fishers' coping and adaptation strategies taken as responses. It explains the progression of the vulnerability of coastal fishers through root causes, dynamic pressures, and unsafe conditions. Poor economic systems, and limited access to resources, structure, and powers are the root causes. Dynamic pressures, such as lack of education, training, and market facilities, seriously undermine the adaptive capacities of the fishing communities, which is further compounded by rapid population growth, migration, debt, reduced fish production, and overfishing. These altogether transform the root causes into disaster vulnerability. Besides, dangerous locations, unprotected buildings and infrastructures, fragile local economy, social vulnerabilities, and lack of disaster preparedness are recognized as unsafe conditions which make fishers further susceptible to disasters. However, coastal fishers adopt different responses at the local level to protect themselves from disasters.

Introduction

Due to geographical location and environmental reasons, Bangladesh is currently ranked as one of the world's most disaster-prone countries (Choudhury, 2002; Islam et al., 2021). The frequent natural hazards such as cyclones, storm surges, floods, droughts, tornados, riverbank erosion, earthquakes, arsenic contamination of groundwater, and landslides account for significant losses in human lives and physical assets (Choudhury, 2002; Khan, 2008). During 1797–2009, 65 devastating cyclones swept over Bangladesh and caused immense harm to the people (Rana et al., 2010). About 80–90 percent of global losses and 53 percent of total cyclone-related deaths worldwide occurred in Bangladesh (Paul, 2010). According to Alam & Collins (2012), cyclones and tidal surges have caused major devastation to human lives and property in Bangladesh for generations. During cyclones, many fishers lost their boats and fishing equipment necessary to sustain their livelihoods. Fish traders were also severely incapacitated and suffered damage to their facilities. Natural disaster-related challenges ultimately affect fisheries production and the economy. This situation warrants initiatives of the government to protect small-scale fisheries from the effects of extreme events. Information on the vulnerabilities of small-scale fisheries to disasters and their consequences on the coastal communities is essential in formulating management decisions for disaster recovery and bringing a secure livelihood to the coastal regions of Bangladesh.

Patuakhali is one of the coastal districts of Bangladesh, which is mostly exposed to disaster due to the geological position of the Bay of Bengal coast (Kulatugna et al., 2014). Various disasters like cyclones, storm surges, coastal floods and erosion, drought, and salinity intrusion are common in this region (Islam et al., 2021). This chapter presents the insights from local fishers regarding the natural and human elements of disasters. It provides policy recommendations to reduce the disasters-driven social, economic, and political vulnerabilities in the Patuakhali region. It also identifies small-scale fishers' coping and adaptation strategies to disaster vulnerability. The data are collected through individual interviews and focus group discussions in Kalapara Upazila of Patuakhali district. This study uses the Pressure and Release (PAR) model as a theoretical model (Figure 1). This important conceptual model was established in 1994 to offer disaster managers a framework to analyze vulnerability to disaster (Blaikie et al., 1994). The model was developed as part of the comprehensive study of human vulnerability to natural hazards by Blaikie et al. (1994). The principal basis of the PAR model is to recognize that a disaster is the intersection of two opposite forces: the processes generating vulnerability on one side and physical exposure to hazards on the other.

Drivers of disasters vulnerability in small-scale fisheries

The PAR model divides vulnerability into three steps: *root causes, dynamic pressures,* and *unsafe conditions*. First, the PAR model identifies the *progression of vulnerability*, in which *root causes* are formed by a series of *dynamic pressures* and give rise to *unsafe conditions.* According to the model, disaster occurs by mixing physical exposure and socioeconomic pressure. In this approach, hazards are placed within the broader context of society, and vulnerability is explained because of biophysical dynamics and social, political, and economic processes.

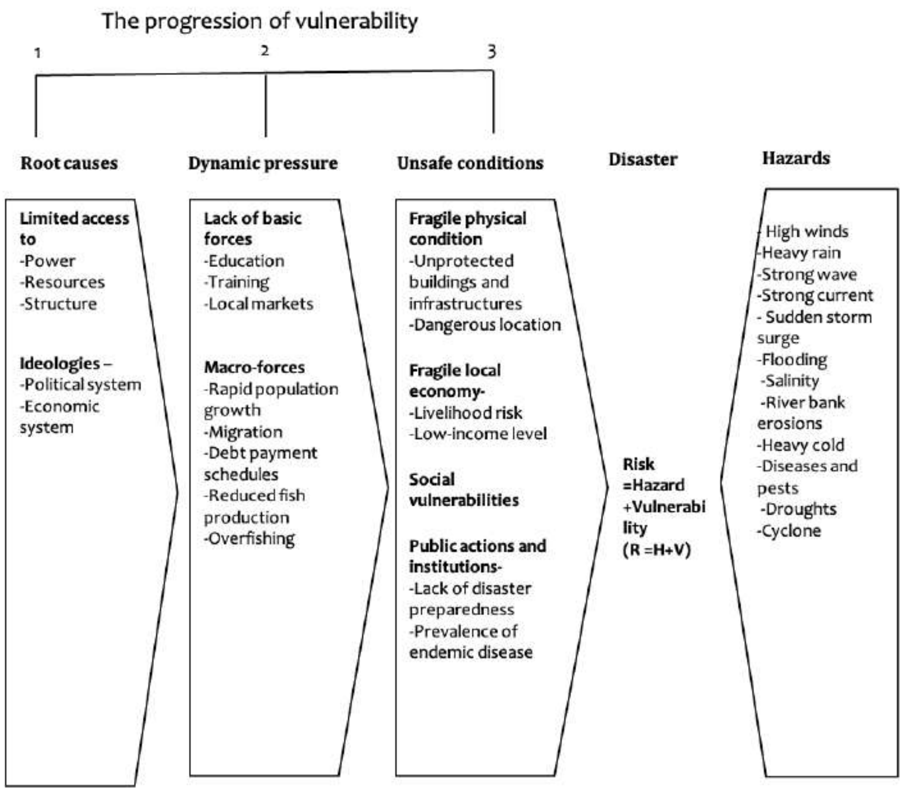

Figure 1. Mechanism of disaster-related vulnerability in small-scale fishers'

livelihoods in Patuakhali region (PAR model modified from Wisner et al., 2004).

Root causes

This section discusses the factors considered at the root of disaster-related vulnerability. Root causes are the most outlying processes in the particular social, economic, and political situation in an area. Root causes are related to limited access to power, resources, and structure. The root causes are also related to the political and economic systems. In general, the small-scale fishers are, for the most part, unorganized and need better representation in the local administration of the Union Council. Therefore, poor fishers lobby the 'socially supreme' for relief materials, loans, and other benefits and facilities from these organizations (Mallick & Vogt, 2011). In summary, the poorer the households, the less connected they are to such networks, and the fewer assets they have to deal with their problematic livelihood situations. The households are remotely located with poor communications and infrastructures. Most fishers live either in thatched or poorly constructed houses, which are vulnerable to being wiped out by strong winds.

Most of the surveyed households are landless. They live on *khas* (government-owned) land or land owned privately by someone else. Thus, they are cut off from enjoying the insurance that land ownership can offer against a sudden loss of livelihood resources. The few who possess the land, possess only small land plots, which are insufficient to use for generating additional income, and can be used only for family settlement. In addition, poor infrastructure, remoteness, and poor transport facilities inhibit access to development and mobilization activities. Another entitlement deficiency is the poor transportation system that inhibits fishers from easy and suitable market access. During the rush period of peak fishing, it is not feasible for fishers to sell their catch in the market directly (as it involves additional time and labour from already tired fishers); instead, they sell the fish at coastal landing sites. In addition, poor transportation facilities pave the way for the buyer, or the *dadonder,* to gain bargaining power over them.

Fisher households are less involved in political processes and local institutions, such as the Union Council. Elected local government officials of the Union Council are perceived as blind to the problem of fishing communities, just as they are to the general welfare concerns of the fishing community. Well-off fishing households are often found to have strong social ties to rich people and influential persons involved in politics, while the poor have very few such networks. Having such social networks is essential for drawing benefits from state and private resources and making better use of local opportunities. The unfavourable political pressure and interference in resource management decreased socioeconomic status of the participants.

They also reported that the local supreme groups are located closest to the cyclone shelters and may control local-level disaster mitigation planning. Accordingly, it became evident in the group discussions that those deemed 'socially supreme' manipulated the determinants of participation in governmental and non-governmental development projects. Their influence in the region ranges from local and district-level influence to the capital city of Bangladesh. Most fishers are powerless and depend on the 'socially supreme' (Mallick & Vogt, 2011). Most fishers mentioned that they don't have enough capital or assets to meet their demand. They don't have sufficient access to formal loans from Government and NGOs. While informal loans are available from *dadonder,* the interest rate of this loan system is very high. Almost 90 percent of the respondent of the study said they have access to informal loans from *dadonder*. The monthly income of the fisher is meagre (Tk 10,942±2,115 or USD 102±20). Thus, the current economic system makes the small-scale fisher community more vulnerable to disaster.

Dynamic pressure

Dynamic pressure is the process and activities that transform the effects of root causes into vulnerability. These change the root causes into a particular form of insecurity that must be considered regarding the hazards vulnerable people face.

Lack of education

As in many other rural communities in Bangladesh, the illiteracy rate in fishing communities is high. The literacy rate at 7+ years of age is around 30 percent, which is below the national average. Although the children of fishing households go to school, the drop-out rate is high (about 80 percent before completing five years of primary schooling). One reason is that fishing is labour-intensive, and fishers cannot afford to take manpower from outside the household and allow the children to attend school. In addition, seasonal and uneven income from fishing is not conducive to bearing the regular costs of education.

Lack of training

Due to a lack of sufficient training, fishers are unaware of disaster preparedness and risk reduction. The less skilled and untrained fishers are not concerned about modern navigational processes and weather forecasting, making their fishing and life more vulnerable. The uneducated fishing people cannot access power-structure and raise their voices against the injustices they face.

Lack of access to local markets

Many fishers lose market access in the immediate aftermath of hazards, which reduces local production and increases localized supply shortages of many goods. Consequently, demand for goods and daily necessities increases, causing a high need for cash and negatively impacting the local credit flow. Furthermore, transport costs also increase the supply of goods from outside areas, increasing food insecurity and creating a prolonged dependency on relief support, ultimately reducing the well-being of local communities (UNISDR, 2010).

Rapid population growth

Patuakhali is one of the most populated regions in Bangladesh. The average household sizes in the interviewed communities are 6.25 persons, which is higher than the national average (4.6 persons)[1]. Large family size, without the necessary skills for income, makes them vulnerable to income shocks.

Migration

In the study area, migrant fishers come mainly from nearby districts during the hilsa shad fishing season. Most migrant fishers are either seasonal fishers or work in agriculture in their place of origin. They migrate to the coast during the rainy season when agricultural production in their settlements decreases. In Patuakhali, they are usually hired by local elites or *dadonder*. Migrant fishers go deep-sea fishing, whereas local fishers usually catch near shore. Local boat owners also prefer to hire migrant fishers whom they perceive to be more experienced, skillful, and willing to risk deep sea fishing than locals.

Debt cycle

Fishers' access to formal credit markets is minimal due to a lack of collateral assets like landed property. Therefore, they depend on an informal credit mechanism known as the *dadon* (advanced loan) system. Regardless of the amount of money owed, the borrowers must give all the fish they catch to the *dadondar*, who determines the price of the produce (or a commission that ranges between 5 percent and 10 percent of sales revenue) (Kleih et al., 2003). Thus, the *dadon* system binds the fishers to the money lender in a debt cycle.

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1 Sample Vital Registration System, 2010. Bangladesh Bureau of Statistics.

Decreased fish production

The decline of fisheries production is not linear and some years are better than others. Nevertheless, the threat of declining fish stocks is always present in coastal communities. The main reasons stated by fishers for the decline in catches are overfishing by commercial trawlers, increased number of boats, use of more efficient/destructive gears, pollution (due to agricultural chemicals, fertilizers, industrial wastage, oil discharge from boats, and ship-breaking yards), and changes in the natural environment (e.g., changes in the seabed, siltation).

Overfishing

Fisher of the Patuakhali region indiscriminately harvests fish from adjacent rivers and seas. The regional Hilsa stock is overfished, and pollution and loss of essential riverine habitats through siltation and water diversion further reduce fish numbers. Widespread use of small-mesh gillnets is leading to fish juveniles being caught, especially in riverine areas, reducing the parent population for the next generation and contributing to the population decline.

Unsafe condition

Unsafe conditions are the specific forms in which people's vulnerability is expressed in time and space in conjunction with a hazard. This may occur through different processes.

Dangerous locations

Many fishers in the region live close to river embankments. Thus, any unsuitability of the embankments makes them unprotected from disasters. Alam and Collins (2012) found that the coastal and island occupants living along the embankment in Chakaria, Kutubdia, and Sandwip are landless and have lost their homes three times on average due to coastal erosion. A rapid spread of unprotected settlements has emerged in hazardous areas because they provide a good opportunity for income generation.

Livelihood at risk

Small-scale fishers are susceptible to income vulnerability because of their high dependency on fisheries (Kulatunga et al., 2014). Thus, the most common disaster-driven vulnerability for the coastal fishers in the study region is the loss of livelihood opportunities. The destruction of standing crops, fisheries, and other household assets drastically reduce livelihood earnings over the short- and long-term. The loss of boats and fishing equipment also continues to limit fishers' capacity to harvest in coastal waters in adjacent areas.

Low-profit margin/ Low-income levels

Fish is a highly valued product compared to other agronomic products in Bangladesh. Still, a good catch does not ensure a reasonable price for fish products for fishers. For instance, Ali (2010) found that there are eight layers of middlemen from the fishers to the consumer in the hilsa marketing channel and that fishers only get 1.5 percent of the final consumer price. Moreover, low economic benefits drastically reduced the adaptive capacity of fishers to changing situations.

Social vulnerabilities

The social stratification of communities is another imperative factor for social unrest and the mismanagement of institutions. A prominent example of the impact of social stratification is the unfavourable relationship between fishers and boat owners. Boat owners often force crew members to continue fishing even in unfavourable weather conditions. This strategy creates positive economic outcomes for boat owners but risks the safety of fishers.

Lack of disaster preparedness

The unwillingness of fishing communities to move into cyclone shelters during cyclones exposes them to natural disaster vulnerability. Further, most of the communities in the Patuakhali region suffer a shortage of resources that can be consumed during a disaster. For example, respondents highlighted how a lack of food stocks, medical facilities, and money makes them more vulnerable during the aftermath of the disaster. Additionally, small-scale fishers often live in remote areas, where food and medical aids are late to reach after a disaster.

Weak disaster warning system

Small-scale fishers face multiple hazards each year. Thus, responses to rough weather warnings depend on the intensity of wind speed they experience, local belief in the probability of dangerous cyclone events, or the presence of a cyclone signal hoisted by the Bangladesh Meteorological Department (BMD). Before moving to safer locations, they adopt a 'wait-and-see' approach and observe whether the cyclone intensity is rising. However, sometimes people do not trust official warnings for several reasons, including a lack of understanding of cyclone warnings, experience with warning failure, and pressure from the employer to continue fishing by ignoring the signal.

How hazards became disasters

A hazard can be defined as a potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation (UNDRR, 2009) whereas disaster can be defined as a serious disruption of the functioning of a community or a society causing widespread human, material, economic, or environmental losses, which exceed the ability of the affected community or society to cope using its resources (UNDRR, 2009). Disasters occur when unsafe conditions are combined with physical exposure to hazards.

Risk is the conditional probability of harm on exposure to a perturbation or stress. It can be defined as the probability of harmful consequences or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted, or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Total risk obtained for all hazardous phenomena (natural and technological) in a specific area, which can cause harm and/or damage to environmental property and threaten people's health and life. The primary basis of the multi-risk concept is that most hazards are not hazards per se and are triggered by other hazards, i.e., the domino effect. Additional hazards can be caused by damaged or affected elements at risk (UNDRR, 2009). For example, diarrhea incidences tremendously increase in the aftermath of a flood or cyclone in Bangladesh due to unsafe drinking water.

Coping strategies adopted by small-scale fishers

Coping capacity means that people or institutes use available resources and abilities to face adverse consequences that could lead to a disaster. As presented in Table 1, small-scale fishers adopt several coping strategies to recover from disaster-induced loss and damage (Table 1). Before a cyclone, fishers take several strategies to reduce losses and save their belongings. While some hide their food, valuables, and money in the ground, others were found to be somewhat apathetic about the preparation. Some fishers send their valuable materials to their relatives in safer areas.

Table 1. Small-scale fishers' responses to extreme events.

A. Response to extreme events when fishers are at the coastal fishing

Before disaster	During disaster	After disaster
• Return to coast	• Tie several net floats together	• Return to home
• Ready life-supporting equipment (plastic drum, buoy)	• Bind some boats together	• Search for their family member if they are found missing
• Continuing fishing near shore	• Use a plastic drum to float	• If the loss is minimum, start fishing
• Go to riverside	• Stop fishing	• Repair the net and start fishing
• Spread the message to another fisher	• Pray to Almighty	• Search for missing boats or crews
• Use radio for the weather update	• Keep the boat in an appropriate position considering wind direction	
• Close sail to escape from strong wind	• Sometimes they give up the net with fish to protect the boat from strong waves and stay in the boat	

B. Response to extreme events when fishers stay at home

Before disaster	During disaster	After disaster
• Move to the cyclone shelter	• Pray to Almighty	• Repair and clean up the home
• Keep domestic animals in a safe and high place	• Stay at home, keeping family members closely	• Collect relief materials
• Make raft for move-in flooding condition	• Sometimes small boats are put above and bound firmly to stay during flood	• Reconstruct dry fish shad
• Transfer family members to a relative's house	• In the cyclone, shelter, stay together, and pray	• Prepare gear and craft for fishing
• Keep necessary materials underfloor by packing with polythene	• Participate in volunteer activities	• Take a loan
• Cover dry fish shad properly	• Livestock animals are set free to find a safer place	• Search for alternative livelihood
• Store dry food	• Provide mental support to a weaker family member	• Sell jewellery, trees, domestic animals, etc., for money
• Bind the home with nearby trees or poles with a rope		• Move to another city to sustain their livelihood
• Keep drinking water source (e.g., tube well) covered		• If boats and nets are damaged, and it takes time to repair, then they go with other fishers who have boats and gears
• If possible, cover the pond with a net to protect the fish		
		• Receive help from relatives

Some also sought shelter in their relative's homes in further inland areas. Many move to cyclone shelters, higher places, and other strong buildings at the eleventh hour. Besides, the fishing communities help each other irrespective of social class. During the disaster period, religious activity increases. These fishers perform spiritual activities believing that only God can help and save them from these devastating disasters. Additionally, local youth play an important role in saving the lives of women, children, and older people during the disaster. Young men in these communities are known to fall victims due to their attempts to save the lives of family members.

After the recession of disasters, various occupational groups respond differently to the devastating situation. The survivors first go out in search of their family members. Then, they focus on seeking out a means of survival and livelihood. The fishers search for their nets and boats. After a devastating disaster, the top priority of survivors is to rebuild their homes and search for house materials to replace those removed by the strong winds and surge water. All the family members, including children and women, help repair the fishing gear. They also catch fish by hand using small nets and locally-made fishing traps. Women of the fishing community also work as maidservants in other houses to earn daily meals. Thus, the occupation of a fishers changes a lot during these periods. While in a normal situation, fishers fish separately, after a cyclone they work as a group and share the same net and boat.

Coping strategies adopted by fishers during offshore fishing include some fishers returning to the coast, some continuing their fishing activity near shore, some moving to the riverside where the impact of the disaster is less, and some fishers preparing life-supporting equipment. During a disaster, fishers also use strategies to protect themselves, including tying several net floats together and binding some boats together. Some fishers use a plastic drum to prevent drowning. They also stop their fishing activity and pray to God. Sometimes fishers sacrifice their nets to protect the boat and their lives from strong winds and waves. After a disaster, fishers return home, search for their family members and crews if they are found missing and repair their boats and nets. If the loss is minimum, they go fishing in the sea again.

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24. Pollution and Small-Scale Fisheries: Impacts of Shipbreaking Activities on the Chattogram Coast

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Ships beached to be dismantled on the Chattogram coast (Photo: Md. Abu Redwan Khan, 2022).

Hundreds of small-scale fishing communities live along the Chattogram coast in Bangladesh's southeast area. They have maintained their

hereditary rights to the adjacent coastal space for fishing and other ancillary activities such as beaching boats and drying nets. However, the expanding shipbreaking industry threatens their tenure rights and livelihoods. Being extremely hazardous, shipbreaking industry was evicted from developed countries in the 1960s and has since gradually established a foothold in developing countries. Based on fishers' perceptions and literature review, this chapter assesses the impacts of shipbreaking on the coastal environment and small-scale marine fisheries. Pollutants discharged from shipbreaking yards affect the surrounding marine ecosystem and biodiversity, having a devastating impact on small-scale fisheries. The quantity and variety of fish species have decreased dramatically as the industry has grown. Fishers are confronted with enormous obstacles; fishing effort has increased, while catch per unit effort has reduced. They are also competing for coastal space at an increasing rate, putting their fishing and fishing-related activities in jeopardy.

Introduction

Shipbreaking is the process of dismantling ships to reuse the parts and scrap recycling, with the hulls being discarded in ship graveyards and materials such as steel and wood being extracted for reuse or recycling. During the shipbreaking process, almost all of the ship's total weight can be recovered for recycling or reuse, making ship breaking an environmentally friendly exercise that reduces the need for mining and raw metal manufacturing (Neşer et al., 2008). On a micro-scale, however, due to weak environmental and labour legislation in developing countries, toxic materials are frequently disposed of and spilled from scrap yards, causing havoc on the surrounding coastal ecosystem and marine biodiversity (Mikelis, 2008; Hossain et al., 2016). Until the 1960s, shipbreaking activities were mostly centralized in highly industrialized countries like the USA and Europe. However, stricter labour and environmental legislation have gradually made it economically unfeasible for these industries to operate in western countries. Eventually, in the 1960s, shipbreaking activities went to South Korea and Taiwan, and then, in the 1970s, to India, Bangladesh, Turkey, and Pakistan (Frey, 2015).

In Bangladesh, the long, flat, and uniform intertidal zone in Chattogram has provided ample space for beaching and dismantling ships. Further, a lack of environmental awareness, weak environmental regulations, inconsistent law enforcement, cheap labour, and substantial local demand for iron and steel drive the shipbreaking activities in Bangladesh. The industrialists of the Chattogram region took advantage of the situation and established a shipbreaking industry along the Bay of Bengal. Over the years, as predicted, weak environmental legislation and industry owners' reluctance to maintain standards have allowed large quantities of highly hazardous substances from shipbreaking yards to escape into the environment, blending primarily with the beach soil and seawater around them. Oil and greasy compounds, persistent organic pollutants (POPs), asbestos, and other trace and heavy metals are among the toxic wastes accumulated in the marine biota (Hossain & Islam, 2006).

The physical and chemical characteristics of soil and seawater have changed significantly in shipbreaking areas over the last few decades. The high turbidity of wastewater generated from shipbreaking has caused a higher concentration of biochemical oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS), electric conductivity (EC), and a lower concentration of dissolved oxygen (DO). In addition, the presence of ammonia (NH3), oil, and grease in the wastewater, elevated the seawater pH value around shipbreaking areas (Hossain et al., 2016). Toxic pollutants have caused low abundances of phytoplankton, zooplankton, benthos, and microorganisms, leading to an increase in trash fish and a decrease in fish species diversity, and even death. As a result, the catch per unit effort (CPUE) has been reduced by more than half compared to the last few decades (Barua, 2011).

The social cost of the shipbreaking activities is also immense. Shipbreaking activities harm the communities around the entire Chattogram coast and beyond, where small-scale fishing communities are most affected. Hundreds of fishing communities are located along the Chattogram coast, from

Mirsharai to Patenga, and thousands of fishers, predominantly lower-caste Hindus, fish in the neighbouring coastal waters. The negative consequences of shipbreaking activities have jeopardized these fishing communities' livelihoods and health conditions. This chapter assesses the impacts of shipbreaking on the coastal environment and small-scale fisheries based on a literature review and individual interviews.

Major pollutants and impacts on fisheries biodiversity

Oil

Black oil residues from dismantled ships are frequently mixed with beach soil and seawater near the shipbreaking yard and are mainly composed of hydrocarbons and sulphur-containing chemicals. Mineral oils that get spilled from shipbreaking are usually present in hydraulic fluids, oil sump (engine, lubricating oil, gear, separator, etc.), and oil tank residuals (cargo residues) (Hossain & Islam, 2006). Because of the old-fashioned beaching approach, engine oil, bilge oil, hydraulic oil, lubrication oil, and grease are inducing acute toxicity, reducing light intensity in seawater, and inhibiting oxygen and carbon dioxide exchange across the air-seawater interface. As a result, the growth and diversity of marine species, including plankton, fish, marine mammals, and benthos, get seriously affected, posing a threat to coastal and marine biodiversity as a whole (Hossain et al., 2016).

Oil spills have adverse effects on both fish and humans. Adult fish exposed to oil may experience stunted growth, enlarged livers, heart and respiration rate abnormalities, fin erosion, and reproductive issues. Fish eggs and larvae are particularly vulnerable to both fatal and sublethal effects. Many young fish species spend their early life stage in shallow vegetative regions (less than 10 meters) and become susceptible to the hazards. Furthermore, fish and shellfish exposed to oil-related hazards become unsafe for human consumption (Saadoun, 2015).

Heavy metals

On ships, heavy metals can be found in paints, coatings, anodes, and electrical equipment, among other places. These are dismantled and reused without precautionary safeguards in place. As a result, these parts are frequently thrown or burned on beaches, polluting the nearby soil and water (Hossain & Islam, 2006). Heavy metals are not biodegradable and can accumulate at dangerous levels in aquatic habitats. The benthos (benthic creatures) accumulates the metals and eventually get integrated into the bottom sediment (Shah, 2017). Off all the heavy metals secreted from the shipbreaking activities, lead (Pb), mercury (Hg), cadmium (Cd), iron (Fe), aluminum (Al), zinc (Zn), copper (Cu), chromium (Cr), and manganese (Mn), pose the most significant hazards (Hossain et al., 2016). Fish suffer from delayed hatching, a reduction in body defense systems, and increased mortality because of the elevated concentration of heavy metals. For mollusks, delayed development and maturation systems happen due to the presence of heavy metals. The ingestion of heavy metals causes increased mortality, delayed development, and irregular cell division of crustacean species, while benthos becomes irregular in structure, face retardation of growth, and acute toxic conditions at the bottom (Ansari et al., 2004).

Persistent organic pollutants (POPs)

Persistent Organic Pollutants (POPs) are carbon-containing toxic chemical substances that do not degrade quickly, tend to accumulate in food chains, and pass from one species to the next through the food chain. Due to their high persistence and toxicity, POPs continue to pose a risk to the environment, and aquatic lives, especially benthos and organisms at the top of the food chain (fish), get exposed to high levels of POPs through bioconcentration and biomagnification (Miniero & Iamiceli, 2008). Marine vertebrates at early life stages face negative consequences at much lower concentrations than those in juvenile and adult stages because crucial biochemical and molecular processes occur during tissue differentiation and organization. For example, POPs disrupt thyroid function in fish, which affects their development, metabolism, and growth (Johnson et al., 2013). POPs include various toxic chemicals, but the ones that are released from shipbreaking activities cause significant harm to marine organisms.

Polychlorinated biphenyl compounds (PCBs)

PCBs are a group of man-made organic compounds with 1–10 chlorine atoms attached to a biphenyl molecule. PCBs drew much attention from scientists due to their toxicity, resistance to degradation, ability for long-distance transport, and proclivity to bioaccumulate via food chains (Johnson et al., 2013). Ships dismantled in Chattogram often contain POPs in cables, electrical equipment such as capacitors and transformers, gaskets, watertight seal material, and painted surfaces (Hossain et al., 2016). PCBs released from shipbreaking activities continue to settle in the sediment and are accumulated by the marine invertebrates such as amphipods that feed on benthic animals. This way, the PCBs pass through the food chain through different trophic levels. Since the fish consume many amphipods, the number of PCBs in their bloodstream increases over time. As a result, the effects of PCBs in benthos are amplified because they accumulate in the tissue of higher trophic feeders, such as humans.

Polycyclic aromatic hydrocarbons (PAHs)

PAHs are a chemical group with two or more condensed aromatic rings primarily formed during the incomplete combustion of organic matter. The toxicity of PAHs has negative consequences on marine animals, especially fishes. Endocrine disturbance, immunotoxicity, and embryonic development are among the effects these chemicals have on fish. During the early development of fish, the heart is vulnerable to chemical pollutants such as PAHs, and any disturbance of cardiac function influences fish survival at all life stages (Honda & Suzuki, 2020). PAH exposure induces bone disruption in fish and marine mammals, causing bone metabolism. In addition, benthic or bottom-feeding fish living in habitats contaminated by PAHs suffer from bioaccumulation that harms liver metabolism (Johnson et al., 2008). Similarly, PAHs induce a detrimental impact on the formation, growth, osmoregulation, behaviour, and reproduction of different marine organisms. PAHs released from shipbreaking activities are also genotoxic and carcinogenic for humans. They interfere with enzymatic degradation, causing malignant tumors in the lungs, stomach, intestine, and skin (Collier et al., 2013).

Polyvinyl chloride (PVC)

PVC is a thermoplastic polymer widely used worldwide on many ship machinery and materials. PVC waste is difficult to dispose of at the end of its use because, when burned, it releases hydrogen chloride (HCl) fumes. When buried, it releases toxic chemicals into groundwater and the atmosphere. PVC is persistent and estimated to take up to hundreds of years to decompose completely. Some of them break down into tiny particles much quicker, which in turn end up in the stomachs of marine fish, and ultimately in the human body through seafood consumption. In addition, PVC can promote pathogen growth in the ocean, making marine organisms vulnerable to diseases (Lusher et al., 2017).

Table 1. Pollutants discharge from shipbreaking activities and impacts on fish species.

Pollutants	Impact on fish species
Oil	▪ Fatal and sublethal effect on eggs and larvae. ▪ Stunted growth, enlarged livers, damaged heart and respiration rates, fin erosion, and reproduction problems of adult fish.
Heavy Metals	▪ Delayed hatching, a reduction in body defense systems, deformities, and increased mortality in fish species. ▪ Bioaccumulation within the food web.
Polychlorinated Biphenyl Compounds (PCBs)	▪ Reproductive and immunological complications, as well as hormonal imbalances. ▪ Bioaccumulation within the food web.
Polycyclic aromatic hydrocarbons (PAHs)	▪ Bone disruption, liver metabolism issues, endocrine disruption, immunotoxicity, disturbance of cardiac function, and severely affected embryonic development.
Polyvinyl chloride (PVC)	▪ Anthropogenic stressor. ▪ Accumulates in the stomachs of fish.

Organotins

Organotins are a group of nerve toxins. Tributyltin (TBT) is a toxic organotin (that kills living organisms) used in anti-fouling paints since the 1970s. TBT is considered one of the most toxic compounds that disrupt the endocrine system of marine shellfish, leading to the development of male characteristics in female marine snails. TBT also has an endocrine-disrupting effect on fish (Hossain & Islam, 2006).

Change in physicochemical properties of seawater and its impacts on the food chain

The marine ecosystem is made up of a complicated food chain that connects primary producers such as phytoplankton to various levels of consumers. The entire marine food chain depends on the abundance and composition of primary producers, zooplankton, and benthic organisms and how they respond to water quality changes (Lipi et al., 2020).

The physicochemical properties of seawater and sediments have a substantial impact on the state of the food web. Over the last few decades, shipbreaking activities in Chattogram have increased total suspended solids (TSS), total dissolved solids (TDS), turbidity, and biochemical oxygen demand (BOD) in the surrounding areas. Shipbreaking activities also reduced dissolved oxygen (DO) levels, indicating a disruption in the food web (Hossain & Rahman, 2011). Firstly, oil floating over vast areas inhibits light penetration and reduces photosynthesis, resulting in lower primary productivity, i.e., phytoplankton production. Phytoplankton is the primary food producer of the aquatic habitat and forms the base in the food chain. The composition of zooplankton, an intermediary species that transmits energy from phytoplankton to larger carnivores, in the shipbreaking area of Chattogram is much lower than in the non-shipbreaking area (Khan et al., 2015). Finally, sediment pollution in shipbreaking sites inhibits the growth of benthic organisms. Benthic bottom-dwelling organisms are ecosystem architects because they create optimal conditions for fish spawning, shelter, and foraging. The absence and presence of numerous taxa of benthic organisms in shipbreaking areas, both of which are pollution indicators, demonstrate the negative effects of shipbreaking activities on the quantity and variety of benthic organisms (Lipi et al., 2020). Changes in phytoplankton, zooplankton, and benthic organism abundance and diversity due to changes in physicochemical parameters have resulted in a drop in fish species populations and diversity in the shipbreaking area. Additionally, the higher turbidity increased BOD and COD and decreased DO elevate anthropogenic stress, making fish species vulnerable to other physiochemical changes. According to the fishers interviewed, the number of trash fish has increased, several commercially important fish species are endangered, and overall fish abundance has declined. Although fishing efforts have grown significantly, the catch has decreased by 50-60 percent (Barua, 2011).

Competition with coastal space and impacts on fishery-based livelihoods

The shipbreaking yards are located in the Salimpur-Kattali region, and the region is one of the most ecologically productive coastal regions. Thousands of hereditary lower caste fishers live in this region. Horizontal shipbreaking yard expansion along the coast makes fishing communities vulnerable in several ways. For example, it increases competition between fishers and shipbreakers for space. An interview with local fishers revealed that the beach along the seashore, which used to be utilized by fishers for drying nets and anchoring boats, is now exposed to encroachment by shipbreaking activities (Figure 1). Similar to coastal land space, the water space is also exposed to encroachment by the imported ships waiting to be dismantled.

Figure 1. Shipbreaking activities have taken over coastal space previously used for beaching boats and drying nets by small-scale fishing communities (Photo: Md. Abu Redwan Khan, 2022).

On the Chattogram coast, small-scale fishers maintain hereditary entitlements in the fishing, known as *Pata*. The *Pata* is subdivided into smaller parts known as *Faar*, where the fishers set Estuarine Set Bag Net (ESBN). The ESBN is the stationary main fishing gear for the coastal fishing communities. These fixed fishing nets are frequently clogged with spilled oil and debris from shipbreaking activities. The fishing gears are frequently damaged when ships are brought to the shore for dismantling. The fishers are given no advanced notice of ships moving into the coast in most cases. One of the fishers explained, *"during the pick-season of the hilsa fish harvest, i.e., August – September, is when the most ships come to the Chattogram coast for dismantling purposes, and this is the time when we must catch enough fish to repay our dadon (loan taken from a moneylender/middleman) back. That situation leads to more damaged nets and less fish catch."*

The shipbreaking activities are detrimental not only to the coastal environment but also to the coastal fishing communities. The fishers also perceived a direct link between the expanding shipbreaking activities and the decreasing fisheries resources in the coastal areas. The fishers argue that pollutants discharged from shipbreaking are killing delicate juvenile species and forcing fish species to migrate away from the coastal areas. Fishers reported that previously they used to catch a good quantity of fish of different species. However, with increased shipbreaking activities, the diversity of fish species and the Catch Per Unit Efforts (CPUE) is declined. One of the respondents said, "*a couple of decades ago, different highly valued fish species were available in the mangrove creeks along the shore, but now most fish have disappeared*." This makes small-scale fishers move deeper offshore in search of fish. Nevertheless, they lack the appropriate fishing equipment and face increased competition from large-scale fishing trawlers. One respondent reported "*our ancestors did not go beyond one or two miles from the seashore for fishing, but now we are venturing beyond eighteen to twenty miles and yet returning mostly empty-handed*." Further, small-scale fishers compete with the industrial fishers for fishing space in the coastal areas. The industrial fishers are supposed to fish beyond the 40-meter depth of coastal water, but often they fish within the 40-meter range, which increases conflicts between those groups. Fishers are aware of the severe environmental repercussions of oil spills caused by shipbreaking activities and the reasons for the depletion of fisheries' resources. *"If tars come in contact with our faces, we can't breathe," one respondent explained. "Similarly, if black oil is spread over the seawater, the fish can't receive oxygen from the air."*

The survival of fishing communities is in jeopardy as more ships are beached, fishing sites are occupied, and increasing fishing efforts and lower CPUE. Fishing communities have continued to move away from their traditional way of life, which had existed for generations before the growth of the shipbreaking industry. Many fishers have left their communities and migrated to cities, searching for jobs in different parts of the country. Furthermore, shipbreaking yard owners frequently compel fishers to sell their property at a low price to expand their operations, leaving the fishing village shrink. These vulnerable fishing communities have hardly received any support from the government and other organizations. The neighbouring fishing villages have been suffering from unfavourable and adverse conditions for more than three decades. They have submitted several complaints to the governing authorities about uncontrolled shipbreaking and its negative impacts. However, none of them has resulted in any action. One of the respondents stated that *"my memory stretches back to 1991 since when I witnessed my community submit several complaints to authorities, speak with local elected public representatives, and even stage protests on the street, but none were effective."* Overall, the future of fishery-based livelihoods is uncertain since the owners of the shipbreaking business are wealthy and powerful, and law enforcement is lenient.

Conclusion

While shipbreaking activities on the Chattogram coast have a positive contribution to Bangladesh's economy, these benefits overwhelmingly go to the powerful section of society that import and dismantle the aged ship. This shipbreaking activity imposes enormous environmental and social costs. Unfortunately, small-scale fishing communities are bearing this cost disproportionally without benefiting from shipbreaking activities. The shipbreaking activities on the Chattogram coast illustrate one example of how small-scale fisheries are increasingly marginalized due to ocean-based economic activities. In this context, any policy regulating shipbreaking activities in Bangladesh should emphasize social justice for the affected people, including small-scale fishing communities.

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25. Heritage at Risk: Multifaceted Threats to Unique Fish Spawning Sites of the Halda River

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Carp seed harvest using traditional gears and fishing crafts in the Halda River (Photo: Jewel Shill, 2021).

The Halda River, locally known as a 'magical fish bank', is one of the unique aquatic features in Bangladesh in terms of providing ecological services and goods, economic returns, and societal contexts. Natural production of Indian major carps happens in this tidal river, which are collected and processed to hatch in the mud-made coop deploying indigenous technology on the riverbank. These eggs, seeds, and fingerlings ultimately cater to 60 percent of the country's carp seed demand in aquaculture. The river's biological and economic productivity that contributes to the local and national income is also important for small-scale fishers. However, this natural resource is losing its uniqueness and productive contexts due to anthropogenic pressures. Among the factors of resource depletion of this river, pollution, man-made infrastructural changes, overfishing, and illegal fishing disturb the natural spawning grounds. This calls for a proper science-based investigation and governance mechanism to sustain human-nature interactions in the Halda River. This chapter discusses current threats and forthcoming challenges, and recommends a basis for the policymakers to secure small-scale fisheries in the Halda River and associated communities.

Introduction

Bangladesh is a land of rivers. That is why the riverine delta system influences the geography and cultures of the country. Here, people talk to the rivers; for ages, they have been living in harmony with the rivers. The services from the rivers are significant, such as fish production, freshwater supply, transportation, tourism, waste assimilation, etc. The Halda River is the third main water stream of Chattogram (South-East region of Bangladesh) after the Karnaphuli and the Sangu (Kabir et al., 2013; 2014). The Halda is situated at 22°54' N and 91°48' E to 22°24' N and 91°53' E; a mainly hilly water stream originates from the Batnatali Hill Ranges of Ramgarh *Upazila* (sub-district) under Khagrachari district. It then drifts through the Fatickchari, Hathazari, and Rouzan of Chattogram district, covering 88 km and runs into the Karnaphuli River, which, after crossing 20 km, runs into the Bay of

Bengal (Patra & Azadi, 1985; Azadi & Alam, 2011). This river covers a total area of 1,682.92 km^2 with a land area of 1670.59 km^2 and a watershed of 12.33 km^2 (Sarker et al., 2020). The Halda River watershed is associated with 19 branch canals and 17 hilly fountains, and these are the primary sources of water of the Halda (Saha et al., 2019). The Halda is the only tidal river in Bangladesh where the fertilized eggs of major Indian carp are collected by fishermen directly, thus making it a distinctive heritage of the country. Sixty percent of the country's pond carp culture depends on the naturally produced fish fry from this river, which is a remarkable contribution in terms of national aquaculture. This is also the only river in Bangladesh known as the natural carp breeding ground in South Asia. The tangible value of this river (Table 1) is approximately USD 20.5 million, based on the observation during a one-year period (Kabir et al., 2013). In terms of its length which totals 88 km, the Halda is comprised of a narrow, 48 km long, mostly hilly stream that flows from the point of origin to Nazirhat and a 40 km long stream between Nazirhat Point and the Halda mouth along Karnaphuli. The latter, 40 km stretch is used for fishery and navigation and has been considered the foremost spawning ground of major carps, which occurs only within 15 km long area — from Satterghat to Madunaghat at the mid to lower zone of the Halda River (Islam et al., 2020).

Table 1. Types of services from the Halda River and its value (Source: Kabir et al., 2013).

Types of Services	Million USD
Fishing	0.07
Fish Fry	0.005
Irrigation	15.78
Drinking Water	1.33
Water Transportation	0.12
Sand Extraction	2.51
Others	0.685
Total	**20.5**

Riverine small-scale fisheries have been largely overlooked in Bangladesh.

Small-scale fishing is not only a livelihood option but also an 'art of living'. Small-scale fishing communities of the Halda River depend on its resources and they supply carp seed throughout the country. The uniqueness of this resource demands indigenous technologies which fishers have been implementing throughout the history and which have been established as Traditional Ecological Knowledge (TEK), mentioned by Berkes (2008). Halda fishers, those directly involved in natural carp eggs and seed collection, deploy their own 'expert knowledge' to collect eggs and seeds during breeding seasons. This historical knowledge and the produced seeds cater to the carp fingerling demand of the whole country.

However, over the years this river has been losing its ecosystem richness due to several anthropogenic pressures such as over-fishing, straightening oxbow bends, excessive sedimentation in river basin, water quality deterioration caused by pollution, unplanned sluice gate establishment, lack of sanctuaries, enormous sand quarrying, improper care of brood fishes, fish biodiversity depletion, unimpeded erosion of riverbanks and especially climate change (Rahman & Bishwas, 2009). These problems are adding layers of vulnerability to this natural seed bank because of the lack of planned river management projects (Kibria et al. 2009, 2018; Kabir et al., 2014). With the growing demand for aquaculture seeds, sustainable management of this river is crucial. A participatory form of genuine adaptive governance that focuses on environmental and resource entitlements for the associated fishers of the river is central to addressing small-scale fisheries management of the Halda River. This requires an in-depth understanding of both natural and anthropogenic stressors affecting the livelihoods of small-scale fishers within their socioeconomic and political contexts and is fundamental to resource-use planning and management of the Halda River.

Natural fish seed bank

The Halda River is rich in fish species diversity, particularly ichthyofauna. Among the recorded 93 species of Ichthyofauna (finfish and shellfish) in the Halda River, there are 83 finfish species under 13 orders and 35 families, and a total of 10 shellfish (8 freshwater prawn, one marine shrimp, and one crab) under one order and three families, based on depth observation (Azadi & Alam, 2013). The 83 finfish species are comprised of estuarine (26 fish species), freshwater (55 fish species) and marine species (2 fish species). Among the recorded species, there are 20 threatened, 3 critically-endangered, 9 endangered and 8 found to be in vulnerable categories (Azadi & Alam, 2011). Besides these, 42 species of birds, the freshwater Ganges river dolphin (*Platanista gangetica*), another critically endangered species of Bangladesh, Asian small-clawed otter (*Aonyx cinerea*) and others mammals have been reported to occur in this ecosystem. Among the reptiles, peacock soft shell turtle (*Aspideretes hurum*), spotted flap shell turtle (*Lissemys punctata*), oriental garden lizard (*Calotes versicolor*), common skink (*Eutropis carinata*), Bengal monitor (*Varanus bengalensis*), yellow monitor (*Varanus flavescens*), copperhead rat snake (*Coelognathus radiatus*), crab-eating water snake (*Fordonia leucobalia*), checkered keelback (*Xenochrophis piscator*), binocellate cobra (*Naja naja*), and annulated sea snake (*Hydrophis cyanocinctus*) have also been reported (Kabir et al., 2015).

Endemic River Halda is the richest spawning ground of four Indian major carps, namely, *Catla catla, Laheo rohita, Cirrhina mrigala and Labeo calbasu*. This ground has long been the source of naturally produced carp spawns in the country and perhaps their only spawning ground in South Asia (Alam et al., 2013). Among many rivers in Bangladesh, the tidal River Halda is valuable and unique due to its well-known major carp spawning ground, carp egg collection, carp spawn fishery, and other fishery-related activities. There are a few factors that have been considered as crucial for the uniqueness of this river including lunar periodicity, water level and tidal cycle, heavy monsoon rain, thunderstorms, floods, limnology, hydrological factors, plankton, and the general biodiversity (Azadi & Alam, 2013). These factors support brood fish by establishing a congenial breeding environment. Usually, there is a relation between the eggs released by mother fish and the dense and darker clouds. Thick clouds and heavy rainfall are the primary factors for releasing eggs. Local fishers state that after thunderstorms, when the environment becomes calm, brood fish spawns. Water turbidity also favours this process.

From an anthropological point of view, the fishing communities maintain certain rituals which are believed to bring luck.

Harvest, livelihoods, and local economy

Traditionally, local fishers collect naturally spawned fertilized eggs of major carps using small-mesh mosquito nets and hatch these in mud pots during the monsoon season (May-August) in the upstream of the Halda River. The eggs usually hatch into fish fries after 4-5 days (approximately 96 hours), and are sold to different stakeholders and distributors or hatchery owners all over the country (Sarder, 2007; Alam, 2013). About 1,100 spawn collectors and 1,600 fishers are directly engaged in the egg collection (Caritas Bangladesh, 2011). After they collect the spawned eggs and, using their indigenous hatching technique, hatch them into fish fry, the egg collectors sell them based on the demand through different distribution channels. These carp seeds are mostly disease resistant, not affected by inbreeding, have a high survival rate, and can live in stressed conditions, which explain why the nationwide demand is so great. Thus, there is a complex market chain in the local and national markets. The carp seeds are bought by local fish farmers (70 percent), distanced fish farmers who buy them for their hatcheries (20 percent, private fish hatchery owners who wish to produce high quality broods (7 percent), and government-managed brood conservation centers (3 percent) for enriching fertile broods and fry. Usually, egg collectors sell them per kg of seed at the cost of BDT 40,000-60,000 (USD 500–700) (Saimon et al., 2016).

The harvesting of carp eggs and seeds and preparing those for selling is genuinely based on traditional knowledge transferred from generation to generation. The majority of the seed harvesters are professional fishers who are fishing or catching prawn post larvae-stage even after the carp spawning period ends. At the same time, some people are only temporarily involved in seed collection for seasonal income and livelihood. During the egg collection period (April-July), a festive mood prevails on the Halda riverbank. The egg collectors use a special kind of boat called '*Sampan*' that is a non-mechanized boat of the villagers. They collect eggs while performing a special song called

'*Halda FADA'* — a traditional local rhythm used for spiritual purpose in that area (Kabir et al., 2015). Fishers collect fertilized eggs of carp fish from this tidal river (Kibria et al., 2009). Each boat consists of 4 to 8 people, who are either family members or fellow fishers. Fishers use longshore nets, gill nets, lift nets, drag nets, and fishing rods to catch fish in the Halda River during day and night (Khan, 2019). Collected eggs are stocked in freshwater bodies throughout the country for carp fish production. Fish seed production and rearing in the river and riverbank is an orthodox and indigenous practice that progressed through the time and has become embedded as a religious practice. Thus, this river also bears a unique cultural value.

The river water is used for bathing, households, and local tourism, which provides livelihood opportunities (Table 2) for the people who live in the riverside. The river also plays other indispensable roles for the river basin dwellers. Many people maintain their livelihood through sand mining, water transportation, irrigation, etc. (Kabir et al., 2013). The overall value stands at about BDT 283 million (USD 3.3 million), which contributes to the national economy of the country.

Table 2. Employment opportunities for the local communities (Kabir et al., 2015).

Types of livelihoods	Number (Approx.)
Fish egg and fry collectors	1,800
Prawn postlarvae collector	200
Fishers (professional)	200
Fishers (non-professional)	150
Boatmen	250
Boat building and mending	150
Sand quarrying	760

Locals believe that the production system of the river creates a rigid and unfair hierarchy. Over time, this has resulted in resource users losing their livelihoods, income, and business. Powerful sections of society are dominating the seed collection during the season and are imposing transformation to traditional cultures. The management processes often miss local fishers' collective voices, and new entrants in the Halda River fisheries violate the rules and disrupt the productive nature of the river ecosystem. Nowadays, the catch levels of carp seed are becoming low and unpredictable. It it believed that the declining trend of carp seed harvest will ultimately lead to a lower aquaculture production in the country.

Multifaceted threats

In 1945, approximately 5,000 kg of carp spawning eggs were collected from the Halda River, but gradually the quantity of eggs from brood fish has been declining (IDF, 2018, Halda Project). Man-made barriers are the main reasons for the reduction of egg production. Indiscriminate catching of brood fish, use of illegal or banned fishing nets, destruction of fish habitats, motorized boat transportation, straightening of natural curves of the river, dumping of industrial toxic effluents, building of sluice gates across the creeks, installation of rubber dams, sand mining and dredging, use of detrimental chemicals, herbicides and pesticides in agriculture lands adjacent to river and tobacco culture in the upstream — these are all major activities that are causing damages to the river. As a result, in recent years carp fish egg release has declined remarkably.

The river habitat, its associated resources, and the living beings are all under threat due to illegal activities and practices. A number of unscrupulous gangs on the banks of the Halda have been evading the vigilance of administration by catching broods indiscriminately and illegally. This reduces the number of broods which in turns reduces the chances of sufficient spawned egg production (Yousuf, 2018). Certain nets and equipment used by some who fish in the Halda River are strictly prohibited under existing regulations. The illegal use of these fishing gears is greatly hampering the river's biodiversity, affecting in particular the brood fish and endangered dolphins. Additionally, daily water abstraction by Chattogram Water Supply and Sewerage Authority (WASA) for urban consumption, sand mining, and quarrying often destroy fish habitats. Overexploitation of fish and other aquatic resources is also causing a loss of fish habitat. Illegal motor-vessel movements along the

Halda River are causing extreme damage to its biodiversity. These vessels are blamed for killing and injuring broods and dolphins by causing collision with engine propellers (Khan, 2019). Other anthropogenic stressors that are continuously threatening the biodiversity of the river include the following:

Straightening of natural curves of the river: massive cutting of banks and cutting of river oxbow-type loops to introduce navigation routes, mainly for transportation of motorized boat and for the sake of the development, hampers the natural rhythm of this river, since brood fish used to spawn in these bends. Furthermore, heavy water flow in the straightened canals increases soil erosion and sedimentation in the basin.

Dumping of toxic industrial effluents: adjacent mills and factories discharge their effluents to the river without proper treatment. Incoming waste or waste materials from the banks of the Halda River and various point sources (e.g., industries, markets, and residential areas) are constantly polluting the river by increasing the level of Total Dissolved Solids (TDS) in the river. Untreated waste from these industries in Chittagong City Corporation (CCC) and adjoining areas flows directly into the river every day via different canals. In addition, household waste that is dumped into the river and the waste from agricultural farms are also a potential source of pollution in the Halda (Khan, 2019). Discharging poultry litters and household wastes or domestic wastes are also rampant (Islam et al., 2020).

Building sluice gates across the creeks: unplanned dams and construction of about 12 sluice gates (Khan, 2019) without considering the fish passes and the impacts on brood fish spawning ground are threatening the free-flowing nature of the river and disrupting the migratory routes.

Installation of the rubber dams: construction of two rubber dams (in Bhujpur and Harualchhari) disturbed the spontaneous propagation of the river upstream. Thus, it threatened this heritage as it disturbed the natural flow of the river. Moreover, rubber dam operations during the pre-spawning season hamper breeding performances of brood fish.

Sand mining and dredging: these two activities are some of the major economic activities on the river. Sand lifting, undiscriminating sand extraction from *Balu Mohal* (sand stations) of the Halda Riverside are also contributing to biodiversity depletion (Yousuf, 2017). In addition, these sand lifts use mechanized boats and dredgers that cause brood fish to migrate and leave, due to the lack of congenial breeding environment, loud noises, and damaged riverbeds. In the Halda River basin, agricultural practices use different types of harmful pesticides and chemicals, which ultimately run into the river through run-off, polluting the river ecosystems (Islam et al., 2020). Higher values of the Water Quality Index (WQI) may be caused by the washing out of excessive fertilizer from the farming fields and the washing up of the materials from the households that are disposed of into the river water (Ahmed et al., 2010). Beside this, some tobacco farming in the riverside area also releases toxic chemicals and harmful residues. The discharge from around 22 brick kilns on both sides of the river (Khan, 2019) are potential sources of water quality deterioration.

In terms of natural causes, irregular and untimely rainfall, drought, and temperature increase are reportedly influencing carp species' breeding performances (Saha et al., 2020). Different climate change-induced events such as floods, soil erosion, and landslides increase the suspended solids, metallic and other pollutants. Due to the sea level rise during the dry season, salinity intrusion through the Karnaphuli River into the Halda River creates an unfavourable environment for freshwater carp species (Ahmed et al., 2010).

Interventions

Initiatives aiming at conservation that encompass natural fish breeding ground and sustainable small-scale fishing practices in terms of seed harvesting were implemented by both the government and non-government organizations. Among some of the remarkable steps that have been put in place since 2007, was when the Bangladesh Government declared the Halda River a fish sanctuary, which aimed to protect and conserve the spawning ground of major carps and its fisheries resources. Other conservation activities include awareness building programs for users, brood stock conservation, vigilance and patrolling to stop illegal fishing by the local government, policy-level advocacy for limiting movement of engine boats, establishment of research laboratory and capacity building programs for the collectors. Because of the unique and valuable features of the Halda, which make it, among other things, the country's only and largest water body for natural carp fish breeding and prime dolphin habitat, it is a national responsibility to conserve and protect the Halda River with dignity. As a result, the National Committee on Biodiversity under the Ministry of Environment, Forests and Climate Change of Bangladesh renamed this invaluable reservoir as 'Bangabandhu Biodiversity-rich Heritage Halda' on 18^{th} March 2021 (The Financial Express, 2021). This reservoir has come under special monitoring and regular observation by the authority under the principles of the Bangladesh Biological Diversity Act 2017.

Yet, further crucial interventions and projects are needed to sustain this unique resource as most of the activities that disturb the river ecosystem are unregulated. To strengthen the embankment of the river, government initiatives were taken in 2018. The practice of using sandbags to reduce embankment-associated depth as well as the use of concrete blocking needs to be investigated thoroughly to see whether those have any adverse effects on the fish breeding grounds. The river must be protected from getting polluted from different outlets like tanneries, dyeing mills, paper mills, and power generation plants. Strong legislation and enforcement is an obvious strategy to protect this resource from pollution and ensure resource conservation. Effluent Treatment Plants (ETPs) for riverbank industries can minimize the river pollution by controlling detritus effluents. Some development organizations are working on introducing bio-pesticides and vermicomposting technologies for agricultural practices to alternate chemical uses. When it comes to water-borne transportation in the river that currently relies on motorized boats, these should be replaced by boat operations that use solar energies that can minimize disturbances. Indeed, experts have been recommending eco-friendly water transport systems to control the negative impacts of mechanized boats.

In terms of aquatic ecosystem and water quality of the Halda River, the Government of Bangladesh should take initiatives through the local government to establish monitoring and routine data recording; they should also take actions to investigate further deterioration of the water quality. For the first time ever in the history of Bangladesh, a unique research organization named 'Halda River Research Laboratory (HRRL)' has been established in the University of Chittagong that focuses solely on a single river. Donors have funded the establishment of this laboratory, which is a three-part specialized laboratory consisting of a river museum, archive and a digital conference center. The aim of the laboratory is to observe the environment and ecosystem of the river, and to establish a center for riverine research of Bangladesh.

This river is not only the single source of carp seeds but also an area of concern for biodiversity conservation as it is the home to dolphins and other aquatic animals. The management plan should incorporate all of the concerned stakeholders to build up a strong network of supporters. The Constitution of Bangladesh (18A) suggests conserving biodiversity, and the Convention of Biological Diversity (CBD) Bangladesh also stresses the need to collaborate with international communities regarding conservation and sustainable use of natural resources. In Bangladesh, wildlife conservation plans are designed to guide the implementation accordingly. The Halda River management should be an integral part of these legal dimensions. At the same time, policy dialogue among different stakeholders and the creation of permanent committees (both managerial and technical) that would focus on conserving the distinctive features of the Halda ecosystem are necessary.

Conclusion

Rich in resources, the Halda River is not only a water body; it is an aquatic body rooted in mystery. We have an opportunity to address the problems and identify potential solutions to ensure Halda's high productivity and sustainability in providing goods and services. At the same time, it is of utmost importance for the local administration and the people along the riverside to improve the overall condition of the water body and ensure the proper utilization of river resources. Envisioning the mandate of the Halda resource conservation and sustaining carp fisheries of Bangladesh also demands exploring governing factors that play a role in comprehensive Halda River management. Community-Based River Resources Management (CBRRM) and concerned departments of government and local administration can play a crucial role. Local communities should be on board in this process because people's participation is essential for improving the state of the environment and its natural resource.

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III

Governance and Responses

26. Assessing the Resilience of Coastal Fishing Communities of Bangladesh to Climatic Hazards and Disasters

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Island fishing communities are vulnerable to climatic hazards (Photo: Aparna Barman, 2021).

This study has measured the resilience of three coastal marine fishing communities of Rangabali Island in Bangladesh and assessed the factors responsible for increasing or decreasing the resilience. The findings have revealed that variations in the resilience scores are strongly affected (p-value < 0.001) by social, physical, and institutional attributes. More precisely, cooperation, trust, and equity among fishers, good leadership, physical assets ownership, proper early warning system, livelihood training programs, and strong government intervention have significant impacts in increasing the resilience of the fishing communities. This study suggests some measures to be taken to further strengthen the resilience of fishing communities, including strengthening social cohesion, introducing new aquaculture practices, incorporating value-added products, enhancing ice facilities, engaging women in income-generating activities, and improving emergency food, water, and medication facilities during disaster. In addition, both government and non-government organizations should work together to enhance the resilience of the fishing communities.

Introduction

Climate change-induced physical events such as cyclones, storms, droughts, floods, tidal water surges, erosion, and salinity intrusion, which are responsible for the loss and damage of life, health, property, infrastructure, livelihood, and other environmental resources, are called climate hazards (Field et al., 2012). Climate change in coastal areas might slow down economic growth by increasing inequalities and poverty incidents. It can lead to surface-water scarcity and cause heat stress, food insecurity, and other health problems, which can lead to displacement of people and involuntary migration, among other hardships. The predicted climate change is adding an extra risk factor to human settlement in coastal areas. Coastal communities are fragile and sensitive to these adverse conditions and ,most of the time, they fail to cope with extreme climatic events.

Bangladesh is one of the top ten most vulnerable countries affected by severe weather events (1999-2018) (Eckstein et al., 2020). Low lying flat topography, anomalies in climatic features, along with high population density and socioeconomic conditions, have made this country highly susceptible to many hazards, including cyclones, storm surges, floods, droughts, salinity intrusion, and earthquakes (Kreft et al., 2014). Bangladesh was ranked fifth in terms of the death toll, losses, and number of extreme events in the ten years between 1993–2012 (Kreft et al., 2014). Fishers occupy a large part of the rural population, and their contribution to the fisheries sector is indisputable. But they are being increasingly exposed to various climatic hazards, making them incapable of coping to extreme situations, especially in the coastal regions where most of the districts are highly or very highly exposed to climate variability and change (Islam et al., 2019).

Walker (2010) defined resilience as "*the capacity to absorb disturbance and reorganize while undergoing change to retain essentially still the same function, structure, identity, and feedbacks*." However, for social resilience, the definition of Timmerman (1981) is most relevant, as it defines resilience as "*the ability of human communities to withstand external shocks or perturbations to their infrastructures, such as environmental variability or social, economic or political upheaval and to recover from such perturbations*." It can be measured by a change of institutional, economic, and demographic structure, property rights, and access to resources (Adger, 2000). For climate change resilience, it is important that it can withstand shocks and rebuild subsequently (Folke et al., 2010) as it will demand susceptible reorganization of social, economic, and ecological systems to continue essential functions, identity, and structure as well as maintain adaptive capacity, learning, and transformation. Measuring resilience to attain sustainability of the fishing community is crucial, as these communalities have not received sufficient attention. There are a few studies available on exploring resilience in Bangladesh (Hossain et al., 2013; Islam et al., 2016; Mozumder et al., 2018). However, no published study has focused on measuring resilience of the fishing communities in Bangladesh. Measuring resilience is crucial for understanding the factors responsible for the increase or decrease of resilience and will help in creating robust plans and policies to increase resilience and decrease impact and vulnerability. In this context, this study aims to measure the resilience of communities and identify the factors responsible for the increase or decrease of resilience using insights from three marine fishing communities of Rangabali Upazila (sub-district), an island in Patuakhali district on the central coast of Bangladesh.

The study was conducted at three fishing communities named Bhuiya Hawla, Sener Hawla, and Shamudafath (Figure 1). Patuakhali is considered as one of the highly vulnerable districts to climate variability and change in terms of both aquaculture and fisheries perspective (Islam et al., 2016; 2019). Severe climatic hazards and disasters i.e., cyclone, storm surge, tidal flooding, riverbank erosion, waterlogging and salinity intrusion commonly invade the Rangabali Island as it is located inside the Bay of Bengal (Rahman et al., 2017). Among these, cyclone and storm surge are considered the most devastating disasters affecting the district (Kulatunga et al., 2013). About 70 percent of the agricultural livelihoods in that area are affected by climate change (Rahman et al., 2017). Most of the houses of this island are poorly built, made of tin or wood which get severely damaged during these disasters. Due to the substandard communication system with mainly unpaved road, it takes about four hours to reach the nearby town. Most of the people in the community do not have access to grid electricity facility, so, they use solar panels for partial electricity supply. For livelihoods, people in the community mostly depend on offshore fishing and limited deep-sea fishing. Agricultural practices, cattle raising, net making and boat making provide supplementary income. Some of the people also collect crabs and sell them to the nearby fish market. People in the community live in an unhygienic condition with poor sanitation and insufficient pure drinking water facility (Paul & Routray, 2011). Development process of Rangabali Upazila is quite slow due to geographical location and undeveloped socioeconomic conditions. The morphology of Rangabali is changing very rapidly due to climate change.

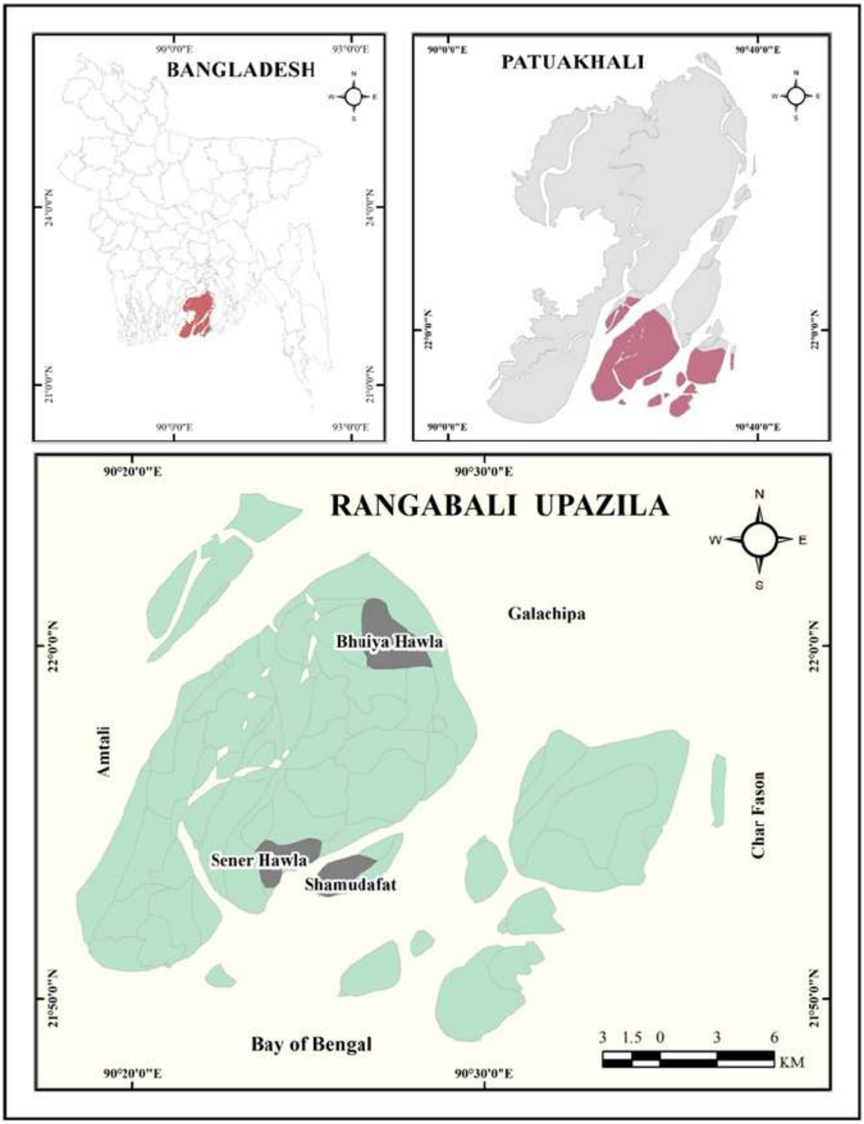

Figure 1. The geographical location of the selected community in Rangabali Upazila in the central coastal zone of Bangladesh.

To assess resilience in three communities, the head of the fishers' households was selected randomly and interviewed in the local language in February 2019. 60 respondents (20 respondents from each community) were interviewed using a structured questionnaire and scored by the surveyor. Besides, three focus group discussions (FGDs) and twelve key informant interviews (KIIs) were conducted to collect additional information and triangulation. Multidimensional scaling was applied to assess resilience in each of the attributes in a field on the scale from good (resilient), medium, and bad (vulnerable) (Stanford et al., 2017). The quantitative data were analyzed by SPSS 20 software. Analysis of variance (ANOVA) F-tests were performed to examine the variation among mean resilience scores of three communities under different fields of interest and determine the factors/fields that significantly affect the variation of resilience scores among the communities. The FGDs and KII data were analyzed by content analysis using manual coding after transcription.

Resilience assessment of island fishing communities

The mean resilience score of Bhuiya Hawla fishing community is 72.65, where human capital has highly influenced (total score 18.05) the resilience score. In human capital, among the attributes, the wife's contribution to the household's income has the highest mean score (3) (Table 1). Besides, economic and physical capital have notably impacted the overall mean resilience score of the Bhuiya Hawla fishing community. However, the significance of each field depends on the number of attributes considered in that field; a higher number of attributes might have a higher impact on that particular field. Though in this study, the number of attributes in human and physical fields are the same (total 7), the human field has a higher impact (18.05) than the physical field (13.05) (Table 1). Conversely, the economic field has a higher impact (13.15) than the physical field (13.05) despite having less attributes (6) than the physical field (7) (Table 1). Therefore, determining the significance of the fields in resilience score in one fishing community is somehow tricky and cannot be concluded considering the mean score of each field. However, in the institutional field, the highest mean score in livelihood program (3) denotes that the fishers of this community attend various livelihood programs arranged by the government and non-government organizations.

Table 1. Resilience scores of three fishing communities along with the mean scores of 31 attributes under six capital fields (data source: questionnaire survey).

Fields	Attributes	Communities		
		Bhuiya Hawla	Sener Hawla	Shamudafath
Natural	Loss and damage	1.30	1.50	1.15
	Coastal resources (revenue)	2.85	3.00	3.00
	Coastal stocks	2.90	2.20	2.40
	Total	**7.05**	6.70	6.55
Social	Community cooperation	2.25	2.25	2.55
	Community leadership	2.90	2.60	3.00
	Degree of trust/ honesty	2.90	2.80	2.90
	Equal right to speak	2.90	2.50	2.95
	Total	10.95	10.15	**11.40**
Economic	Ability to save	2.60	2.50	2.80
	Access to credit	1.70	1.85	2.30
	Collateral credit	2.45	1.80	2.05
	Ability to repay	1.85	1.95	1.95
	Current savings	1.85	1.95	1.95
	Supplementary income	2.70	2.90	2.85
	Total	13.15	12.95	**13.90**
Human	Awareness of market	2.85	2.65	3.00
	Productive activities	2.85	3.00	3.00
	Occupational multiplicity	2.70	3.00	2.75
	Contribution (Wife)	3.00	2.90	2.45
	Family thriftiness	2.70	2.55	2.50
	Sufficient food	2.05	1.95	1.85
	Hygienic food	1.90	1.65	1.85
	Total	**18.05**	**17.70**	**17.40**
Physical	Boat ownership	2.25	1.70	2.70
	Adequate gears	2.25	2.00	2.10
	Physical asset ownership	1.85	2.00	1.90
	Ice availability	1.80	1.10	1.90
	Processing value	1.35	1.00	2.00
	Livelihood condition	1.35	1.05	1.30
	Market place	2.20	2.00	2.00
	Total	13.05	10.85	**13.90**
Institutional	Functionality of Government office	2.55	2.55	2.65
	Early warning	2.85	2.60	2.85
	Emergency response in disaster	2.00	1.95	1.90
	Livelihood program	3.00	2.05	3.00
	Total	**10.40**	9.15	**10.40**
	Resilience Score:	72.65	67.50	**73.55**

The total resilience score of the Sener Hawla Fishing community is 67.50, and similar to the Bhuiya Hawla fishing community, the human field has the highest impact (17.70) on the overall resilience score. In the human field, two attributes (i.e., productive activities and occupational multiplicity) have the highest mean score (3) (Table 1), which means that the fishers of this community have more access to other income-generating activities along with fishing and are more engaged in productive activities. Interestingly, the economic field of this fishing community contributes more (12.95) to the resilience score than the physical field (10.85). However, the physical field has a higher number of attributes than the economic field (Table 1).

The resilience score of Shamudafath fishing community is 73.55 and has been particularly impacted by the human field (17.40). Interestingly, economic and physical fields have the same mean score (13.90) despite having different attribute numbers in each field (6 and 7 respectively) (Table 1). Fishers of this community have knowledge of the market and are highly engaged in income-generating activities. Besides, the fishing people of this area generate more revenue from fishing now than they did ten years before. They are also more involved in livelihood programs arranged by the government and NGOs.

What makes livelihood resilience different?

The comparison among the livelihood resilience status of the three fishing communities and the total score of six different fields are presented in Table 2. The highest score in each field shows the significance of the field in strengthening the resilience of the fishing communities. The higher the score, the higher resilience, and vice versa. The resilience of Shamudafath fishing community (73.55) is higher than Bhuiya Hawla (72.65) and Sener Hawla (67.50) fishing communities (p-value < 0.012) as the mean score of three important capital fields (social, economic, and physical) are higher in Shamudafath fishing community (Table 2). However, in natural and human fields, Bhuiya Hawla fishing community have the highest scores (7.05 and 18.05 respectively), which means the natural and human capital of Bhuiya Hawla fishing community are better than Sener Hawla (6.70 and 17.70 respectively) and Shamudafath fishing community (6.55 and 17.40 respectively) (Table 4). However, in social (11.40), economic (13.90), and physical (13.90) fields, the Shamudafath fishing community has a higher score than Bhuiya Hawla and Sener Hawla fishing community (Table 2).

Interestingly, the total score of institutional field (10.40) is the same for both Bhuiya Hawla and Shamudafath fishing communities. However, while comparing the resilience score of the fishing communities, the attributes of social, physical, and institutional fields are found to be highly significant for the variation of resilience scores of different fishing communities (p-value < 0.001) (Table 2). The attributes in these three fields are good leadership, cooperation, trust, equity among the community in social field; ownership of physical assets e.g., fishing boats and gears, livelihood condition, marketplace, ice availability and processing value in the physical field; and efficient early disaster warning and response system, long or short-term livelihood training program and government intervention in institutional field. At the same time, other attributes among natural, economic, and human fields are not statistically significant for the variation of resilience scores among the three fishing communities (Table 2).

Table 2. Mean resilience score, standard errors (SE), 95 % confidence interval for the mean score, and p-value of ANOVA F-test for three fishing communities of Patuakhali by different fields.

Field	Community	Total Score	SE	95% CI	*p*-value
Natural	Bhuiya Hawla	**7.05**	0.135	(6.77, 7.33)	0.065
	Sener Hawla	6.70	0.147	(6.39, 7.01)	
	Shamudafath	6.55	0.170	(6,19, 6.91)	
Social	Bhuiya Hawla	10.95	0.185	(10.56, 11.34)	<0.001
	Sener Hawla	10.15	0.284	(9.56, 10.74)	
	Shamudafath	**11.40**	0.134	(11.12, 11.68)	
Economic	Bhuiya Hawla	13.15	0.716	(11.65, 14.65)	0.405
	Sener Hawla	12.95	0.344	(12.23, 13.67)	
	Shamudafath	**13.90**	0.435	(12.99, 14.81)	
Human	Bhuiya Hawla	**18.05**	0.573	(16.85, 19.25)	0.554
	Sener Hawla	17.70	0.300	(17.07, 18.33)	
	Shamudafath	17.40	0.336	(16.69, 18.10)	
Physical	Bhuiya Hawla	13.05	0.583	(11.83, 14.27)	<0.001
	Sener Hawla	10.85	0.182	(10.47, 11.23)	
	Shamudafath	**13.90**	0.410	(13.04, 14.76)	
Institutional	Bhuiya Hawla	**10.40**	0.169	(10.05,10.75)	<0.001
	Sener Hawla	9.15	0.182	(8.77, 9.53)	
	Shamudafath	**10.40**	0.184	(10.02, 10.78)	
Overall	Bhuiya Hawla	72.65	2.007	(68.45, 76.85)	0.012
	Sener Hawla	67.50	0.958	(65.49, 69.51)	
	Shamudafath	**73.55**	1.323	(70.78, 76.32)	

The most significant fields ($p < 0.001$) influencing the variation of the resilient scores are social, physical, and institutional fields. This means that the attributes residing in these three fields (i.e., good leadership, cooperation, trust, equity among the community, ownership of fishing boats and gears, community's livelihood condition, market place, ice availability, processing value, efficient early disaster warning and response system, short-term livelihood training programs and government interventions) are the key in changing the resilience of a community. Cooperation, trust, equity, and strong leadership can bring social harmony (Sharma, 2015), which can significantly increase a community's relative resilience (Sharifuzzaman et al., 2018). A community network can allow individuals to draw on the social resources in their community (Green & Haines, 2015); in order to facilitate a sustainable development process, it is necessary to resolve collective problems (Mayunga, 2007). More than eighty percent (85 percent) of the respondents agreed that they have a supportive leader who works for the development of the community. Communities with a common goal and intention to work together have the ability to strengthen their resilience (Davidson, 2006).

On the other hand, ownership of fishing boats and gear can enhance the resilience of the fishing communities by 20-40 percent (Sharifuzzaman et al., 2018). In the present study, though 8.3 percent of fishers have no physical asset, most of them (88.3 percent) own limited fishing gear; this lack of fishing gear can force the fishermen to adopt more climate sensitive strategies as they have limited household options (Islam et al., 2014). About 90 percent of the fishers sell their catch in the nearby fish market due to the lack of ice facility, and 83.3 percent do not have the most current knowledge of fish price, which prevents them from getting a fair price. Providing sufficient ice facility and proper market knowledge could mean not only that they can sell the fish in the market of a nearby town but that they also receive a fair price. In case of severe hazard risks, i.e., cyclones or floods, the early warning system can greatly increase resilience by decreasing impacts. Communities can get the chance to prepare for the pre-disaster, during disaster and post-disaster situations (Fakhruddin et al., 2015). Besides, short-term livelihood programs are beneficial to the community in building resilience. In coastal regions, non-government organizations (NGOs) play a significant role in attaining resilience in climate change (Hasan et al., 2018).

This study has identified that the impact of natural, economic, and human fields in building resilience is not significant as the community's geographical, livelihood, and economic conditions are indistinguishable. However, 68.3 percent of people became affected by the severe climatic hazards and lost their belongings despite all their effort in building resilience. Disasters like cyclone, storm surge, flood, and riverbank erosion destroy coastal communities' major assets such as houses, lanyards, and cattle (Khan et al., 2015) and make them vulnerable (Alam & Collins, 2010). Sufficient credit access can increase a community's resilience, but earnings in the fisheries sector are highly uncertain and seasonal as fishers who do not own boat or fishing gear eventually cannot catch nor can they earn more (Allison et al., 2007). Borrowing money from family, relative, bank, or *mahajan* (moneylender who impose higher interest rate) can help cope in post-disaster conditions though sometimes a lack of collateral hinders this process. The involvement of local NGOs in attaining coastal resilience can be a better way to reduce stress against coastal disasters by providing loans (Hasan et al., 2018). At the same time, taking a large loan is a difficult task for the fishing community as they need to pay it back on time, otherwise they have to sell their assets. In addition, geographical isolation can restrict both the capacity to access market and the opportunity to adopt alternative livelihood (Allison et al., 2007). Nonetheless, proper management is crucial for the sustainable utilization of the resources, where stakeholders should be directly involved in the management process (Pomeroy, 1995). Societal rules, norms and formal institutions like groups, organizations, and government bodies can enhance adaptive capacity, which is crucial for building resilience (Speranza et al., 2014).

Conclusion and way forward

Climatic hazards, such as cyclones, floods, erosion, tidal water surges and salinity intrusions, seriously affect the socio-economic conditions of the fishing community in the coastal area of Bangladesh, and undermine their resilience. Community cooperation, trust, equity, good leadership, physical asset ownership and accessibility, suitable disaster warning and response system, livelihood programs, and government interventions can significantly influence a community's resilience. More specifically, in the context of Rangabali Island, the following initiatives can be taken to make the community more resilient to climatic impacts and decrease its level of vulnerability. First, strengthening social cohesion in taking new initiatives (e.g., crab culture, cage culture) will increase the community's resilience. Second, fishers' association and cooperative marketing can facilitate the process of adopting new initiatives, getting a fair fish price by increasing market knowledge, and improving loan facilities for poor fishers. Third, since there are existing fish drying practices of Shamudafath fishing community, incorporating practices of value-added product (e.g., preserving fish or shellfish by drying, smoking, or salting) can help increase their income and increase their resilience. Fourth, providing an adequate icing facility can help with preserving as well as selling fish far from the village or nearby town and can increase the value of fish, thus increasing resilience. Fifth, the active participation of women in fishing, drying, harvesting, and other income-generating activities can make them stronger and more financially independent to fight against hazards Sixth, in extreme climatic hazards, an adequate emergency shelter, food, water, and medication facility must be ensured (both by government and NGOs). Finally, the meaningful coordination and management of different national and international NGOs and government projects can ensure equal distribution of relief or compensation schemes among all fishers during hazards or fishing ban periods.

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27. Building Resilience Towards Climate Change Vulnerability: A Case Study of Fishing Communities in Southern Bangladesh

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Fishers on the Sangu River on their way to fish in the southern coast of Bangladesh

(Photo: Prabal Barua, 2020).

This chapter focuses on the river-based livelihood and economies of local communities along the Sangu River basin in Bangladesh in response to climate change-induced problems. The fishers experienced climate change impacts through loss and damage of physical assets, reduced fisheries productivity, low fish catch and a decrease in fishing income. Socioeconomic impacts were felt through changes in capture, production, and income, as well as through possible greater risks of fishing gear and crafts being damaged or lost. Due to a low adaptive capacity, fishers tend to be poorer, more marginalized and at risk of losing their occupation as a direct impact of extreme, climate change-induced events. While the fishers adapt different strategies, these adapting mechanisms are coming under increasing strain with both the increase in climate change and an increase in the frequency and intensity of naturally occurring hazards. Consequently, climate change impacts are magnifying the existing inequities among fishers and other communities in the Banskhali sub-district of Chattogram district. The adaptive capacity of small-scale fishers can be strengthened through policies that enhance social and economic equity, reduce poverty, improve fisheries resources and coastal management, and increase community participation in strengthening the institutions.

Introduction

This chapter highlighted the impact of climate change-induced natural disasters on small-scale fishers dependent on the estuarine Sangu River. It also reported autonomous adaptation practices of the fishing communities towards formulating an integrated adaptation framework. The Sangu is a transboundary river, originating on the Indo-Burma border (North Arakan Hills of Myanmar, located at 21°13’N 92°37’), which flows northwards through the Chittagong Hill Tracts of Bangladesh, bending West at Bandarban until it breaks into the Bay of Bengal to the west of Dohazari, Chittagong.

The River is 295 km long. In the recent years, due to excessive deforestation in the river basin, its ecosystem is facing a severe water crisis and degradation. Previously, the basin was covered by dense forest that collected and stored water, releasing it as waterfalls into the river. Nowadays, the denudation of forest covers in the catchment area causes the rain to hit the soil directly, leading to riverbank erosion and sedimentation. Sediment ends up filling up the river and leads to it drying up (Shaci, 2018). The major tributaries of the River are Chandkhali River and Dolu khal. The Sangu River is also significant as one of the major habitats of Indian major carps that migrate to the River Halda via Karnaphuli River for spawning during the breeding season. There are 127 fish species in the Sangu River: 109 finfish, 3 exotics and 18 shellfish species (Azadi & Alam, 2014).

The Sangu River is closely interlinked with the livelihood of local people. The people in the area depend on the river for irrigation, transportation, drinking water, sanitation, and for practicing religious, ethnic, and cultural rituals and traditions. About 1,390 fishers are engaged in fishing throughout the Sangu River in the Anwara-Banshkhali region. Too much reliance on the Sangu River is creating a conflict over resources and, in the long run, might diminish the potential of Sangu River to serve the communities due to overexploitation. This study is based on 75 semi-structured interviews with individual fishers, 8 focus group discussions with village elders and a household survey using a Rapid Rural Assessment. The study was undertaken over twelve months, between January and December of 2020. The findings were discussed and re-evaluated in a workshop focused on participatory scenario development in order to build a robust understanding of feasible adaptation measures and pathways, and their relevance for vulnerable fishers' groups.

Climate change impacts: As experienced by fishers

More than seventy percent (72 percent) of fishers perceived climate change impacts as effects caused by storm surges that resulted in loss of their physical assets such as fishing gears and crafts. The remaining number of fishers focused on low income, linked to low fish productivity (e.g., limited egg production), which is indirectly affected by climate change. The local fishers experienced an increase in the intensity and frequency of storm surges, which directly threaten fishers' livelihoods. They were not able to operate the fishing gear when the river is rough due to harsh weather and storm surge effects. In recent times, the fishers of the Sangu River of Banskhali and Anwara region, faced a category V cyclone named 'Amphan' that hit on May, 2020 and which displaced 50,000 people. This created an economic loss of approximately 5 crore BDT and led to a loss of 20,000 houses in Anwara-Banskhali region, many of whom belonged to fishers. These fishing communities of Sangu River were also greatly affected by cyclone 'Komen' on July 28, 2016 and cyclone 'Giri', on October 22, 2010, that had peripheral effect on Banskhali coast. As a result of the cyclone Amphan, the tidal surges were hitting seven to eight meters above the normal water level, and 78 percent of fishers of Banskhali had to move to safer shelters. Still, they were not able to put the fishing boats and gears in a safe place for protection. These cyclones caused severe damage to fishing boats and stationary fishing gear (Estuarine SetBag Net-ESBN) and injured 186 fishers. The estimated cost of such damage was BDT 20.5 million (Table 1).

Table 1. Estimates cost (BDT) of assets, damaged by the Cyclones Giri (2010), Komen (2015) and Amphan (2020) in the Sangu River.

Particulars	Cyclone *Giri* (2010)		Cyclone *Komen* (2016)		Cyclone *Amphan* (2016)	
	Unit	Loss (BDT)	Unit	Loss (BDT)	Unit	Loss (BDT)
Physical injury when fishers tried to protect their fishing gears and crafts	186	93,000	250	1,25,000	350	1,90,400
Rowboats						
75-100% damage	11	165,000.00	25	500,000.00	45	800,000
50-75% damage	17	170,000.00	15	180,000.00	12	190,000
25-50% damage	32	224,000.00	15	135,000.00	12	110,000
1-25% damage	46	161,000.00	30	150,000.00	20	140,000
Medium boats						
75-100% damage	23	575,000.00	20	600,000.00	30	800,000
50-75% damage	28	504,000.00	22	484,000.00	20	450,000
25-50% damage	39	390,000.00	30	360,000.00	28	370,000
1-25% damage	18	90,000.00	15	105,000.00	20	120,000
Engine boats						
75-100% damage	2	110,000.00	5	300,000.00	10	420,000
50-75% damage	2	70,000.00	2	80,000.00	4	90,000
25-50% damage	4	100,000.00	6	80,000.00	8	100,000
1-25% damage	6	60,000.00	2	30,000.00	3	50,000
Stationary gears ESBN						
75-100% damage	22	2,200,000.00	40	8,000,000.00	60	12,00,000
50-75% damage	40	2,000,000.00	45	270,000.00	60	420,000
25-50% damage	18	450,000.00	10	300,000.00	15	410,000
1-25% damage	35	420,000.00	20	300,000.00	22	400,000
Catch loss due to the damage of fishing gears and crafts	276 MT	11,932,000.00	520 MT	26,000,000.00	700 MT	50,000,000
Total (BDT)		**19,150,000.00**		**37,874,000.00**		**55,020,400**

Overall, the annual yield of the Sangu River declined to 162 MT from 658 MT over the last 15 years (2005 to 2020), which resulted in approximately 72 percent revenue loss. Though the catch price increased by 48 percent over this period, the monthly income from ESBN operation was not increased due to the reduction of yield and an 90 percent increase in operational cost. Consequently, the majority of the fishers could not earn enough to meet their family needs. One of the FGD participants, Mr. Polin Das reported: "*We are compelled to lead a miserable life. With limited earnings, we are barely surviving. We try to first ensure meals and clothes for our family members, but we cannot bear our medical and educational expenses*". Most of the fishers come from families with long fishing tradition. Mr. Polin Das has been fishing for over the 25 years but he was very disappointed with his profession. He added that the fishers here can only catch fish during the full moon or new moon but that they do not have any work during the rest of the time. "*But fishers cannot change their professions as they are not so educated and lack experience in other jobs,*" Mr. Das observed. A fisher leader Mr. Bashir said: "*Fish production is decreasing day by day. No fish is available in the Sangu River in abundance as before. Fishers were moving to the deep sea to catch fish.*" At the same time, all participants echoed the opinion of Mr. Bashir. The fisher-leader blamed the changes in weather patterns for a decrease of fish in the Sangu River. He further observed that frequent strikes of cyclones in the coastal areas are posing a threat to the lives and livelihood of the fishers. Mr. Jafar Ahmed, a fishery entrepreneur. locally called *bahaddar*, incurred a loss of BDT 100,000 in this season, when his three fishing boats were damaged due to the strong surge, though he put his boats in a small narrow canal for shelter.

Mr. Kokon Kanti, an ESBN fisher, shared a horrible experience about the strong surge, which hit on October 22, 2010 and said: "*I saw a big surge that raged on my boat and broke it. Then I felt a complete darkness around me; somehow, I grabbed a plastic drum with my hand as a float; fortunately, it kept me alive and then other fishers rescued me*". After the storm surge on October 22, 2010, most of the ESBN fishers struggled to reinstall their net in the Sangu River until November, with the monthly yield dropping over the following months. Mr. Nazibul, another participants in the focus group discussion, reported: "*My fishing gear (ESBN) was almost damaged through strong water current during the storm surge, which required BDT 50,000 for necessary repairs – but I wasn't able* *to arrange such funds immediately. For these reasons, I had to borrow money from the local money lenders with high interest. It also took 20 days to repair my net, during which time I was unable to continue fishing and did not have any alternative means to recover financially"*. A fishing crew member, Mr. Jolil Mia said: *"I was unemployed when my employer lost his boat and fishing gear during the cyclone Amphan which hit on 13 May, 2020. It was quite difficult for me to maintain my family expenses as fishing was my only source of income. Then I had to borrow BDT 30,000 from a local NGOs with high interest, as a result of which I was bounded to pay BDT 800 per week. Then I had to work as a daily labourer in salt bed and in earth filling works where they paid BDT 180 per day, which led to me changing my profession"*. Mr. Kolim, who worked in ice-factory said: *"My income is decreasing as I don't have sufficient work in loading and unloading ice for fishing boats"*. Mrs. Chemon Ara, a mother of five sons and four daughters who works at a dry fish processing plant said: *"Now fish landings are interrupted and reduced due to the bad weather. I get only a small amount of trash fish after sorting dry fish, and it has been very difficult to sustain my livelihood, as I get only BDT 50-75 per day by selling the trash fish."*

Autonomous adaptation strategy

Barua et al. (2020) stated that exposure to floods and cyclones, sensitivity to disaster and a lack of adaptive capacity concerning physical, natural, and financial capital as well as a lack of diverse livelihood strategies are creating social and economic vulnerabilities for fishers of Bangladesh. Over the last ten years, 20 percent of household heads nearby Bakkhali estuarine river of Cox's Bazar coastal area have changed their profession, leading to a growth in dependency on non-fisheries livelihoods such as rickshaw pooling and small business, as observed in the fishing villages in this study. However, many of them are applying their traditional knowledge to cope with the changing climate stress and in conserving the biodiversity of the coast. In order to strengthen the adaptive capacity and to build resilience, government and the external agencies need to facilitate the existing traditional knowledge and systems with which the fishing communities have been historically responding to the environmental stresses.

The field research underlined that fishers along the Sangu River have been adapting to the impact of naturally occurring changes and other natural hazards for decades. They have experienced periods of scarcity in the past, and they are well accustomed to employing coping mechanisms. However, as climate change is increasing so is the frequency and intensity of naturally occurring hazards, and these coping mechanisms are coming under increasing strain, with the potential of this leading to conflicts in the future. Focus group participants from the study area provided examples of the types of autonomous adaptations that have been listed below (Table 2).

Table 2. Autonomous adaptations measures practiced by the fishers of the Sangu River.

Impacts	Adaptation strategy
Reduced fisheries productivity	• ESBN gear modification: Fishers reduced mesh size of the net to increase the catch rate.
	• Community-based mangrove plantation: All fishers believe there is a positive correlation between mangrove plantation and fisheries productivity.
	• Fisheries management: Fishers are in the process of adopting fisheries co-management with the help of some NGOs.
Damaged fishing gear and crafts; increased physical injuries during fishing due to bad weather	• Changes in gear operations: Using mobile gears (e.g., gill net, push net) instead of stationary gears like ESBN. For example, numerous ESBN fishers were operating push net as it requires low investment.
	• Changes in net-mending materials: Fishers preferred imported thick yarns rather than locally produced yarns for better longevity.
	• Craft modification: By increasing the size and draft of the fishing boat.
	• Anchoring in a sheltered place: Keeping the boat in narrow canals of the River to avoid the damages caused by the storm surge.
	• Life safeguards: Using plastic drums as a float for protection during fishing.
Increased variability of the yield and reduced income	• Changing fishing grounds: Fishers from the islands (Khankhanabad Superior Dip) moved to other fishing grounds located in the Bay near Kutubdia island.
	• Borrowing money: For the financial crisis caused by the low fish yield, they borrowed money from different sources, paying high interest.
	• Changing fishing occupation: Unemployed fishers had to change their profession, as they struggled to meet their family demand since their income had been reduced. But the options were very limited and they mostly worked as labor in the salt pens, grocery shops, or in earthwork.
	• Migration: Both temporary and permanent migration were observed when fishers moved to near urban areas and cities to search for jobs, most in rickshaw poling.

Compared with the previous socioeconomic data (Nabi et al., 2011; Adnan et al., 2019; Zzaman et al., 2020), the present study revealed a number of negative changes (Table 3). It showed that about 20 percent of the heads of the household changed their fishing profession, leading to an increase in the dependency on the non-fisheries livelihoods (e.g. rickshaw pooling, other business). In addition, the overall fishing efforts declined in the last 15 years. Mr. Monsur, a young fisher, delivered interesting information noting that: *"In recent years, there is a growing tendency to reduce the mesh size of the net to increase the catch rate."* The survey found that the mesh size of the cod ends was reduced to below 5 mm. Most fishers are indebted as they borrowed from neighbors, relatives, local rich people, and NGOs to cope with the crisis as access to bank credit was very limited. Under these circumstances, a significant number of fishers changed their profession since they couldn't support their family. Numerous ESBN fishers changed their fishing activities in wild shrimp fry collection, which had adverse effect on aquatic biodiversity. One of the participants, Mr. Porimal Das, who is a wild shrimp fry collector said, *"I was an ESBN fisher; when my nets were damaged in a devastating storm surge, I did not have money to repair it and there was no other options for earning except to engage with wild fry collection where I did not have to invest so much to buy the push net."* Moreover, the livelihood of fish workers involved in selling, repairing nets, fish processing and other supporting jobs was also affected as their works depended on the fishing activities in the river.

Table 3. Changes in the number of fishers, fishing gears and crafts over the last 15 years.

		Comparative changes (in number) over the last 15 years		
		2005	2015	2020
Fisher		2,500	1,538	1,010
Gears				
i	ESBN	157	145	130
ii	Beach Seine	15	10	7
iii	Gill Net	10	6	4
iv	Push Net	221	205	180
Crafts				
i	Non-mechanized smaller boat	113	105	95
ii	Non-mechanized medium boat	166	145	130
iii	Engine boat	25	20	15

Those who had lost their livelihoods in fishing had been forced to search for alternative work as labourers or to migrate temporarily or permanently in search of alternative employment. Temporary migration was a traditional mechanism for sustaining livelihoods during periods of environmental insecurity. It usually comprises of a short-term movement of one or two family members to a different location to secure employment. Temporary migrant fishers moved to urban areas to seek employment in the informal sector (such as rickshaw driving) or to rural areas to work on salt farms, grocery shops, and in earthworks. Mrs. Bilkis Banu, a wife of a fisher, stated: "*My husband was unemployed for the last few months as he lost his job in operating ESBN gears and had to migrate to Chittagong, where he now works as pooled rickshaw*." Moreover, the number of fishers migrating temporarily from the fishing villages that are vulnerable to natural hazards had significantly increased over the recent years, as localized coping strategies had become more difficult to sustain. Although the decision to migrate temporarily was determined by a number of push and pull factors, the frequency and intensity of naturally occurring hazards had increased the pressure on fishers to relocate both temporarily and on a more permanent basis.

In response to the severity and recurrent nature of storm surges and cyclones temporary migration of fishers often turned into a more permanent one. For example, in two fishing villages it was found that over 10 percent of families had made a deliberate and permanent move to Chittagong city. In contrast, an additional 20–30 percent of people had not returned after a temporary migration. Although several factors may have contributed to this increase in permanent migration, climate change appears to have accelerated the process because of the reduction in opportunities in the affected fishing villages. However, certain factors prevent people from permanent migration, in particular the costs of relocating. It is estimated that about BDT 10,000-15,000 is required to migrate the short distance from Banskhali to Chittagong, and it would cost a lot more to relocate over longer distances. However, as the situation worsens, the number of permanent migrants was set to increase as more fishers save money to move away. Mr. Abul Monsur, a veteran fisher, stated: "*The majority of fishers living in areas affected by storm surge* *on this fishing village are 'potential migrants'. For now, they are trying to cope through finding temporary employment and shelter, but most are trying to save up the money needed to migrate*." From the overall discussion in the workshops, it was revealed that fishers in the investigated areas had a low adaptive capacity and were likely to be less resilient to recover from stressful climate change events and conditions. Moreover, the exposure and sensitivity indicated high vulnerability of the fishing community, where such low adaptive capacity showed less ability to manage and reduce this vulnerability. Nevertheless, many fishers want to stay in their homes and reverse the adverse situation through different strategies. For example, one veteran fishers, Mr. Jafar Ahmed, said: "*If we could create a green belt with the mangrove forest, it could reduce the intensity of wind power and reduce the storm surge effects*." He also said: "*We are trying to develop a safety green belt in our area through mangrove plantation with the support of local NGO*". Mr. Rahim Sheik, the most senior participant in a focus group discussion, added: "*This mangrove forest is favouring the fish, where fish come in the mangrove swamps to eat those leaves and fallen litter. During my fishing, I always found a high abundance of fish in adjacent areas of mangrove swamps rather than in other places*".

As agents for change

Fishers were not only the primary victim of climate change, but can also be effective change agents, managing both mitigation and adaptation. Fishers have extensive knowledge and expertise that can be applied in assessing community risk, selecting adaptation measures, and mobilizing communities to manage risk. In participatory workshops, all participants from different stakeholder group felt the necessity of an integrated approach to formulate the climate change adaptation strategies, which aim to address the full range of coastal climate change hazards to meet societal objectives. All the findings from this study were discussed in the final workshop to select the potential adaptation measures, during which fishers, fish traders, processors, net menders, boat makers, government officials, concerned NGOs and other fisheries resource user groups actively participated and provided their valued opinions. Finally, fisheries adaptation measures and strategies were developed with the assistance of all stakeholders. Local knowledge and perceptions influence people's decisions, both in deciding whether to act or not and what adaptive measures are taken over both short- and long-term. Therefore, local observations and perceptions were taken into account in effort to understand climate change, its impacts and how to adapt and mitigate it (Figure 1).

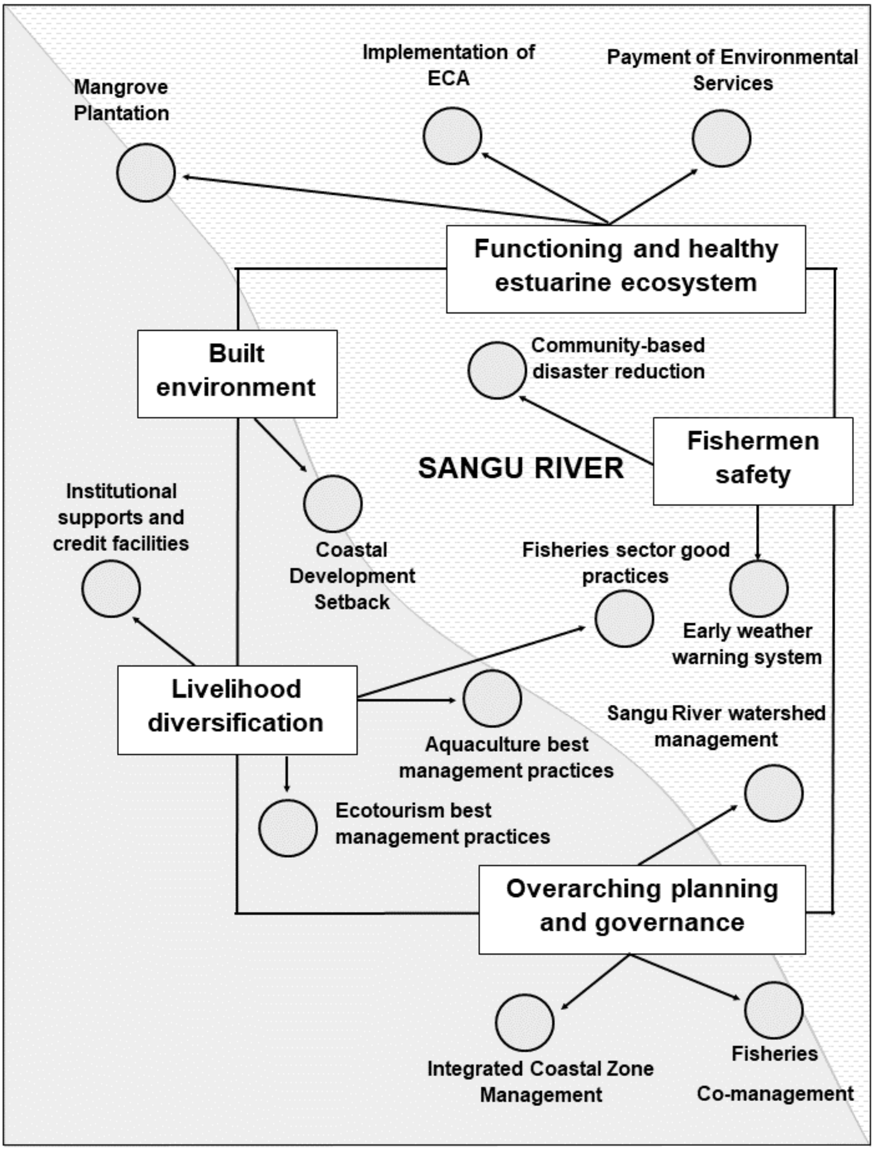

Figure 1. Climate change-adaptation goals and their relative measures as identified by the local resource user group in Banskhali-Anwara.

Mangrove plantation along the bank of the Sangu River was identified as one of the potential climate change restoration, mitigation and adaptation measure, which provides feeding, breeding and nursery habitats for fisheries. It also provides ecosystems services for communities and their protection and livelihoods, and serves as a natural water filter and a buffer against coastal disturbances. To fulfill the environmental functioning and healthy ecosystem goals, financial instruments are needed under which beneficiaries of mangrove ecosystem services can compensate the suppliers to fund sustainable environmental management policies and actions. Coastal development setbacks protocol can be developed, with a set distance from a coastal feature within which all or specific types of development (e.g., navigational jetty, coastal aquaculture pond in the intertidal zone) need to be prohibited. Fishers pushed for a development of fisheries co-management for livelihood sustainability and a strengthening of their capacity to deal with long-term climate-related effects on habitats and ecosystems of the Sangu River. Fisheries management seeks equity for organizing and empowering vulnerable or less privileged groups of fishers to participate in management in a free and collaborative way. The participants identified diverse fisheries management-related options for the Sangu River, focusing on fishing, fishers, and productivity, which includes various management issues and their potential implementations at different management levels. Biological conservation should incorporate measures that will enhance the ecosystem and livelihood security. In addition, regulatory approaches, fishing gear or mesh size restriction, area allocation, fishing season prohibition, i.e., closure of fishing during the peak recruitment periods (July to September and February to April in selected areas) can be introduced for ESBN on the assumption that the juveniles would escape. Some of the immediate needs for the development of the fisheries management of the Sangu River include the development techniques for processing bycatch and non-traditional fishery items for the preparation of improved quality value-added products and the development of post-harvest technology to prevent deteriorative changes occurring in fish and shellfish during different stages of handling, transportation, processing. In addition, coastal aquaculture could be one of the potential alternative livelihood options. In this regard, largely selfenforced measures need to be taken to improve the efficiency and cost in the aquaculture sector to increase the benefits and promote development.

Moreover, cruising across the Sangu River was identified as another promising sector. Actions need to be taken that will enable the tourism sector to improve services and business while also minimizing the adverse effects on the environment and local communities. Besides, initiatives that enable capacity building for other alternate income generations should take place including livestock rearing, tailoring, handy crafts making for tourists, etc., through training and demonstration with necessary inputs and institutional supports. A mechanism for community-based disaster risk reduction and early weather warning systems should be developed in the area to ensure safety against natural disasters. Safety of the fishing people and their fishing accessories, as well as the disaster preparedness will reinforce equity. Moreover, to bundle a series of measures, an overarching integrated management approach or strategy involving planning and decision-making could be geared to improve economic opportunities and environmental conditions for the coastal people of Banskhali.

Many of these adaptation measures were not 'new' to those involved in autonomous adaptations. They included strategies and actions familiar to fishers for respond to episodes of natural hazards and shocks. There were also new approaches and tools being developed, such as nature-based approaches to coastal adaptation. Nature-based approaches include new tools for managing fisheries resources and strategies to conserve biodiversity in the face of shifting geographies. They focused on helping fishers and communities deal with climate change impacts by protecting mangroves, estuaries, and other systems on or near shorelines and the benefits they provided. These benefits included protection from storms, controlling erosion, and retaining and assimilating nutrients and sediments. In addition to these benefits, functional ecosystems were critical to maintaining biodiversity and to fishers and other resource users whose livelihoods rely on the conditions of natural systems. These approaches provide a departure for the next generation of adaptation guidelines. Using a single, stand-alone measure was usually not the best approach. To respond effectively to a wide array of climate change impacts requires combining complementary measures. Selecting the best combination helps to look for measures that have interdependencies, contribute to good fisheries resources management, and bring additional benefits in terms of climate change adaptation. Most of the fishers along the Sangu River were not educated enough to have a basic understanding of the long-term management goals. Therefore, it doesn't appear that it will easy to implement even a well-formulated plan, which requires extension and awareness building at different levels. Supporting fishing communities and involving them in the management process depends on the existence of appropriate institutions relating to education, training, as well as demonstration and creation of alternative livelihood options. But the people of fishing villages were poorly organized above the level of households; they don't have a history of associations and institutions and, hence, have little cultural background in collective action. A major challenge of capacity building is to reverse the effects of centralized resource management that existed over many generations, which tends to suffocate fishing communities' ability for self-governance. Top-down resource management over a long time can result in the loss of civic institutions and local mechanisms for consensus building, rule-making, enforcement, and monitoring.

Conclusion and recommendations

This research gives an account of adaptation to environmental change in the context of the Sangu River fisheries. The study of Sangu River fisheries provided a wealth of information about how people live with environmental change, which is often presented in the extreme form. Climate change is not a purely physical or even solely an ecological phenomenon but has also social, cultural, and economic aspects. To understand these phenomena, local actors and their accounts of these changes and events are directly relevant. Only local people can explain how climate change is manifested locally and how it is evaluated, interpreted, and handled by the affected people. While local observations cannot substitute for scientific measurements and models, they are essential supplements that detail local phenomena and perceptions and insight into local concerns. Local observations can inform scientists by directing attention to the overlooked aspects and can aid in formulating new hypotheses and research questions.

Fishers along the Sangu River were affected differently by the impacts of climate change and climate vulnerability. Due to the low adaptive capacity, fishers tend to be poorer, more marginalized, and much more likely to be afflicted by natural hazards like storm surge. Fishers were vulnerable because of their social roles, inequalities in the access and control of other resources, lower education, and low participation rate in decision-making. Climate change magnified existing inequities among the fishers and other communities in Anwara-Banskhali region. Autonomous adaptations were not adequate to reduce the vulnerability, and all those who took part in participatory workshops called for participatory-based planned adaptations as a way to combat climate change impacts. Adaptive capacity can be strengthened through policies that enhance social and economic equity, reduce poverty, improve fisheries resources and coastal management, increase community participation, generate valuable and actionable information, and strengthen institutions.

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28. Power Dynamics: Implications for the Long-term Sustainability of Tropical Hilsa Fishery

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Small-scale fishers are taking preparation for fishing in the Meghna River, Bhola (Photo: Mohammad Mozumder, 2018).

This chapter considers the hilsa shad (Tenualosa ilisha) fishery of southern Bangladesh as a case study regarding power dynamics in a small-scale fishery and its relevance for the sustainable management of coastal fisheries. The findings demonstrate an imbalance in the present hilsa governance structure, with some stakeholders exercising more power than others, sidelining small-scale fishers, and indirectly encouraging illegal fishing practices that ultimately harm fisheries and those dependent on them. To reverse this situation, a co-management system can play a vital role in equalizing power asymmetry among hilsa fishery stakeholders and ensuring effective hilsa fishery governance. The findings further suggest that recognizing analyzed power dynamics has substantial implications for the planning and implementation of such co-management and the long-term sustainability of the hilsa fishery.

Introduction

Small-scale fisheries are essential for food security and employment in developing countries (Purcell & Pomeroy, 2015). Despite contributions, small-scale fisheries face several threats, including overfishing in degraded coastal and riparian ecosystems (Cinner et al., 2012). Also, the sustainability and economic viability of small-scale fisheries is seriously threatened, warranting improved governance (Jentoft & Bavinck, 2019). Fisheries governance is the sum of the legal, social, economic, and political arrangements used to manage fisheries (Symes, 2006). Several scholars agree that establishing appropriate governance means is paramount for small-scale fisheries to thrive (Béné, 2006; Barr et al., 2019; Barreto et al., 2020). Fisheries management problems are related to power dynamics among stakeholders (Njaya et al., 2012). Power in capture fisheries is an opportunity to participate in and influence decision-making in managing fisheries resources (Quimby & Levine, 2018). Understanding power and power relations is central to discussions of participation and empowerment, with the need to investigate how power is manifested and by whom (Cavalieri & Almeida, 2018). Power can be a constructive force, but it can also be disruptive and corruptive and may serve special interests (Jentoft, 2007). Power relationships should be understood and examined as embedded within a social-ecological system (SES), such as small-scale fisheries, to avoid community authority (Ingalls, 2016). However, there is little consensus in the literature about how power dynamics affect linkages between desired outcomes and different forms of governance in small-scale fisheries (Basurto et al., 2017).

The hilsa fishery in Bangladesh has a total annual value of USD 1.3 billion, accounting for more than 4.3 percent of the nation's total GDP and employing approximately 2.5 million people directly and indirectly in the process (Porras et al., 2017). Thus, hilsa has become the most valuable single-species fishery in Bangladesh. In 2003, progressively declining hilsa catches led the Government of Bangladesh (GoB) to adopt the *Hilsa Fisheries Management Action Plan* (HFMAP), including scientific fish stock assessments and sanctuary areas (where fishing is forbidden during the hilsa breeding seasons) and compensation for fishers adversely affected by these regulations. However, the management plan was implemented with little input (Islam et al., 2020). Afterward, sanctuaries were established and hilsa production increased from 0.255 million MT in 2005-06 to 0.517 million MT in 2017-18 (Hossain et al., 2018). Despite this success, many dependent communities remain vulnerable to food insecurity and poverty, particularly during the fishing ban (Mozumder et al., 2019).

Consequently, this hilsa restoration project's sustainability is at risk due to the over-exploitation of brood fish during the breeding season through flouting fishery bans by the social elite, non-compliance, and conflicts over resource use (Hossain et al., 2019). To avoid over-exploitation and sustain the natural resilience of the hilsa fishery, it is essential to understand ecological limits and enhance social resilience, i.e., individuals' and communities' ability to manage their resources (Brakel et al., 2018). In this regard, establishing a functioning co-management regime in the hilsa sanctuaries could enhance their sustainability in both sociological and ecological terms. Furthermore, it can increase local actors' participation in decision-making for fisheries management by power-sharing, implying a partnership among fisheries users, related business enterprises, non-government organizations, and the government (Jentoft, 1989). One of the gaps the present study aims to address is whether and how co-management could be designed and implemented through power-sharing agreements to mitigate the sustainability challenges to hilsa fisheries. In doing so, fieldwork was conducted in four hilsa fishing communities of Bangladesh, in the villages of Rahmatpur and Sudirpur (Andharmanik sanctuary, Kalapara Upazila of the Patuakhali district-Study Area 1), and Uttar Bagula and Dakxin Bagula (Upper Meghna sanctuary, Haimchar Upazilla of the Chandpur district-Study Area 2).

Power dynamics in the hilsa fishery

Value chain and power relations

Fishers, assemblers, processors, traders, intermediaries, transporters, and day labourers are all involved in the hilsa fishery. The endeavour is capital-intensive and most fishers need help to afford to go fishing at their own expense. Small-scale fishers work without collateral, meaning they cannot access standard bank loans. Thus, an informal loan (*dadon*) from a fish trader (*aratdar*) is the only available financing. In return, the *aratdar* can buy the catch at a lower-than-market price. A *mohajan* (owner of a boat and fishing nets) uses this *dadon* system to purchase and maintain his productive assets in a typical situation. Nevertheless, the *mohajan* often loses money by selling his catch at a lower price and paying a commission to the *aratdar*. A *mohajan* usually works as his boat's captain (*majhi*) or can hire another experienced fisher as *majhi*. Crew members are called *malla* or *vaghi — these are* general labourers in operation who receive a daily wage or a share of the proceeds from the catch's sale.

The power relations based on wealth and dependency among the value chain actors, going from the most to least powerful, are as follows: *aratdar* → *mohajan* → *majhi* → *malla/vaghi*. Given that the *aratdar* provides loans to the *mohajan*, the *aratdar* can be considered the most powerful in the chain. However, the benefits of hilsa fishery are unevenly distributed among different groups along the value chain, with *aratdar* as investors being the vital players in capital-intensive hilsa fishery. The primary limitations of hilsa fishers are a lack of brokering power and market information at the market level.

Power relations among stakeholders

In addition to the main stakeholders in the hilsa fishery value chain described above, there are also other stakeholders involved in hilsa fishery management that include the following: local government administration personnel (*Upazila* Nirbahi Officer [UNO], *Upazila* Fishery Officer [UFO], Coastguard, and Police), Non-Government Organizations (NGOs), local political leaders, local government representatives (*union parishad* members/chairman), transport services, net traders, wholesalers (*paikar*), ice traders, diesel oil merchants, the chief *aratdar* (in the city of Dhaka), and journalists. All these stakeholders have relations with at least some (not necessarily all) of the other stakeholders, involving multiple power relations (see Figure 1).

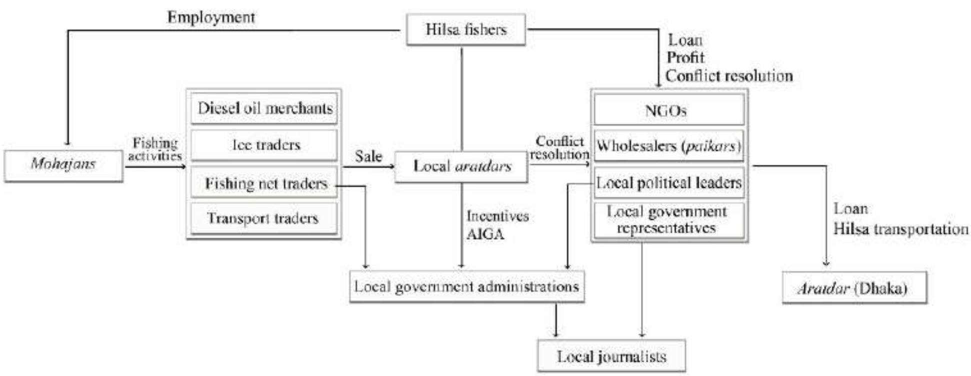

Figure 1. Power relations and service provision among stakeholders in the hilsa fishery value chain and management.

As indicated in the summary of the relationships and power dynamics illustrated in Figure 1, the *mohajan* has relations with diesel oil merchants, net traders, ice traders, and transport services, which allows *mohajan* to run the fishing boat and preserve the fish for sale to the *aratdar*. In this case, ice sellers, oil merchants, and net traders have more power than the *mohajan,* as the latter cannot run his boat without oil or preserve the hilsa without ice. Second, the *aratdar* has relations with the NGOs and wholesalers (*paikar),* as *aratdars* get monetary support from them. *Aratdars* also have ties with the local political leaders and local government representatives as a way to solve conflicts among crew members in hilsa fishing boats. Hence, local government representatives and local political leaders have power over the *aratdar*. Third, net traders have relations with the local government administration because it enforces the law and seizes illegal fishing nets, such as the monofilament gill nets that are still commonly sold. Besides, local government representatives depend on local political leaders who can influence local people and fishers during the election period (vote bank). The local government administration is the most powerful because it has judiciary power to implement compliance measures and address management issues. Local political leaders and local government representatives (i.e., union parishad members and chairman) work on the local government administration personnel's guidelines.

In addition, wholesalers (*paikar*) have a relationship with the prominent *aratdar* in Dhaka through which they can secure more substantial loans, have the local *aratdar* buy hilsa from them, and transport services to transfer hilsa to the *aratdar* in large cities in Bangladesh, including Dhaka. Furthermore, local journalists have relations with the local stakeholders (i.e., political leaders, local government representatives) involved with the hilsa fishery and local government administrative personnel as journalists publish updates on the law and enforcement measures related to hilsa fishery management. Finally, general hilsa fishers (*vaghi)* have relations with the *mohajan* to obtain work on a boat, catch hilsa fish, and profit from the catch. Fishers take loans from NGOs during crises, including the fishing ban period. The local leaders help fishers to solve conflicts with their *mohajans*. The local government representatives also help fishers to resolve social disputes and to be included on beneficiary lists to receive the fishing ban compensation. Finally, the local government administrative personnel help small-scale fishers to get incentives and favours for alternative income-generating activities.

Power dynamics in scheme-based compensation for hilsa shad conservation

There were complaints by the general hilsa fishers during the in-depth interviews about the distribution of compensation schemes for compliance with regulations in the form of food supplements. In addition, there was a widespread perception that corruption among local government officials kept the hilsa fishers from getting the amount of rice they were entitled to. Further, the delays caused by bureaucrats bargaining over the rice were causing the families of fishers to go hungry for extended periods.

Power spaces

It was evident that stakeholder participation is mostly lacking, even though it is essential to have all stakeholders involved in the fishery's management to ensure sustainability. Many fishers urged the local government administration to include only genuine hilsa fishers in the incentive payment beneficiary lists. Nevertheless, many hilsa fishers were excluded. Furthermore, some non-fishers were given benefits intended as incentives not to fish during the ban periods through favouritism.

Several NGOs and the GoB have recently made initial efforts to widen the participation of hilsa fishery stakeholders in the decision-making process. For example, the Department of Fisheries (DoF) and WorldFish have been jointly implementing 'Enhanced Coastal Fisheries in Bangladesh (ECOFISH-Bangladesh),' a USAID-supported project (2014–2019) to further enhance the annual fishery production. The project supports the DoF and local communities in establishing a science-based 'adaptive co-management' strategy that protects brood hilsa and juvenile fish, prevents illegal fishing gear use, and promotes overall ecosystem resilience for all stakeholders. When fishers were asked what empowerment would mean to them in practical terms, respondents, especially hilsa fishers, spoke of electing representatives who would legally and responsibly represent their interests, of being able to bargain for better prices for their fish outside of the control of the local *aratdar,* and being able to buy their equipment through government-subsidized credit systems.

Forms of power

A hilsa fishery worker (*vaghi*) gets work through their relationship with a *mohajan,* who shares the profits of the catch with the crew members. However, *vaghi* has never been told the selling price of the products they harvest. *Mohajan* can decide how much to pay the *vaghi*, who has no bargaining power in the matter. They cannot take their shares of the catch and try to sell those fish through other intermediaries. A *mohajan* can also use their political influence with lenders and government officials to quell dissent in their crew. If someone argues over wages, he may be threatened with exclusion from access to loans or food supplements during the off-season. For a *vaghi* then, the mohajan is the primary manifestation of visible power.

Local *aratdars* have a certain degree of hidden power in their dual role within hilsa fishery management. Many a*ratdar* supports seasonal restrictions on hilsa fishing, which ban the catch of juveniles and brood stock imposed by the government and support prohibitions against using monofilament gill nets. However, some hilsa fishers claimed that by refusing to re-negotiate loan payment schedules to take seasonal restrictions into account, the *aratdar* effectively forces them to fish illegally.

Female fishers have a specific invisible form of power in the hilsa fishery. Increased involvement of women in fishery management could improve household well-being by establishing viable alternative income-generating activities during the fishing ban seasons. These include net making, cage aquaculture, poultry rearing, small dairy ventures, plant nurseries, gardening, and handicrafts. While a few fisherwomen were involved in alternative income-generating activities (AIGAs), they felt they could play a more substantial indirect role in conserving hilsa by supplementing their family income.

The findings suggest that recognizing power dynamics has substantial implications for the planning and implementation of co-management and long-term hilsa fishery sustainability. The findings revealed a significant power imbalance among various hilsa fishery supply chain actors. It is evident that small-scale hilsa fishers are marginalized and underrepresented in decision-making. The DoF, local government administration and representatives, law enforcement authorities, and *aratdars* practice their authority in closed spaces, which they use to create rules and make decisions that adjudicate all fishery functions, from catch to consumer.

Recommendation

These findings further reveal that the current hilsa governance structure needs to be better balanced because some actors are exercising more power by closing or creating spaces, thereby sidelining primary fishers, and encouraging non-compliance and illegal fishing, thus ultimately bringing harm to both the fishery and its users. The primary driver for non-compliance with fishery regulations was desperation caused by poverty among hilsa fishers. They cannot support their families while abstaining from fishing during the ban period, so they take high-interest loans from *aratdar*. This *aratdar* and his regular *mohajan* compel them to break the rules and fish illegally. The *aratdar* and *mohajan* are power holders with solid political connections who can sometimes manipulate law enforcement and policy implementation through bribes and other forms of corruption. In fishing households that try to abide by the rules, government compensation for wage loss often arrives late, and corrupt officials tend to skim off part of the amount that has been principally allocated to fishers.

Despite several problems with hilsa fishery governance, there are possible means of improving the situation and realizing the goals of good governance initiatives in hilsa fishery. First, participants urged a complete ban on monofilament gill net production in local industries. Official corruption must be stamped out, especially among law enforcement and distribution authorities. Proper and fair incentive support must be paid to those who cannot work during ban periods. Finally, credit must be made more readily available to buy fishing boats and gear and enhance alternative livelihood opportunities.

Co-management

A co-management system could reduce power asymmetry among hilsa fishery stakeholders and ensure effective hilsa fishery governance. It can also help overcome the power dynamics challenges in the hilsa fishery. However, co-management has mixed outcomes because its context, role, efficacy, and success vary widely (Chuenpagdee & Jentoft, 2007). For example, co-management practices may have undesirable social and ecological outcomes, such as the risk of elite capture and dominance by the powerful, creating incentives for over-exploitation that may increase social inequality and create conflicts. Furthermore, sharing power and responsibility are essential characteristics of co-management, with the enablement of legislation, participation, representation, and empowerment seen as critical for success (Sandström et al., 2014). Based on the case study here, the present study proposes that the issues described below should be considered regarding the equalization of power relations among the stakeholders to initiate better and implement co-management arrangements in hilsa fishery governance.

Power-sharing can be arranged at different levels according to the resource-users participation in the decision-making process. This can range from the lowest level of 'informing,' where the resource users are passive actors in co-management and are informed about what the government has decided to do, to the highest level of partnership, where genuine political power is delegated to resource users. However, equal power-sharing only occurs when the resource users have the same rights as the government in resource management decisions.

Fishery management involves balancing the competing demands of all fishery resource users. Conflicts among fishery stakeholders arise due to differences in power, interests, values, priorities, and resource exploitation. Conflicts also emanate from institutional failures in managing fisheries and enforcing laws and regulations. The lack of conflict management mechanisms in the hilsa fishery case relates to problems that reduce the effectiveness of sanctuaries, bringing about rampant non-compliance among the users. It also compromises the legitimacy of the conservation measures as powerful actors such as *aratdars* are often indirectly involved in illegal fishing but do not face any penalties, making the general fishers resentful toward conservation measures. Furthermore, most hilsa fishers need more means to operate in their profession with outside capital. Thus, to continue fishing, they must seek credit from NGOs or the local *aratdars,* with their restrictive terms and high-interest rates. From the present study, it was evident that the local *aratdar* has immense power in buying and selling hilsa fish at the local level. However, if fishers can sell their fish to another *aratdar* at a better price by bargaining rather than to the same *aratdar* they are bound to by a credit contract, the power of the *aratdar* will diminish. *As a result, aratdar* will be more likely to compromise with the fishers and offer a better price for their fish.

Most hilsa fishers consider their income from fishing to be quite limited. Fishers should be provided adequate compensation for their financial losses, enabling them to meet their basic subsistence needs during the fishing ban periods. It is evident from the present study that hilsa fishers fish illegally or use destructive fishing gear not because they want to but because they feel it is the only way they can survive. More robust schemes are needed to enable local fishers to lift themselves out of poverty. Fishers' traditional knowledge, experience, observations, and opinions should also be integrated into fishery management policies and their implementation. Such knowledge can help set the dates for hilsa fishing ban periods and the geographical boundaries for fish sanctuaries and formulate other fishery policies.

Conclusions

In this study, the analysis demonstrated that the hilsa fishery's power relations are highly asymmetrical and unequal, with small-scale fishers holding the least power. Also, these findings lead us to seek answers as to why local fishers remain marginalized and underrepresented in decision-making. The present work illuminates the hilsa fishery governance structure that enables and produces problematic power distribution and consequent legal, social, economic, and ecological outcomes. To rectify the problems, a co-management system is proposed as essential for dealing with the power asymmetry among hilsa fishery stakeholders to ensure effective and fair hilsa fishery governance. The results show that power matters. By employing power redistribution, the management regime could shift hilsa fishing decision-making onto a sustainable pathway. There are loopholes in hilsa governance, gaps in the execution of hilsa incentive-based conservation, and ambiguities in compliance with regulations – all of which may lead to a significant policy influence if communicated and disseminated effectively with the hilsa management planners and decision-makers. In the present study, we specifically argue that the redistribution of power necessary for the sustainability of the hilsa fisheries and co-management is the potential strategy for this. There may be similar studies in other parts of the world. Still, we believe this is the novelty of our research in the Bangladesh context. Although this study focuses on Bangladesh's four coastal fishing villages, the results can potentially apply across a broader perspective with a similar tropical context.

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29. Small-Scale Fisheries in Bangladesh in the Context of COVID-19 Pandemic: Impacts and Responses

Md. Ruyel Miah, Memorial University of Newfoundland

Atol is the common crab harvesting gear in the Sundarbans (Photo: Md. Ruyel Miah, 2019).

This chapter provides an overview of the impact of the COVID-19 pandemic on small-scale fisheries in Bangladesh and the subsequent responses from the government to support small-scale fisheries. The findings show that, similar to the global situation, the COVID-19 pandemic has brought wide impacts on small-scale fisheries in Bangladesh, affecting production, processing, distribution, market, food security and nutrition. In response, some initiatives have been taken at the national and local levels to minimize the effects on small-scale fisheries. The main responses were online-based buy-and-sell programs, mobile fish-selling facilities, reduced meal plans, money lending from middlemen, and alternative income-generating options, such as vegetable farming and working as day labourers in the agricultural field. However, the responses have primarily focused on small to medium-term recovery rather than long-term resilience. The study suggests strengthening the adaptive capacity of small-scale fishing communities, especially in response to crises like the COVID-19 pandemic, by promoting meaningful partnerships among the fishing communities, researchers, and formal and informal institutions to improve fisheries governance.

Introduction

In December 2019, the first case of the COVID-19 virus was reported in China. Since then, the virus has spread rapidly throughout the world. On March 11th, 2020, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic (WHO, 2020). Although COVID-19 is a global pandemic, challenges for small-scale fisheries are more pressing in developing countries, where the majority of the world's small-scale fisheries operate than in developed countries, due to pre-existing stressors and pressures. In Bangladesh, for instance, small-scale fisheries face a wide range of social problems, including poverty, lack of livelihood options, weak governance, and under-representation of local stakeholders in the decision-making process (Islam, 2011). The COVID-19 pandemic has worsened their conditions by disrupting the domestic and export market chains, thus posing further threats to their income, food, and nutritional security (Islam et al., 2021; Sunny et al., 2021). In addition, the COVID-19 pandemic has posed an additional challenge to governance, as it has caused changes in the market structure of small-scale fisheries, affecting its governance (FAO, 2020). Similar to other countries around the world, how the government and the market institutions have responded to the COVID-19 pandemic, especially in terms of support for small-scale fisheries, is not explicit.

This chapter aims to provide an overview of the impact of the COVID-19 pandemic on small-scale fisheries in Bangladesh, the government responses to support small-scale fisheries, and the interactions that take place based on the government's responses. As a developing country where key small-scale fisheries were affected by COVID-19, Bangladesh serves as a good illustration of the small-scale fisheries governing needs and capacities during and after the COVID-19 pandemic. Thus, the chapter will address two questions: (1) What are the impacts of the COVID-19 pandemic on small-scale fisheries in Bangladesh? (2) What initiatives have the governing actors taken to support small-scale fisheries, and how do the communities react to the government's responses? Given the COVID-19 restrictions on in-person meetings and fieldwork, the study relied on web-based data, such as newspapers, podcasts, proceedings, and blogs. Additionally, informal virtual discussions were carried out with key informants about small-scale fisheries in the context of the COVID-19 pandemic to supplement and validate the gathered web-based data.

Impact of COVID-19 on small-scale fisheries in Bangladesh

The COVID-19 pandemic has brought wide impacts on small-scale fisheries in Bangladesh, affecting production, processing, distribution, market, food security and nutrition. At the same time, sudden shocks, both in the production and distribution sectors, have affected the governing system of small-scale fisheries.

Production

The pandemic has affected the production sector of small-scale fisheries in Bangladesh, including the capture and culture fisheries. As presented in Figure 1, the inland and marine capture fisheries production has been disrupted due to the lockdowns, mobility restrictions, and lack of logistical support at the beginning of lockdown measures, e.g., in March and April 2020 (Islam et al., 2021). Given the situation, many fishers have reduced their fishing activities for fear of being exposed to the virus and complying with the government restrictions. At the same time, some fishers have tried to continue fishing, making shorter trips for a subsistent living. The culture fisheries sector faces similar situations. Those who could continue producing fish had to reduce their operation due to the lack of fish seeds and the absence of buyers (Sunny et al., 2021).

Distribution and supply

The transportation disruptions have made the situation more challenging. At the beginning of the pandemic and during subsequent lockdown measures in 2020, the transportation of fish and fisheries products from remote areas to different domestic markets was reduced due to mobility restrictions (WorldFish, 2020). Although the government later allowed the transportation of agricultural and fisheries goods, the restrictions on public and private transport have been one of the reasons for the absence of buyers in the domestic markets (Figure 1). This has led to reduced demand for fish in the domestic markets. In addition, the traders were unable to buy fish from rural markets due to high transportation costs.

Fish processing and small-scale workers

Reduced fish production from capture and culture fisheries and distribution problems have lowered the supply of raw materials to the processing industry. The export markets for processed fish and fisheries products, such as fish fillets and steaks, breaded shrimp, canned fishery products, and fish meal and fish oils, have been closed due to international travel restrictions. As a result, the fish processing industries in Bangladesh have been negatively affected (WorldFish, 2020). The processing industries have reduced their hours of operation and processing volume (Figure 1). Many shrimp and crab processing industries have been shut down in some cases due to high processing costs and low sales (Moni, 2020; Roy, 2020). Although the operations of processing industries are predominantly large-scale, this sector's workforce mainly consists of small-scale workers, mostly women. Some of the processing industries have sent their workers on unpaid leave, and many women were affected (Hodal, 2020).

Market

The transportation difficulties have reduced the amount of fish bought, and the labour shortages demotivated traders in continuing their business. Traders reduced their business operations due to reduced demand for fish in domestic and international markets (Rosen, 2020). The domestic markets of small-scale fisheries products in Bangladesh are mainly place-based, with buyers and sellers gathering is a commonplace to buy and sell fish through a bargaining process. The outbreak of the COVID-19 pandemic and subsequent mobility restrictions led to the limited presence of buyers in the markets, and small-scale fishers hardly received fair prices for their products.

Food security and nutrition

Fish is the primary source of animal protein for the fishers and the majority of the consumers in Bangladesh. Hence, limited access to markets and reduced fishing activities has threatened the food and nutritional security of small-scale fishers and their family members (CGIAR 2020) (Figure 1).

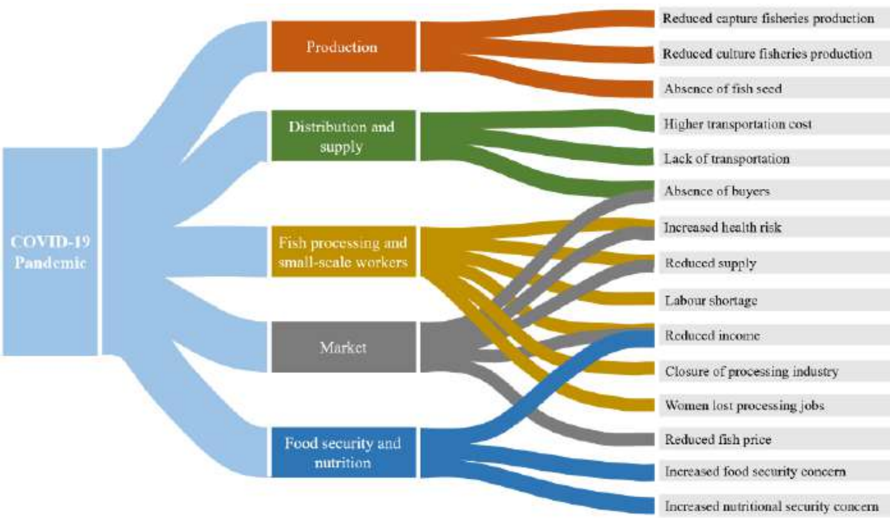

Figure 1. The effect of COVID-19 on small-scale fisheries in Bangladesh. Source: key informants.

Responses to the COVID-19 pandemic and interactions

In response to the pandemic, different governing actors have taken initiatives to support the fisheries sector, including small-scale fisheries. These initiatives have taken place at the national and local levels and are summarized in Table 1.

At the national level

The Ministry of Fisheries and Livestock (MoFL) and the Division of Information and Communication Technology have launched an online fish buy-sell program to help fishers find buyers. The MoFL has set up information booths in different regions to help fishers and fish farmers. They have provided helpline numbers for fishers and fish farmers to call if they face any difficulties during the pandemic. They have also arranged mobile fish-selling facilities (i.e., selling fish in a van) in the cities to continue the fisheries supply chain. In addition, the Bangladesh government has launched food and monetary support for poor rural people, including small-scale fishers. However, these measures are insufficient to continue feeding people who have lost their income during the lockdowns.

The Department of Fisheries (DoF) has disseminated updated information regarding domestic and export markets to local fisheries offices. The DoF has suggested that the government should not include the fisheries sector in the lockdown measures. They have sent a letter to the government asking to keep the supply chains functioning. In addition, they have kept communicating with wholesalers and mobile fish sellers in Dhaka. The department has organized a meeting with those groups and has noted the problems they have been facing due to COVID-19.

Despite the effects of the pandemic, the Bangladesh Fisheries Research Institute (BFRI) has kept producing fish seed under the COVID-19-related guidelines and distributed it to local small-scale farmers in many regions at a lower price. They have also provided helpline phone numbers for farmers to contact, place their orders, or ask for help.

The Bangladesh Fisheries Development Corporation (BFDC) has collaborated with the MoFL in the mobile fish-selling initiative. This corporation has helped extend fish-selling services in Dhaka and other big cities through its branch offices. In addition, they have used offices near fish lending centers to manage fish buy-sell and helped fishers during the COVID-19 crisis.

At the local level

Fishing communities – in many cases, fishing communities have reduced the number of meals per day during the tough times of the COVID-19 pandemic, especially during the period of March-April in 2020. Some small-scale fishers and farmers have also started vegetable farming to fulfill their nutritional needs. They have worked in agricultural fields as day labourers. Many fishers have borrowed money from the middlemen to buy necessary food and grocery items. Small-scale fishers have continued fishing practices to avoid hunger and poverty in many areas. Many fishers have utilized the unsold fish for consumption or dried the fish so they can sell it in the future, hoping to reach a better price. A similar effect has been observed in aquaculture, where many farmers temporarily stopped harvesting fish.

Middlemen or local traders – many of them have continued buying and selling fish in the local markets, but only in a small amount. Some of them discontinued their fish trading work and invested money in other sectors, such as paddy culture. They have been trying to take loans from the bank as the government declared a loan stream for them with less interest (Dao, 2020). However, it was not easy for them given that they needed to show different legal documents, for instance, property ownership, which many of them do not have. In some cases, middlemen have voluntarily helped small-scale fishers by providing food and grocery items.

Fish processors – the processing industry has reduced the number of workers. In some cases, they have sent their workers on forced leave (Roy, 2020). However, some processing industries have continued their activities following the government guidelines, which have helped small-scale fisheries, especially women, to continue the workflow.

Upazila (sub-district) and District fisheries offices – at the beginning of strict lockdown measures in 2020, local fisheries officers monitored and restricted fishing activities. They also disseminated up-to-date information about the pandemic and restrictions to the small-scale fishers in rural areas.

Table 1. The governing responses by different actors and subsequent challenges during the COVID-19 pandemic. Source: web-based data and key informants.

Level	Actors	Responses	Interactions
National	Ministry of Fisheries and Livestock	• Launched an online fish buy-sell program • Set helpline booths in different regions • Provided food and grocery support	Fishers are unaware of such government initiatives and are not accustomed to online-based marketing.
	Department of Fisheries (DoF)	• Updated the market-related information to the supply chain stakeholders • Suggested the government keeps the supply chain functioning	Small-scale fishers have rarely benefited from these initiatives.
	Bangladesh Fisheries Research Institute (BFRI)	• Continued research activities • Continued fish seed production and supply to aquaculture farms	Culture fisheries have mostly benefited from them.
	Bangladesh Fisheries Development Corporation (BFDC)	• Helped to continue the fish supply • Helped fishers to sell their products	The benefits have not properly reached small-scale fishers.
Local	Small-scale fishers and fishing communities	• Reduced number of meals per day • Vegetable farming • Physical labour in the agriculture field • Increased household fish consumption • Dried unsold fish • Women diversified their income options through mending net mending, sewing clothes, etc.	Food and nutritional insecurity concerns for small-scale fishing communities. In addition, those who have continued fishing become susceptible to COVID-19 infection.
	Middlemen or local traders	• Continued a small amount of fish trade in local markets • Started trading other agricultural goods, e.g., vegetables • Took a loan from the bank	Traders have faced difficulties in taking loans from the bank since the process of acquiring money is challenging.
	Fish processors	• Reduced the number of workers in the processing industry • Reduced fish processing amount	Processing workers, especially women, lost their income due to job losses.
	Upazila and District fisheries offices	• Monitored fishing activities and fish landing areas • Disseminated COVID-19 related updates and guidelines to small-scale fishers	Conflicts occurred between small-scale fishers and government officials based on the monitoring activities.

Discussion

The COVID-19 pandemic has brought new challenges, such as lockdown measures and mobility restrictions, especially for small-scale fisheries supply chains. The pandemic has exacerbated the pre-existing social and economic crises for small-scale fisheries in Bangladesh (Belton et al., 2021). The closure of major domestic and international markets has put pressure on the governing system. Since the governing actors were not prepared to tackle such an unexpected crisis, responsive measures have been taken by all levels of governing actors, from the local to the national. In the context of the markets and trades, the government's sudden lockdowns and mobility restrictions have largely affected supply chains of fish and fisheries products, including small-scale fisheries, increased social tensions, and threatened food and nutritional security. The responses have mostly focused on short to medium-term recovery to minimize the effect of the pandemic (Table 1). Similar to what Belton et al. (2021) suggest, this study has found that the supply chain actors' common reaction to the challenges brought on by the pandemic consists of reducing production costs, making loans more available, seeking alternative income opportunities, and reducing food consumption. In some cases, small-scale fishers have involved their children and wives in income-generating options (e.g., net mending and sewing clothes) to supplement the family income. Béné (2020) considers that some of these coping strategies are likely to undermine well-being and long-term resilience in fisheries due to their short-term recovery focus. Ferrer et al. (2021) have suggested that long-term adaptive measures can contribute to building specific and generalized household resilience to the COVID-19 pandemic-related difficulties.

The lack of capacity and inadequate initiatives of the government to support small-scale fisheries have further made small-scale fishers susceptible to poverty and food and nutritional insecurity. Poverty is one of the main reasons why small-scale fishers have violated both existing legislation (Islam et al., 2017) and the COVID-19 pandemic-related lockdown measures and mobility restrictions. Without proper alternatives, restrictions such as lockdowns or gathering bans in marketplaces in Bangladesh have become a huge burden for small-scale fishers in terms of food and nutritional security. Although the government had a compensation plan for the imposed restrictions such as food, grocery, and monetary support, distributing money and food to vulnerable people has not been effective (WorldFish, 2020). As a result, the rural poor often complained that they did not get what they were supposed to receive. Moreover, these responses have not been viable options due to poor implementation and effectiveness (Islam et al., 2021; Sunny et al., 2021).

Participation, accountability, coherence, and effectiveness are the hallmarks of good fisheries governance (Pinkerton, 1989). The findings of the study reveal that the existing governance structure of fisheries and their market channels, including the small-scale fisheries in Bangladesh, especially in the context of the COVID-19 pandemic, are weak. Small-scale fishers do not have opportunities for active participation in the decision-making process concerning the governance-related issues that affect their income and livelihoods. Local traders are the dominant and powerful actors in the supply chains, primarily at the local level. Mozumder et al. (2020) have found that local traders are the power holders at the local level. They had secure political connections and could manipulate law enforcement and policy implementation through bribes and corruption. Overall, the study suggests that the existing governance of small-scale fisheries is not well structured, which requires changes and modifications by understanding the dynamicity of small-scale fisheries and fishing communities as well as the capacities of the government. Although small-scale fishers are the most important actor in fisheries supply chains, small-scale fishers' fates have remained the same: marginalized, underestimated, unrecognized, and often victimized.

Globally, fisherwomen involved in the supply chains have been more affected by the COVID-19 pandemic than men (Roy, 2020; Belton et al., 2021; Ferrer et al., 2021). Unfortunately, none of the responsive measures by the Bangladesh government has specifically supported fisherwomen who have lost their jobs due to the COVID-19 pandemic. Furthermore, the government has not considered women's perspectives in preparing COVID-19 related responsive measures. The participation of women in the fishing and decision-making processes has been compromised due to social, cultural and religious barriers. Further, the outbreak of the COVID-19 pandemic has accelerated the existing vulnerabilities of small-scale fisheries and brought on new challenges. The small-scale fisheries issues related to COVID-19 are not highlighted by the media or government, compared to other sectors, such as the readymade garments industry. Similar to Salas et al. (2019), this study suggests strengthening the adaptive capacity of small-scale fishing communities, especially in response to crises like the COVID-19 pandemic, by promoting cooperation among the community members, scientists, and formal and informal institutions as a step towards improving fisheries governance.

Conclusion and recommendations

Overall, the analysis of the COVID-19 pandemic situation of small-scale fisheries in Bangladesh highlights how small-scale fisheries are not given their desired recognition and space in the decision-making process, which to some extent, threatens their income and livelihoods by disrupting the supply chains. The government should pay more attention and provide direct support to small-scale fisheries in facing future crises by offering subsidies, increasing fish prices, and developing new local fish markets. The government should also support alternative job creation for small-scale fishers, thus lowering poverty in future crises similar to the COVID-19 pandemic. A consultation process should be put in place between the government, fisheries professionals, and supply chain stakeholders, including small-scale fishermen and women, to identify emerging problems in fisheries supply chains and enhance capacities. A gender-inclusive governance structure should be developed where both men and women can contribute to the decision-making process. Furthermore, fisheries development plans and policies need to address the fundamental social, economic, and environmental issues that affect small-scale fishing communities and their livelihoods. The country should pay attention to the power relation between small-scale fishers and other supply chain actors. The government should also consider necessary changes/restructuring in the supply chains and institutions involved so that small-scale fisheries can hold out during such a crisis moment and keep supporting food and nutritional security at the local as well as national levels.

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About the author

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30. Fishing Bans and Compensation Schemes for Fisheries Conservation and Livelihood Development: Challenges and Opportunities

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A group of fishers involved in fishing in the Meghna River, Bhola (Photo: Atiqur Rahman Sunny, 2021).

The Government of Bangladesh has taken several initiatives to conserve fish, including the national fish hilsa shad (Tenualosa ilisha) and enhance community development. This chapter assesses the role and contributions of compensation schemes that support fisheries conservation and livelihood sustainability. Under this scheme, the government established six fish sanctuaries and enforced several fishing ban seasons. Simultaneously, the government adopted an alternative income generation and compensation scheme for lost income during fishing bans. These bans include hilsa fishing ban and juvenile (jatka) fishing ban in the sanctuaries, marine fishing ban in the Bay of Bengal, and a freshwater fishing ban in the Kaptai Lake. Although these bans appear to be effective in achieving ecological outcomes, they have led to adverse impacts on livelihoods, including loss of income, long-term indebtedness, and less nutritional intake. Therefore, this study recommends an improved compensation scheme and logistical support, a participatory management plan, and a strengthened legal framework towards sustainable fisheries resource management and livelihood development.

Introduction

Livelihood-focused development interventions can be categorized into three broad and overlapping categories: alternatives, compensation, and incentives (Wright et al., 2016). Alternative livelihood intervention focuses on reducing the dependency on natural resources by generating economic benefits to increase community support for conservation (Roe et al., 2015). A compensation scheme includes explicit recognition of community and individual costs of conservation, particularly access restrictions that adversely affect people's livelihoods, with the aim to reasonably compensate for losses (Clements et al., 2010). Compensation schemes could be based on social justice and human rights principles or they may be explicitly used to minimize conflicts (Springer, 2009). Incentive schemes, on the other hand, provide in-kind support, especially in case of behavioral changes that do not comply with the conditions agreed-upon under the scheme (Wunder, 2013). Payments for ecosystem services (PES) is a classic example of an incentive scheme that directly links desired alternatives to conservation objectives.

Conservation of the national fish hilsa shad (*Tenualosa ilisha*) is a priority for the Government of Bangladesh. The government provides direct assistance in hilsa conservation efforts, although different terms have been used in literature to describe these types of assistance. These terms include alternative Income Generative Activities (AIGAs), incentives, compensation scheme, ban period allowance, and PES (Islam et al., 2018; Nahiduzzaman et al., 2018; Sunny et al., 2021). Nonetheless, the term compensation scheme seems the most appropriate based on the categorization outlined above, as the assistance is limited to in-kind supports (rice bags) and the promotion of other alternative income-generation activities. The capacity to generate a positive impact on fishers' livelihoods is a crucial aspect in relation to compensation schemes. This study reviews available literature to explore the challenges and opportunities of a compensation scheme during fishing bans towards supporting biodiversity conservation and improving fishing livelihoods.

Implementation of different fishing bans

Hilsa shad is the most important fish species in Bangladesh, both economically and socioculturally, and is highly prized in markets. Before the 1980s, hilsa was affordable across income groups, including the poorest of the society, due to abundance of hilsa in over 100 rivers in the country. However, the catch sizes declined sharply during 2001-2003 from 2,400,000 to 200,000 metric tonnes (MT) (Nishat et al., 2019). This decline attracted the attention of policymakers who promoted scientific research on hilsa fisheries to understand the causes of the decline and how the fishery can be rebuilt through better resource management. Subsequently, in 2003, the Government of Bangladesh adopted a Hilsa Fisheries Management Action Plan (HFMAP) to maximize production levels of hilsa sustainably and improve the socioeconomic status of fishers (Islam et al., 2017). Furthermore, under the Protection and Conservation of Fish Act of 1950, the government declared six hilsa sanctuaries in Padma, Meghna, Tertulia, and Andarmanik rivers and associated tributaries that cover over 432 km in length. Fishing bans were also imposed on these sanctuaries, aiming to prevent overexploitation and conserve hilsa juvenile and breeding stocks to maintain fish biodiversity (Islam et al., 2016).

Table 1. outlines the ban periods on these hilsa sanctuaries and associated resource boundaries.

Area and boundaries of hilsa sanctuaries	Ban Period
100 km stripe in Meghna River – from Shatnol of Chandpur to Char Alaxandar of Laxmipur districts	March-April
90 km stripe of Shahbazpur Channel at Meghna estuary from Char Ilish Mosque Point to Char Pial Point in Bhola district	March-April
100 km stripe of Tentulia River from Beduria of Bholato Char Beduria in Patuakhali district	March-April
40 km stripe in Andharmanik River in KalaparaUpazilla of Patuakhali district	November- January
20 km stripe at lower Padma (Padma confluence) in Shariatpur district	March-April
83 km stripe in Meghna River (from Hizla to Mehendiganj) in Barisal district.	March-April

Juvenile hilsa (Jatka) fishing ban

An eight-month-long yearly ban is imposed on fishing, transportation, marketing, and selling *jatka* (hilsa juveniles, less than 25 cm in length) from November 1st to June across coastal, estuarine, and riverine areas of Bangladesh (7,000 km^2 area). The ban is expected to increase fish production and ensure free breeding (Nishat et al., 2019). To protect juvenile hilsa, fishing is banned from March and April in all sanctuaries, except the Andharmanik River, which is banned from November to January.

During these ban periods, the Government of Bangladesh provides 40 kg of rice to all fishers with a fisher identity card (*jele* card), considered poor and most vulnerable. During the 2019–2020 financial year, only 280,963 *jatka* fishing households (the poorest) received this support out of 505,787 fisher households in total due to limited resources (Islam, 2021). In addition, the Department of Fisheries (DoF) conducted a campaign during the ban period to raise people's awareness using local, print, and electronic media (Nahiduzzaman et al., 2018). Furthermore, a special task force consisting of officials from the country's police, navy, coast guard, river police, local government administration, and fisheries officers conducts raids against illegal fishing during these ban periods. For breaching a fishing ban, a convicted person can be fined up to 5,000 Bangladeshi BDT (equivalent to USD 11.89) or sentenced to one or two years of imprisonment or both.

Fishing ban on brood hilsa

The peak breeding season of hilsa is October to November, although breeding occurs all year round. During peak periods, fishers tend to catch a huge quantity of gravid hilsa indiscriminately. Therefore, the government imposed a country-wide 22-day ban to conserve gravid hilsa. Initially, the ban was set for 11 days (five days before and after the full moon), but in 2015 the duration was extended to 15 days. Furthermore, it has been extended to 22 days since 2016 (October 14th - November 4th) based on scientific evidence to ensure a sufficient spawning period for sustainable production (Rahman et al., 2017). The DoF has been implementing this ban since 2007 with the support of different stakeholders and law enforcement agencies (Rahman et al., 2015; Sunny et al., 2017). The ban is also enforced through different means, including motivational meetings, awareness campaigns through media (television, radio, and newspaper), and closing ice-producing factories in coastal regions. In special cases, all government agencies also deploy additional workforces to coastal districts to strengthen the enforcement of this ban.

Fishing ban in the Bay of Bengal

Bangladesh has introduced a monsoonal fishery closure in the Bay of Bengal to conserve fish stocks and ensure the safer breeding of marine species. Since 2015, the government of Bangladesh imposes a 65-day annual ban from May 20th to July 23rd under the Marine Fisheries Ordinance of 1983 (Rule 19). Initially, this ban was imposed only on industrial trawling. However, since 2019, artisanal fishing was also included under the ban. Extending this ban to artisanal fishers has brought severe economic hardships on artisanal fishers due to pre-existing poverty and a lack of sufficient alternative employment opportunities. The disappointment caused among artisanal fishers even led to street protests as this new ban pushed them into an even more vulnerable conditions (Islam et al., 2021).

Fishing ban in the Kaptai Lake

Since 1961, fishing in Kaptai Lake has been prohibited from early April to mid-August under the fish act of 1950 although the ban was not effectively enforced. Since 1992, a shorter three-month (May 1st to July 31st) fishing ban has been imposed by the Bangladesh Fisheries Development Corporation (BFDC) to protect and conserve biodiversity and to facilitate fish breeding in the lake. During this period, harvesting, processing, marketing, selling, and transporting fish in the lake is illegal (Shalehin et al., 2022). In addition, a naval police team is also patrolling the lake together BFDC while constantly monitoring fish landing centers and local markets (Ahmed et al., 2006). BFDC patrolling operations are conducted through five stations: Rangamati Sadar, Kaptai, Marishya, Mahalachari, and Longadu. However, the lake's large size, remote location, and the lakeside hills that block visibility over large areas make it hard to police the entire lake effectively.

Effectiveness of fishing bans and compensation schemes

During the first stage of the ban period in hilsa sanctuaries, the government provided in-kind support, 10 kg of rice once every two months. Almost 146,000 fishing families received this support in 2007-08 across ten districts and 59 sub-districts of Bangladesh. Gradually this aid scheme increased, with 186,264 families from 15 districts receiving 30 kg of rice every month in 2011-12. Finally, In 2013-14 fiscal year, 224,102 families received 40 kg of rice for four months. These periods included one month before the ban period, two months during the ban, and finally, one month after the ban ended. Many fishers mentioned receiving an average of 30-32 kg of rice/per month instead of 40 kg. However, the fishers claimed that the leadership of the lowest tier of the three-tiered local government administration (*Union Parishad*) allocated a portion of rice intended to be distributed among families to cover the costs of transportation and other logistics.

The process of finalizing the list of recipients of rice and allocating and distributing rice is lengthy and complex. It includes 13 separate steps and involves every tier of Bangladesh's administrative hierarchy, including meetings at the *Union Parishad* to get approval from the Director General of the Department of Fisheries, with several in-between steps. Each step incurs transaction and administration costs, such as personnel time and transport. Together, administration and transaction costs account for BDT 918 for each metric ton of rice distributed, which is three percent of the total cost. According to some studies, this cost is lower compared to other similar schemes, such as the PES scheme in Costa Rica, for which the transaction cost ranges between 12-25 percent (Miranda et al., 2003). However, in Bangladesh's hilsa sanctuaries, the compensations are provided only for hilsa fishers although other fishers are also affected as fishing of other species in the sanctuaries is also hampered during ban periods. Therefore, out of dissatisfaction, non-hilsa fishers try to qualify themselves as hilsa fishers through the fisher registration scheme owing to their power and sociopolitical connections, despite the negative effect on both hilsa conservation and the compensation scheme (Bladon et al., 2016).

Although the government compensation scheme through in-kind support proved to be supportive, the fishers claimed that the compensations were poorly administered, non-inclusive, and insufficient. Further, they felt they did not receive the support they deserved due to a lack of monitoring, unfair distribution, and corruption (Islam, 2021). Additionally, the government only provided in-kind support (rice) with no financial support or any other daily needs of the families, such as oil, pulse, sugar, and salt. Oftentimes, compensation support is not provided before the start of the ban period (Islam, 2021). As a result, many fishers are bound to borrow money from various money lenders at high-interest rates throughout the fishing bans. This also increases illegal fishing as fishers must repay the debts within a given time. These challenges hinder the management of fishery resources, which, in turn, impact the effectiveness of conservation efforts (Islam, 2021). Furthermore, the exclusion of fishers from the decision-making process in the management of local fisheries leads to increased non-compliance (Mohammed et al., 2016).

Since 2009, the Hilsa Management Program has also provided support for Alternative Income Generating Activities (AIGA), including training in livestock rearing and other micro-business operations. This support included cash for buying and selling small fishing gear, interest-free credit, and sewing machines for fisherwomen, rickshaws, and livestock (sheep, goats, cows, and poultry). However, there was no follow-up or post monitoring of whether the recipients could effectively utilize the support to generate alternative income, which limits the initiative's success (Haldar & Ali, 2014). Further, the selection process of the types of AIGA assistance didn't take household preferences into consideration. For instance, some families were provided sewing machines even though they lacked the knowledge and skills to use them. Consequently, they often end up selling these sewing machines below the market price and use the cash for purposes that do not contribute to establishing alternative income sources (Haldar & Ali, 2014).

Influence of bans on fisher lives, livelihoods, and way of living

Since the fishing bans are introduced in Bangladesh, it has gradually positively impacted inland and marine fish production in various waters and sanctuaries (Bladon et al., 2016). However, in communities where dependence on fisheries resources is high and livelihood options are few, periodic or permanent closures across large fishing grounds may create significant economic hardship and may be met with resistance. The present study's findings demonstrated that small-scale fishers have lower literacy rates than the national average. Fishing skills, combined with the lower levels of education, are not easily transferable to other skilled professions. It is also difficult for them to manage temporary employment during the specific time of the year when various bans occur, as most lucrative careers demand long-term commitment. Moreover, the fishing communities live in marginal areas far from economic centers. These challenges make it hard for fishers to find alternative employment during ban periods (Islam et al., 2018), resulting in unemployment and loss of income during ban periods. These financial and economic challenges lead to non-compliance with closed-season strategies (Sunny et al., 2021). A key shortcoming of the compensation scheme is the exclusion of important stakeholders of the hilsa value chain, such as fisheries entrepreneurs. Moreover, not all hilsa fishers are supported by the scheme, while non-hilsa fishers do not receive compensation. They are sometimes forced to fish illegally to support families, sell their family properties to reduce debt or are forced to spend days without sufficient food intake. Fishers mentioned that the current management strategy should have considered community input and perceptions to improve compliance with the law.

Overall, the current hilsa management strategy should be revised, taking the community input into consideration. A need-based effective compensation package, inclusive of all stakeholders, and cash should be distributed through m-banking (mobile banking), making the compensation more effective. Permitting regular special interest-free loans for affected fishers can also help in this regard. We also recommend proper distribution of compensation and adequate subsidy amounts to the fishers in a timely manner. It is also important to arrange alternative livelihood options considering community preferences. Without resolving the underlying financial issue, both community- and incentive-based conservation programs cannot be successful. In Bangladesh, similar to elsewhere in southern Asia, fishing communities are considered among the poorest communities (Islam et al., 2016). Therefore, to increase the success of long-term management through permanent or temporary fishing closures, the affected populations should be lifted out of poverty by developing effective alternative income-generating options.

Conclusion

This study focuses on the impact of fishing ban related compensation schemes on biodiversity conservation and livelihood development in the fisheries sectors of Bangladesh. As we have already pointed out, the compensation packages for fishers need to be upgraded and diversified to make them effective during bans. Adequate compensation such as rice, cash, and AIGA's support could be modified considering the community's needs and preferences. In addition, earning losses during ban periods and credit opportunities towards improving the welfare of fishers need to be addressed more carefully. Bangladesh also experiences frequent climate disasters, making fishers more vulnerable. Improper management, unequal compensation distribution, and avoidance of frontline stakeholders' involvement put the effectiveness of biodiversity conservation and livelihood development strategies at risk. Well-planned livelihood diversification and climate resilience assistance need to be planned and implemented in coordination with national and international agencies while also ensuring the participation of key stakeholders.

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31. Straddling Stocks: Transboundary Cooperation in Managing Small-Scale Fisheries of the Bay of Bengal

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Fishers from the Sundarbans's Dublar Char Island, close to the maritime boundary with India harvest their catch using traditional fishing boats and gears (Photo: Shariful Islam, 2021).

This chapter depicts how coastal fisheries of the Bay of Bengal can be managed through cooperation with neighbouring countries of India and Myanmar. Bangladesh has greatly emphasized hilsa stock enhancement by imposing strict ban seasons and food relief for the affected fishers. As a result, hilsa production is increased, which benefits not only Bangladesh but also neighbouring India and Myanmar. However, those countries need to more hilsa conservation whilst benefiting from Bangladesh's investment. Fishers of Bangladesh face hardship and poverty during ban seasons, but neighbouring fishers fish illegally in Bangladesh waters during ban seasons. These unjust situations anger Bangladeshi fishers, resulting in non-compliance with the ban seasons. Although some foreign fishers get arrested by the Bangladeshi coastguard each year, the overall situation is not suitable for fisheries conservation.

Introduction

The term 'transboundary' refers to an approach to fisheries management that looks into the effects of setting boundaries and proposes strategies for adjusting or transcending static and inflexible spatial boundary limits (Song et al., 2017; Scholtens et al., 2019). Transboundary fishing has increasingly become a part of greater territorialization and nation-building difficulties arising from events like maritime boundary disputes or claims to sovereignty for islands and coral reefs (Song et al., 2017). Legal benefit-sharing agreements, historical precedent, enhanced environmental quality, and inadvertent border crossing are grounds for transboundary fishing (Kadfak et al., 2012). Cooperative transboundary river management is essential for maximizing economic benefits from water use and reducing poverty, ensuring food security, and preventing and monitoring water pollution. Transboundary collaboration can benefit cooperating countries in various ways, including increased economic growth, enhanced human well-being, environmental sustainability, and political stability (UNECE, 2015). Cooperation between neighbouring countries can bring many economic, environmental, social, and political benefits when it comes to transboundary river fisheries management. In addition to addressing challenges like degraded watersheds, rising water demand, and tense regional relations, this transboundary collaboration also provides benefits such as increased water supply, sedimentation reduction, flood control, agricultural and hydropower production, available renewable energy, and integrated regional markets and trade (Tafesse, 2009).

Transboundary fisheries management in the context of the Bay of Bengal

Along the northern boundary of the Bay of Bengal, the shallow coastal waters are shared between India and Bangladesh (Modak, 2021) as well as the bulk of fish stocks. Straddling fish stocks are exploited in an unsustainable manner since their distribution is not limited by human-made boundaries and can easily traverse two or more marine zones (Palacios-Abrantes, 2020; Arif, 2021). Small-scale fishers in the Bay of Bengal has been found to share common fishing grounds with other fishers from neighbouring countries such as Bangladesh, India, Myanmar, Sri Lanka, Thailand, Malaysia, and Indonesia (Kadfaq et al., 2012). To secure sovereign access to the marine resources in Bay of Bengal, Bangladesh, India, and Myanmar resolved the maritime boundary disputes in 2012 and 2014 by verdicts of the Permanent Court of Arbitration (PCA) and International Tribunal for the Law of the Sea (ITLOS), respectively (Arif, 2021; Bose, 2021). However, there is no viable regional framework covering all coastal states in the Bay of Bengal to ensure the protection and management of these fish stocks (Arif, 2021). Due to a lack of a comprehensive regional fisheries management plan, these marine fisheries resources in the Bay of Bengal are unsustainably harvested, thus emphasizing the need for a robust regional cooperation framework to guarantee the conservation and management of marine biological resources in the Bay (Kadfaq et al., 2012; Arif, 2021).

This study focuses on the transboundary species of hilsa shad (*Tenualosa ilisha*), which is shared between Bangladesh, India, and Myanmar (together accounting for over 90 percent of the landings) and is currently experiencing recruitment overfishing (indiscriminate catching of juvenile hilsa) and growth overfishing (harvest of mature female hilsa) (Hoq et al., 2013; Goswami, 2020; Suresh et al., 2021). Although hilsa migrate across Bangladesh, India, and Myanmar, which benefits all three countries, there is no transboundary management agreement to protect this species from overexploitation. Therefore, it is crucial to have a transboundary management plan through cooperation and coordination between countries that share the stock to ensure the sustainability of Hilsa fish species. The Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication (SSF Guidelines), endorsed by the member states of the United Nations, also encourage transboundary cooperation between coastal states to conserve and manage to straddle fish stocks (FAO, 2015). It also suggests that states should work together to grant protection for the tenure right of small-scale fishing communities in shared waters and fishery resources (FAO, 2015). Moreover, in resolving the problems of the transboundary movement of fishers, the SSF Guidelines specify the responsibility of the State, urging that states should recognize and address the underlying causes and consequences of transboundary movements of fishers and contribute to the understanding of transboundary issues affecting the sustainability of small fisheries (FAO, 2015; Kurien, 2015).

Current hilsa management practices in Bangladesh, India, and Myanmar

The tropical anadromous fish hilsa shad has become an essential component of the quality of life and well-being for the small-scale fishers of Bangladesh as well as in India and Myanmar (Hossain et al., 2019). This species not only connects the transboundary ecosystems of these countries but also shares a tremendous social, cultural, economic, and emotional bond with the people of the countries (Ahsan et al., 2014; Ahmed et al., 2021). According to global hilsa catch data, Bangladesh has secured the largest share of hilsa (86 percent) among the three countries, followed by Myanmar (4 percent percent), and India (8 percent) (Ahsan et al., 2014; Hossain et al., 2019; Rahman et al., 2020; Dutta et al., 2021). In Bangladesh, hilsa (also known as the national fish and the geographical indicator) catch accounts for more than half of all marine catches and 12.22 percent (5.50 lakh MT) of total fish production (DoF, 2020). This iconic flagship hilsa alone produces more than 1 percent of the country's GDP, employs 0.5 million people, and generates USD 12.5 million in foreign exchange revenue yearly (Ahmed, 2021; Modak, 2021).

Considering the observed declines in annual hilsa catches in the Bay of Bengal region and the enormous importance of small-scale hilsa fishing, the Government of Bangladesh has adopted several proactive conservation efforts to regulate the production (Table 1). The Government of Bangladesh introduced Hilsa Fisheries Management Action Plan (HFMAP) in 2005, which included the declaration of fish sanctuaries to allow uninterrupted breeding and nursing of juveniles, enforcement of patrolling against the use of monofilament nylon nets (*Current Jal*), the introduction of modest compensation of food grains to poor fishers (presently 40 kg rice/fisher for almost seven months) during fishing ban periods, and enabling Alternative Income Generating Activities (AIGAs) (Hossain et al., 2019; Keya et al., 2020; Rahman et al., 2020; Modak, 2021). These initiatives contribute to a more stable utilization of hilsa resources in Bangladesh, which also benefits India and Myanmar by increasing hilsa production in their brackish waters.

However, these two countries need to do more to protect hilsa. Compared to Bangladesh, hilsa fish management initiatives in India have been patchy, with inadequate law enforcement, resulting in a decline in the share of hilsa catches and increased reliance on hilsa imports from Bangladesh and Myanmar. In India, while West Bengal has some plans to manage hilsa fisheries, the central government needs to put more effort, resulting in less capacity and resources to implement comprehensive management measures (Hossain et al., 2019; Goswami, 2020). Through the Ministry of Agriculture and Farmer Welfare, India has taken unilateral initiatives to revive hilsa fisheries, such as the National Action Plan for hilsa. Still, it has failed to achieve the desired goals (Goswami, 2020). Moreover, five hilsa breeding grounds in Hoogly-Bhagirathi of West Bengal have been identified and designated as hilsa sanctuaries, with fishing bans in place from June to August and October to December each year (Hossain et al., 2019; Goswami, 2020;), but the relevance of this initiative to hilsa fishing or spawning season is unclear (Hossain et al., 2019). Furthermore, there is no control over the fishing effort and fine mesh nets for catching hilsa juveniles. The involvement of small-scale fishers in making regulations is uncertain, which resulted in the governing bodies being unable to identify and map the major spawning and nursery areas of the hilsa (Hossain et al., 2019).

On the contrary, from July to August, the Myanmar government imposed a closed season for hilsa fishing in the Ayeyarwady delta (Meyer et al., 2020). Despite the rules that impose temporal restrictions to safeguard hilsa fish spawning and recruitment, the hilsa population is overfished, and juveniles are caught using small-mesh fishing nets, which limit their recruitment (Merayo et al., 2020).

Table 1: Hilsa management practices between countries.

Countries	Hilsa fish management plan/strategies	References
Bangladesh-Incentive based protection and conservation measures opted by the Government	• Introduction of Hilsa Fisheries Management Action Plan (HFMAP) in 2005 • Establishment of six fish sanctuaries and spawning grounds (Under the Protection and Conservation of Fish Rules 1985) • 22-days seasonal fishing ban of brood hilsa shad in October every year • From November to May every year, there is a legal ban on the capture, transportation, and sale of juvenile hilsa • Prohibition on the use of monofilament nylon nets (<10 cm mesh size) (under 2002 amendment of the Fish Act, 1950) • Enforcement of fish protection and conservation acts • 65-days ban on all forms of marine fish harvest from May 20 to July 23 each year • Introduction of food grains (40 kg rice/fisher for almost 7 months) since 2013 • Enabling Alternative Income Generating Activities (AIGAs) • Introduction of Payment Ecosystem Services (PES) • Under the Mobile Courts Ordinance 2007, law enforcement agencies operate a number of mobile courts and other initiatives to seize illegal *jatka* or hilsa catches • Establishment of MPA to strengthen institutional capacity of hilsa fishery management	Hossain et al., 2019; Goswami 2020; Keya et al., 2020; Rahman et al., 2020; Dutta et al., 2021; Modak, 2021
India-the state alone manages hilsa fisheries rather than the central government	• Under the West Bengal Act XXV of 1984, the West Bengal Fisheries Department developed a national action plan to conserve hilsa fisheries and breeding sites • Identification of five hilsa breeding grounds in Hoogly-Bhagirathi of West Bengal • Declaration of fishing bans in places from June to August and October to December each year • Although there is a ban on the size of monofilament gill nets (<90 mm), there is no control over fishing effort or fine mesh nets for catching juvenile hilsa • From April 15 to June 15 of every year, fishing is prohibited in Indian marine waters • Yet to be identified and mapped are hilsa fisheries major spawning and nursery grounds	Dutta & Hazra 2017; Hossain et al., 2019; Hossain et al., 2019; Goswami, 2020; Dutta et al., 2021; Suresh et al., 2021
Myanmar	• National Plan of Action to deter illegal fishing • Myanmar government imposed a closed season for hilsa fishing in the Ayeyarwady delta from July through August • Juveniles are caught using small-mesh fishing nets	Merayo 2019; Meyer et al., 2020; Merayo et al., 2020

Transboundary fisheries management challenges

Transboundary fishing, especially on the high seas, has emerged as one of the global challenges of sustainable fisheries management. However, the management of transboundary fisheries through cooperation may face many challenges due to transboundary water pollution, lack of coordination between coastal states, less priority given to fisheries resources as areas of cooperation, inadvertent transgressions etc.

Lack of coordination among the countries

The management of transboundary hilsa stock in the Northern Bay of Bengal is particularly challenging due to the need for coordination between neighbouring countries. An example of inadequate bilateral coordination and cooperation in the Bay of Bengal can be seen in the construction of the Farakka Barrage in India, which has detrimental effects on Bangladesh in terms of hilsa migration routes, soil salinization, and water salinization (Ortolano et al., 2016). Even though Bangladesh, India, and Myanmar harvest the same stock of hilsa fish, their fishing ban periods differ. The absence of complementarity in the fishing closure season between neighbouring countries forces fishers to cross borders. Every year in October, Bangladesh imposes a 22-day seasonal fishing ban on brood hilsa shad based on the entire moon cycle. The neighbouring Indian State of West Bengal also sets a temporary, seasonal ban on hilsa fishing from September 15 to October 24, five days before and after the full moon (Hossain et al., 2019; Modak, 2021; Rahman et al., 2020). Also, all states on the east coast of India impose a 61-day ban on fishing from April 15 to June 14, while Bangladesh imposes a 65-day ban on all forms of marine fish harvest from May 20 to July 23 each year. Myanmar has a general (non-hilsa-specific) freshwater closure season from May to July but no specified marine closure season. Bangladeshi fishers view the 65-day ban as unfair, especially as fleets from neighbouring countries continue to fish illegally in their waters (Modak, 2021). Such inequalities during periods of prohibition, combined with the scarcity of alternative livelihoods, only reinforce acts of violation. Though Bangladesh has strict enforcement legislation prohibiting hilsa fishing during the breeding season, Myanmar and Indian fishers do not have such laws or regulations. However, such a lack of compatibility between the countries and the lack of forward-thinking attempts affects relations between neighbouring countries, which dictates transboundary cooperation to maintain stocks in the natural environment and maintain sustainable production.

Fisheries are less priority as area of cooperation

Transboundary cooperation in managing shared fish stocks with neighbouring countries becomes more challenging unless the countries equally prioritize fishing as an area of collaboration. Regarding negotiations and implementation, the Indian government has not prioritized fisheries management, particularly hilsa fisheries management, the way Bangladesh has. In this regard, the Bangladesh government has been more forward-thinking in its efforts and has pioneered hilsa protection within its borders compared to India and Myanmar (Modak, 2021). In India, hilsa fisheries management is the responsibility of the state rather than a national responsibility. These circumstances revealed that fishery resources like transboundary hilsa fish management are not a top priority for India and Myanmar when it comes to managing sustainable fisheries through cooperation. The Indian government was not geared up for a blue growth fisheries revolution, and state government budgetary allocations to fisheries were insufficient to secure long-term success (Singh, 2020). As a result, the country's fishing sector is inadequately regulated, while its practices are environmentally detrimental (Singh, 2020). Transboundary fisheries cooperation also appeared less focused on the legal frameworks of these countries. For example, the recently introduced Marine Fisheries Act, 2022, of Bangladesh remains silent on the transboundary fisheries management cooperation (Arif & Karim, 2022). Without a regionally coordinated policy, conservation efforts by a single country may have limited benefits and encourage illegal fishing, overexploitation, and violations of regulations.

Transboundary water pollution

Transboundary pollution, which includes downstream river or ocean pollution from upstream activities or damage to a nation because of the actions of one or more other countries, poses a challenge for shared transboundary resources. Despite numerous efforts, overfishing of juvenile and brood hilsa, siltation, habitat loss, water management projects, and pollution pose threats to hilsa, which can challenge the transboundary management approach. For example, the construction of the Farakka Barrage has undermined the attempts to protect barrier-free spawning migration channels in Bangladesh and its abundance further upstream in India and downstream in Bangladesh (Ahsan et al., 2014; Modak, 2021;). Thus, upstream pollution impacts hilsa spawning and migratory patterns, while silt accumulation in river bottoms obstructs normal migration pathways and water flow. The extent and periodicity of pollution from industrial and domestic wastes in the river also hinder the migration of hilsa, thereby underscoring the need for transboundary cooperation in maintaining sustainable, highly migratory, and straddling fish stocks. There are several other constraints towards transboundary collaboration such as inadequate resources and a lack of dedicated funding. Moreover, fisheries policies primarily focus on revenue generation and increased production, and the science-policy linkage is weak. Pollutants from power plants, ballast water from ships, and increased vessel traffic can threaten the hilsa habitat and upward migration (Hossain, 2020).

Consequences of no transboundary cooperation

One of the main consequences of a lack of transboundary management is Illegal, unreported, and unregulated fishing (IUU). Small-scale fishers from neighbouring countries continue to have unlawful access to each other's sovereign waters for fishing. Such recurrent incidents of fishing trespass result in fishers being arrested and detained (Kadfaq et al., 2012; Bose, 2021). Transgressions by fishers in search of a better catch can setback the transboundary cooperation in managing migratory and straddling fish stock. In addition, incongruence in fishing bans between neighbouring countries leads fishers to fish illegally across maritime borders, disrupting breeding seasons and resulting in overfishing and confrontation with local authorities and fishers (Kadfaq et al., 2012; Bose, 2021). Such incidents endanger fishers' livelihoods, while recurrent incidents undermine relations among the countries and create unconventional security threats, leading to the imposition of punitive measures against individuals accused or convicted. For example, neighbouring fishing trawlers frequently intrude into Bangladeshi waters to catch hilsa, especially during the ban season and are detained by the Bangladesh Navy and Coast Guard (Kadfaq et al., 2012; Bose, 2021). According to the latest report of the arrest incident in December 2020, 13 Indian fishers were detained by the Bangladesh Coast Guard and 100 Bangladeshi fishers were detained in a single prison in West Bengal, India (Bose, 2021). Fishers arrested for trespassing in sovereign maritime zones lose their jobs and spend months in foreign prisons while their cases are pending and those imprisoned face brutal conditions (Bose, 2021). Thus, the arrest and imprisonment of fishers, whether by Bangladesh, India, or Myanmar, increases the suffering of the people, disturbs the general bonhomie between the countries and raises disputes. Due to a lack of transboundary cooperation between countries sharing the same stock, new issues and challenges including national security, resource conflicts, environmental and social justice, intentional or unintentional trespassing, arrest and repatriation, and illegal fishing may arise, thereby posing a threat to sustainability.

Status of transboundary cooperation

Maritime connectivity between Bangladesh and India provides a powerful policy driver for developing a rules-based maritime order in the Bay of Bengal (Hossain & Islam 2019). As India and Bangladesh share 54 rivers, water-sharing agreements have been developed between the two countries, enabling each country to retain and secure all interests in the trade relationship. Despite not being a BOBP-IGO member, Myanmar's involvement in managing the transboundary hilsa conservation action strategy with India and Bangladesh was deemed essential due to its major impact on the fisheries (Dewhurst-Richman et al., 2016).

In addition to some intergovernmental cooperation on fisheries management, several cooperative mechanisms are working at the non-governmental level to increase transboundary collaboration and overcome fisheries management challenges in the common seas. The ongoing intergovernmental initiatives to boost transboundary cooperation between the countries include the Regional Plan of Action on Hilsa Fishery Management (Myanmar-Bangladesh-India), the Chittagong Resolution of 2008, and Regional Co-operation in Fisheries Monitoring, Control, and Surveillance (Bangladesh, India, Maldives-Sri Lanka). Another non-governmental effort to foster transboundary collaboration is citizen dialogues on the hilsa fishery to protect the hilsa and draw clear policy and practice implications (Glaholt & Gonsalves, 2012; Huntjens et al., 2017).

Unsustainable fishing practices, a lack of cooperation and mutual trust among countries, and a lack of technologies have resulted in depletion of fish stocks and illegal trespassing by fishers across national maritime borders. In this scenario, India and Bangladesh signed a Memorandum of Understanding (MoU) on September 6, 2011, for five years of bilateral fisheries cooperation (Ortolano et al., 2016; Hossain and Islam, 2019; Modak, 2021). It also covers hilsa fisheries management (MoU, Article II) but only mentions "training in fish stock assessment" rather than joint exercises for stock assessment. The MoU is supposed to meet annually to discuss issues of mutual interest. However, the Memorandum needs a dedicated budget and a fixed schedule for meetings. The formation of a Joint Fishery Committee (JFC) can aid in the effective and cooperative management of transboundary fisheries resources. It can recommend conservation and management measures, such as catches in the fishing industry, quota allocations, and other specific circumstances for the other coastal state fishery (Zou & Wang, 2020).

Bangladesh and India signed an MoU on 'Blue Economy and Maritime Cooperation in the Bay of Bengal and Indian Ocean Region' on June 6, 2015, which calls for establishing collaborative relations to combat transnational illegal activities at sea (Hossain & Islam, 2019; Bose, 2021). In addition, for the first time, both countries agreed to form a Joint Working Group (JWG) to work on resolving the issue of fishers unintentionally crossing international maritime borders and their repatriation (Bose, 2021). This group will meet to discuss specific issues regarding India and Bangladesh, including the management of hilsa and other transboundary species, collaborative research programs in aquaculture and fisheries, exchange of visits, and skill development of stakeholders (Bose, 2021). Nonetheless, there has been no effort to turn the 'MoU on Blue Economy' into an agreement in the six years since it was signed (Bose, 2021), and it is taking a long time to build suitable protocols for formal communication between government officials in Bangladesh, India, and West Bengal (Ortolano et al., 2016).

Suggestions

The first and foremost step should be to adopt the Ecosystem Approach to Fisheries Management (EAFM), which focuses on long-term fisheries management that encompasses and integrates all factors affecting coastal fisheries productivity (Heenan et al., 2015). EAFM provides a paradigm for fisheries management and aims to develop and manage fisheries to address a wide range of societal needs without compromising the ability of future generations to enjoy all the goods and services provided by marine ecosystems (Modak, 2021). With this holistic approach, contiguous parts of the sea under different tenures will be managed as a unified unit, facilitating cooperation between the two countries in conserving commercially valuable marine species such as transboundary hilsa and retaining the ecosystem healthy (Modak, 2021). In addition, this management approach can address multiple challenges and multi-stakeholder engagement in the use of shared resources.

A transboundary hilsa working group between Bangladesh and Myanmar, similar to India and Bangladesh, could be set up with the approval of the fisheries departments. Furthermore, to enhance cooperation over their shared hilsa shad populations, dialogue programs involving Bangladeshi, and Myanmar's scientists, NGOs, and government officials can be established.

These dialogue programs can lead to combined research and long-term knowledge exchange between Myanmar and Bangladesh and eventually to a united hilsa fisheries management strategy. To best imitate the natural processes in the bay and ecosystem, the two countries, India and Bangladesh, must develop comprehensive water and sediment management strategy (Bose, 2021). The fluidity of the resource and the historical leniency of coastal communities in sharing their fishing waters with surrounding fishers must be considered when considering the severity of penalties established by the Acts for violation.

In the northern Bay of Bengal, a joint declaration (by partnership/neighbouring countries) of protected marine areas holding a common stock can also help protect hilsa (Goswami, 2020). To limit juvenile hilsa capture, bilateral agreements are required to restrict mesh size (not less than 110 mm), common moratorium times, and a decrease in the number of fishing vessels currently operating in the Hilsa fishery. A real-time monitoring system prevents illegal fishing and gives accurate data from the river and marine systems for all countries, enabling the implementation of a 'quota plan' in hilsa fishing. To improve hilsa stock and sustainable management, forming a Joint Science Council or Hilsa Regional Management Expert Group for cross-border management of hilsa fisheries is critical. Priority should be given to long-term management of the hilsa fishery through transboundary cooperation among adjacent nations and digitization of governance at the grassroots level with the participation of fisheries stakeholders. In addition, India and Myanmar must continue to engage with Bangladesh since cooperation will be critical in resolving illegal fishing and crossing borders. In these contexts, transboundary cooperation in managing shared fish stocks and convergence in fishing bans between neighbouring countries is necessary for better fish protection and to reduce cases of ban violations and consequent arrests of transgression.

Conclusion

Shared or straddling fish stocks in the Bay of Bengal are threatened by overfishing, illegal trespassing, and mismanagement, which emphasize the need for transboundary collaboration between Bangladesh, India and Myanmar for conservation and economic benefits. In hilsa stock management, comprehensive country-specific action plans have been formulated in the Bay of Bengal by Bangladesh, India, and Myanmar. Still, the scale of operation among the nations is not uniform. Such inconsistencies in managing hilsa stock between coastal states cause small-scale fishers to illegally access each other's sovereign waters, resulting in illegal fishing and arrest or imprisonment for their strategic location and movement near the border. Therefore, transboundary cooperation between neighbouring countries in managing straddling fish stock is necessary to strengthen fish protection and reduce illegal transgressions and arrests of violators. A complete prohibition of fishing of undersized fish, the establishment of well-targeted temporal and spatial bans, the construction of protected areas in crucial locations, incentives for hilsa fishers, and ecological restoration of hilsa habitats are all advocated for successful transboundary management of the hilsa stock. Implementing EAFM can assist coastal states in cooperating more effectively in managing transboundary fish stocks. This approach is not confined by international borders and allows for more sustainable and profitable fishing. In addition to safeguarding the livelihoods of millions of small-scale fishers, the coastal states should set the way for strong political will and deliberate, cooperative action to protect shared or straddling fish stocks.

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32. Regulatory Framework of Small-Scale Fishers in Bangladesh: Safeguard or Jeopardy?

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Small-scale fishers using seine net in Sonadia Island (Photo: Mahmudul Islam, 2022).

The chapter analyzes the legal and institutional framework for managing small-scale fisheries in Bangladesh. The findings reveal that the overarching institutional framework is embroidered with a paradoxical allocation of business, jurisdictional overlapping, conflict of interests, infirmed coordination and integration mechanism, and fisheries governance. The legal framework is entangled with outworn, scattered, segmented, and widespread non-compliance. The existing legal and institutional framework is not well suited to establish the rights of small-scale fishing people to natural and financial resources. The market chain is controlled by many intermediary groups, which causes a deprivation in income and increases inequality as the hegemony of commercial fishers sidelines small-scale fishers. The chapter recommends the reallocation of business of the Ministry of Fisheries and Livestock. Active participation of the small-scale fisheries in governance and resource management is warranted to minimize commons tragedies.

Introduction

The small-scale fishers of Bangladesh usually live in coastal areas, riverbanks, floodplain banks, *haor*, and lakes and catch fish using traditional knowledge, techniques, and equipment for their livelihood. In Bangladesh, about 17 million people are involved in this sector, representing approximately 11 percent of country's total population (Alam et al., 2021). Furthermore, Sustainable Development Goal (SDG) 14 (i.e., Life Below Water) emphasized the importance of small-scale fisheries. SDGs advocate for small-scale fisheries' access to resources and markets through target 14b. Bangladesh also accepted the aspiration of the 'leaving no one behind' approach to meet SDGs. Hence, this chapter focuses on analyzing the drawbacks of legal and institutional framework embedded in small-scale fisheries and whether they facilitate or make barriers to achieving SDG.

An ordinance and a few rules provide a legal framework for small-scale fisheries, but they are very old and are not appropriately enforced for multiple reasons. On the other hand, the institutional mechanism is not well developed to engage multi-stakeholders and develop coordination among different actors (Islam, 2012; Shamsuzzaman & Islam, 2018). In addition, there are ambiguities in the allocation of business and the parental ministry and departments' roles and responsibilities. The sustainable outreach use of marine fish is capped by several factors, such as a lack of knowledge of the potential resources, inadequate mapping of the resources, and erroneous institutional and legal frameworks (Shamsuzzaman et al., 2017a). The legal and institutional framework reform can facilitate right of small-scale fisheries to natural resources. The reform is indispensable for enhancing small-scale fisheries and sustainable extraction of marine living resources. Hence, this chapter proposes solutions to improve small-scale fisheries' rights to resources.

Rebuffed legal protection

Small-scale fisheries, sustainability and conservation are governed by several laws (Table 1). Small-scale fisheries are also managed under the same legal frameworks. Rahman (2021) reported that only a few policies regulate Bangladesh's marine and coastal resources, which are too old. For example, the 'Marine Fisheries Ordinance, 1983' stressed establishing marine reserves. The 'Protection and Conservation of Fish Rules, 1985' was framed to fulfill that ordinance's objectives. The rules have also emphasized conservation. The Marine Fisheries Ordinance of 1983 is now replaced with The Marine Fisheries Act of 2020. The Marine Fisheries Act of 2020 distinguishes between artisanal and industrial fishing. The 2020 Act provides a separate 'license' system for artisanal fishers operating fishing vessels with a capacity of 15 tonnes or less. The 'Bangladesh Merchant Shipping Ordinance, 1983' sketched the registration procedures of marine vessels. 'Bangladesh Oceanographic Research Institute Act, 2015' was enacted to conduct oceanography research. The 'Environment Conservation Act, 1995' was depicted to preserve biodiversity through ecosystem management and controlling pollution. This act has a provision declaring 'ecologically critical areas (ECAs).' The 'Department of Environment' was established and legitimized by this act.

Table 1. lists major and associated laws for regulating small-scale fisheries in Bangladesh.

SL	Major/associated laws	Main features	Empowered ministry/division
1	Marine Fisheries Act, 2020	The license system for small-scale fisheries stressed establishing marine reserves	Ministry of Fisheries and Livestock (MOFL)
2	Protection and Conservation of Fish Rules, 1985	Fulfilling the ordinance's overall objectives through conservation initiatives	MOFL
3	Bangladesh Merchant Shipping Ordinance, 1983	Sketched the registration procedures of marine vessels	Ministry of Shipping (MOS)
4	Bangladesh Oceanographic Research Institute Act, 2015	Carrying out research on oceanography	Ministry of Science and Technology (MOST)
5	Environment Conservation Act, 1995	Biodiversity conservation through ecosystem management and pollution control	Ministry of Environment, Forest and Climate Change (MOEFCC)
6	Bangladesh Environment Conservation (Amendment) Act, 2010	Made clarity in the definition of an ecosystem, ecologically critical area, and wetland	MOEFCC
7	The Ecologically Critical Area Management Rules, 2016	Formed various committees starting from national to grass root levels incorporating diverse stakeholders to manage ecologically critical areas	MOEFCC
8	Bangladesh Environment Court Act, 2010	Ensuring justice against any sort of environmental and social damage	MOEFCC
9	Bangladesh Biodiversity Act, 2017	Achieving three goals of the Convention on Biological Diversity (CBD)	MOEFCC
10	Wildlife (Conservation and Security) Act, 2012	Focused on wildlife and conservation	MOEFCC
11	Disaster Management Act, 2012	Legitimized the organizational structure of disaster management	Ministry of Disaster Management and Relief (MODMR)
12	Weather Act (Abhawa Ain), 2018	Entrusted Bangladesh Meteorological Department to prepare a strategic action plan incorporating the guidelines of the Intergovernmental Oceanographic Commission (IOC) and the International Maritime Organization (IMO)	Ministry of Defense (MOD)
13	Coast Guard Act, 2016	Redefined the functions, jurisdictions, and code of conduct of the Bangladesh Coast Guard	Internal Security Division (ISD)

The 'Bangladesh Environment Conservation (Amendment) Act, 2010' clarified the definition of an ecosystem, ecologically critical area, and wetland. 'The Ecologically Critical Area Management Rules 2016' were approved consequently. These rules formed various committees from national to grass root levels incorporating diverse stakeholders. The 'Bangladesh Environment Court Act, 2010' was enacted to ensure justice against any environmental and social damage. The 'Bangladesh Biodiversity Act, 2017' focused on achieving three goals of 'The Convention on Biological Diversity (CBD). The 'Wildlife (Conservation and Security) Act, 2012' explained different terminology related to forest biodiversity, especially wildlife, and conservation. The Forest Department is entitled to conserve and manage the country's biodiversity. The 'Weather Act (*Abhawa Ain*), 2018' entrusted 'The Bangladesh Meteorological Department' to prepare a strategic action plan incorporating the guidelines of the 'Intergovernmental Oceanographic Commission (IOC)' and the 'International Maritime Organization (IMO).' The 'Coast Guard Act, 2016' was ratified to define the functions, jurisdictions, and code of conduct of the 'Bangladesh Coast Guard.' The 'Disaster Management Act, 2012' legitimized the organizational structure of disaster management. From the above discussion, it is clear that no existing law was enacted to provide a guideline for small-scale fisheries and acknowledge their rights to resources.

Webby institutional arrangements

The institutional framework for regulating small-scale fisheries is characterized by a complex arrangement involving a mix of formal and informal institutions like public departments, non-government organizations, private sectors, and communities (Shamsuzzaman & Islam, 2018). The main government organization, i.e., the 'Ministry of Fisheries and Livestock,' hardly pays attention to small-scale fisheries in its business allocation. Moreover, not a single word indicating marine fishery is found in the business allocation of the 'Ministry of Environment, Forest and Climate Change' (Rahman, 2021a). However, it plays a crucial role in regulating fisheries in the mangroves, wetlands, coastal forest areas, and marine protected areas, for instance, the 'Swatch of no Ground.' Consequently, the fishing communities in the *Sundarbans* mangrove areas hang around a double-edged sword of conservation and livelihood protection. As per mandates defined by the laws, the Department of Environment maintains water quality on the fishing grounds. Forest Department works on behalf of the sister organization The Department of Environment, which has no premises and staff at the grassroots level (Rahman, 2021). Consequently, foresters are the key actors in regulating small-scale fisheries in Bangladesh. The Bangladesh Fisheries Research Institute (BFRI) conducts research on both freshwater and marine fisheries, but it is incapable of carrying out need-based research for small-scale fisheries. The newly established Oceanographic Research Institute has started walking and is limping with underdeveloped legs. Fragmented laws and ambiguous mandates of different ministries and divisions have caused overlapping jurisdiction, followed by conflicts of interest and a lack of cohesion.

The conflict between security measures and insecurity

Security and law enforcement are one of the grey areas and crucial challenges for small-scale fisheries in Bangladesh. Piracy is considered a life-threatening concern for small-scale fisheries. Often the local criminal gangs kidnap and kill small-scale fishers. The foreign pirates attack suddenly to loot fish and other valuable items. Many law-enforcing agencies like River Police, Bangladesh Coast Guard, Rapid Action Battalion, Forest Guard, and Bangladesh Navy work to ensure security. However, different studies showed that criminals remain untouched in many cases due to a lack of coordination and a proactive approach (Alam et al., 2021). Simultaneously, small-scale fishers are mostly unable to reach and gain attention from these agencies or cannot determine the focal point or coordinating agency primarily responsible for controlling maritime crime.

The hegemony of the intermediaries in the market chain

The formal banking channel is not interested in providing loans to small-scale fishers. Therefore, small-scale fishers depend on *Dadan* (local credit) and *Mahajan* (local moneylenders). Small-scale fishers pay 80-120 percent interest to *Mahajan* under this *Dadan* system (Rahman & Alam, 2020; Rahman 2021c). There are seven classes of intermediaries in the fish market, including collector, *majhi* (the captain of the boat), *Chhoto Mahajan* (small moneylender), *Boro Mahajan* (big moneylender), *Aratdars* (stocker and preserver), wholesaler, and retailer. Small-scale fishers receive only 30 percent of retail prices (Alam et al., 2021). In the *Dadan* system, the fishers are obliged to sell fish to the *Mahajan,* who provide the loan.

Commons tragedy

Ordinary people in Bangladesh cannot seek environmental justice directly (Rahman, 2021b). Consequently, small-scale fishers are deprived of various inherent rights. The commercial fishers occupy small-scale fisheries' fishing grounds due to weak monitoring, control, and surveillance system. It is reported that the fish stock near the shore is declining sharply due to the incremental incursion of commercial fishers. Likewise, most small-scale fishers live on government-owned land, locally known as '*khas land*.' In remote areas, they are oftentimes deprived of medical facilities, electricity, life support equipment, and communication devices. The *dadon* system, market intermediaries, and commercial fishers spawn the tragedy of small-scale fisheries.

What can be done?

Fisheries laws should be updated by merging scattered and fragmented laws. Before the amendment of the existing laws or enacting new laws, the current laws' enforcement should be ensured. Everybody's business turns into nobody's business, and many players can make a game messy. The

Ministry of Fisheries and Livestock's allocation of business should be revised to include its prominent role in regulating small-scale fisheries. On the other hand, the foresters' role should be confined to terrestrial ecosystems. The business reallocation can facilitate establishing fisheries governance. The Ministry of Fisheries and Livestock can develop spatial and temporal governance with the Bangladesh Navy and Bangladesh Coast Guard's help. The active participation of small-scale fishers in coastal governance should be legitimized to develop polycentric governance.

Monitoring, control, and surveillance systems should be activated and modernized to control commercial fishers' hegemony over small-scale fishers. SDG target 14b stresses correcting the market chain and clearing all obstacles to ensure food security. Department of Fisheries should work closely with the Trading Corporation of Bangladesh (TCB) to get rid of the fish market chain intermediaries. The marketing system and fish landing stations should be modernized with better post-harvest processing. The state banks should provide loans to stop the monopoly business of the local lenders (*Mahajan*). The Department of Fisheries should be equipped with the necessary logistics and workforce at the operational level.

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33. Thinking about Justice and Equity in Bangladesh's Fisheries: Where to Start?

Md. Kutub Uddin, Sagar Seba

Fishers living on boats are among the most marginalized group (Photo: Md. Kutub Uddin, 2022).

Conservation of fisheries in Bangladesh has become heavy-handed and militarized, while poverty in fishing communities remains unmitigated.

Systemic economic and environmental injustices to peasants and fishers date back to the British colonial takeover of Bengal when the administration de-commonized the aquatic commons. In the post-empire era, we are yet to see any significant efforts by independent national governments to address distributive and procedural injustice to artisanal fishers. Open-water fisheries have been shrinking for decades due to various anthropogenic pressures. To date, no efforts have been made to restore and conserve fisheries' habitats or to address external threats to fisheries. Instead, the government prioritized compliance with fishing laws and expanding aquaculture while the open-water fisheries have been shrinking. However, a few measures (such as open-access fisheries in the rivers) in the past decades could have brought changes. Still, those measures have largely failed in the absence of appropriate recognition of the customary tenures. In this context, the government and stakeholders must consider the well-being of right-holder fishing communities an integral part of sustainability in fisheries. Equity and justice for fishers should be the government's top priority.

Introduction

On March 16th, 2021, water police opened fire on a small fishing boat and killed a young fisherman named Mohammad Masud in the Meghna River. The shots were fired in the river north of Chandpur, the town famous for its well-known trading center of *ilish* (anglicized as *hilsa*) —Bangladesh's most prized fish. Twenty-four-year-old Mr. Masud and his fellow fishers went fishing during a ban season imposed by the government to protect juvenile ilish. Police said they opened fire in self-defense after the fishers threw brick chips and attacked the police with sticks (United News of Bangladesh, 2021). When a local journalist went to the home of the deceased Mr. Masud, he found that the family of the poor fisher did not have even a "handful of rice" to feed themselves (Hossain, 2021).

Official estimates tell us that the catch in mixed-species open-water fisheries has increased throughout the last decade. Catch in the ilish fishery is also rising; this is the largest fishery in volume and economic value. Still, fishing families like Mr. Masud's are either ultra-poor or poor. Fishers go hungry during fishing ban seasons. Armed police, coast guard, and navy patrol the fishing grounds to enforce ban seasons. The air force conducted aerial surveillance in recent years (Ministry of Defence, 2018). During the ban season in 2020, at least 5,533 fishers were jailed (Bangladesh Sangbad Sangstha, 2020). How did conservation in Bangladesh become so heavy-handed and militarized while the poverty in fishing communities is still proverbial?

Economic and environmental injustices

Systematic economic and environmental injustices to peasants and fishers date back to the British colonial takeover of Bengal. Exploitation and draining of resources were the main goals of the British colonial authorities. The British East India Company, and later the British monarchy, used diverse legal, financial, and trade mechanisms (Mukherjee, 2010) to industrialize England at the expense of Bengal's local economy and society. To do that, the colonizers uprooted the Indigenous and customary rights to land and environmental commons. In addition, the colonial administration took control of water bodies and aquatic commons.

The British East India Company established its new land administration and revenue regime through the Permanent Settlement Act of 1793. It permanently transferred all lands as estates to a newly created small group of Zamindars. Rivers and other open water bodies in or adjacent to such estates were now effectively privatized and part of the estates of these Zamindars. Unlike the previous local revenue collector *Zamindars*, these new Zamindars had legal proprietorship over the land and virtually no oversight by the civil administration. Without proprietorship and right to public access, the fishers had to pay high rents to the Zamindars and their suzerainty. The absence of tenure rights also diminished the environmental stewardship of fishers. Later, the colonial administration introduced more legal instruments (Singh & Gupta, 2017), and ultimately there was no public-access fishery in inland

and inshore waters. All rivers and open water bodies were divided among Zamindars as their *jolmahal* (water estate). Only the offshore areas in the Bay of Bengal were an exception. In marine fisheries, the main priority of colonial administration was securing new supplies for the urban center of Kolkata (Jenkins, 1911; 1938), the main seat of the British Indian colony.

The empire is now long gone. But we are yet to see any significant efforts by the independent national governments to address distributive and procedural injustice to artisanal fishers. When the British empire was forced out, the newly elected democratic government abolished the colonial Zamindar system and reformed land tenures by enacting a new law, the East Bengal State Acquisition and Tenancy Act, 1950. Successive governments have changed land laws to alter provisions related to existing landowners (Jabbar, 1978). However, they must still fully implement fundamental and direct tenure reforms to benefit landless people like traditional fishers. There has yet to be a process to restore fishers' Indigenous and customary tenure rights. Instead, the national land and revenue administrations took over all *jolmahals* in rivers and other water bodies previously owned by colonial Zamindars. The officially stated policy of authorities is to lease out *jolmahals* to fishers. However, the government does not invest public funds in fisheries cooperatives, and fishers need access to private investment from the formal financial sector. Executive agencies that are responsible for leasing *jolmahal* need more accountability and transparency. Consequently, in almost all cases, the fishing rights in *jolmahals* have always been bought by non-fisher investors.

The rent-seeking governance regime in open water fisheries has been continued for decades aggravating distributive injustices to traditional subsistence and artisanal fishers. Sustaining the fisheries and fishing habitats is not a priority of the lessee or the lessor agencies in the government. The fishers have been working as labourers under lessees who own small-scale commercial fishing units or earn extraordinarily little as artisanal fishers after paying rent. In 1986, the national fisheries agency tried to use the new fisheries improvement policy to address access issues of subsistence and artisanal fishers. The fisheries agency started to take control of three hundred *jolmahals* from the land administration. The officially stated goal was to begin leasing those *jolmahals* out to 'genuine' fishers and introduce a fishing license for them. However, the fisheries agency failed to achieve its goals. Later in 1995, the government abolished all *jolmahals* in the rivers and streams and effectively introduced riverine open-access fisheries (Thompson & Hossain, 1998). However, other *jolmahals* in floodplains and other wetlands are still in force and being leased out to date.

Abolishing private-access fisheries in the rivers could have been an opportunity to start working for equity and justice in artisanal fisheries. Newly introduced open-access fisheries in the rivers partially improved access for riverine fishers. However, legal reforms have yet to recognize the customary tenures of traditional artisanal fishers. The government needs to invest in artisanal fishing communities to enable them to secure a fair share of the income from fisheries. As a result, the fishers have yet to use that window of opportunity fully. Like marine areas—where fishing was open access from the beginning—structural barriers to equity and justice rooted in tenures, local political economy, and the state's economic programs remained the same in riverine fisheries. So, the rural poor have benefited little from riverine open-access fisheries.

The peasants and fishing communities did not stand a chance against regional and national policy priorities (such as World Bank-led Structural Adjustment Programs and Flood Action Plans) that resulted in shrinking and degraded habitats of open water fisheries. Open water fisheries have been shrinking for decades due to various pressures. Reduced water flow in transboundary rivers due to dams, barrages, and water diversion in the upstream countries also significantly impacted the aquatic ecosystems in Bangladesh. Industrial and agricultural runoffs have polluted the water and affected water quality. Changes in land use, including intensive farming, flood control measures, water infrastructure, draining for agriculture and land development, and encroachment, drastically reduced and degraded the habitats of open water fisheries (Ali, 1997). Mainly, water engineering, including embankments, impacted fish biodiversity, population, and unit value of the catch (Halls, 1997).

No efforts have been made to restore and conserve fisheries' habitats, to stop or mitigate the impacts of those external threats to fisheries. Instead, the government prioritized expanding aquaculture in the wake of shrinking open-water fisheries. Wealthy landowners in rural areas have benefited from profitable aquaculture expansion that is often responsible for reducing and degrading habitats of open water fisheries in Bangladesh. In the late nineties, Bangladesh was experiencing a decline in the total estimated catch in open water fisheries, including the single largest contributor among the species–ilish–none of these factors were prioritized to address in fisheries management plans. For instance, the Hilsa Fisheries Management Action Plan (HFMAP) in 2003 was mainly used to establish seasonal no-take zones and ban seasons. The management plan started with a target to protect *jatka* (juvenile ilish less than 25 cm in size).

Several top-down interventions have been gradually placed since 2003 to increase the ilish catch. These interventions include spatial and temporal restrictions on fishing, limitations on the use of fishing gears and size of ilish at the catch, regulations for fishing vessels, and distributing food grains as rations among a minimal number of fishers during the fishing-ban season. For implementing the conservation measures under the HFMAP, the most notable temporal interventions for the conservation of ilish are two different fishing ban seasons; one to protect the brood ilish and another to protect the *jatka*. To protect the brood (mature and about to spawn), there is a 22-day long ban on catching, carrying, transporting, offering, selling, exporting, or possessing ilish fishes in the country; days of this ban period is evenly divided before and after the first full moon of Bengali month of Aswin (usually in October). The second ban is to protect jatka; the ban is for seven months, from November 1st to May 31st every year; during this time, catching, carrying, and selling of *jatka* is prohibited.

The government relies on heavy-handed enforcement to force subsistence and artisanal fishers to comply with these interventions. There are measures in place to ration food-grain through the Vulnerable Group Feeding (VGF) program since 2004-2005 fiscal and support for Alternative Income Generation Activities (AIGA) from 2009-2010 during fishing ban periods (Haldar &

Ali, 2014); but still, the authority needs to implement strict enforcement to force the fishers to comply. For instance, from 2011-2012 to the 2013-2014 fiscal year, non-judicial *summary courts* embedded with law enforcement agencies (known as 'mobile courts') imposed 2,462 prison sentences and fined USD 106,509 to law-breaking fisherfolks under *jatka* and brood ilish conservation activities (Islam et al., 2016). All seasonal no-take zones of ilish, aka sanctuaries, are in the Ganges and Meghna Rivers systems and coastal near-shore waters of the Bay of Bengal. There are two declared Marine Protected Areas in offshore waters to protect megafauna species of conservation interest. Planning and designation of these riverine and marine protected areas were done in a way that did not adequately consider social outcomes. Consequently, these protected areas are underperforming in "effectiveness and social equity" (Islam, 2021).

Most of the factors (Islam, 2011) behind the endemic and proverbial poverty of fishers in Bangladesh can be traced back to the absence of distributive and procedural justice for fishers. Nevertheless, the erratic efforts were hardly participatory from the beginning of state interventions to govern and manage open water fisheries (Ali, 1997). Over two decades later, that 'hardly participatory' approach in fisheries governance has morphed into heavy-handed top-down enforcement-based, increasingly militarized conservation. The government does not see the well-being of fishing communities as an integral part of sustainability in fisheries. Instead, the authorities focus on increasing the catch volume (or 'production,' as the government says) at any price. Equity and justice for fishers are not a priority of the government as per the existing fisheries policies and plans, such as the National Fisheries Policy 1988, the Marine Fisheries Act 2020, the Eighth Five Year Plan, and the Workplan for Marine Fisheries Resources Management. As described by Ali (1997), the threats to open-water fisheries are largely unmitigated and still exacerbate the problems in artisanal fisheries. On the other hand, the old pattern of ownership over the means of fishing operations, capital, boats and gears, and other support equipment and infrastructure continues today, both in inland and marine fisheries. Moreover, now, new uses of inland and marine waters in Bangladesh are creating new threats to artisanal fishers.

These new uses include unregulated navigation and shipping, sand dredging, rapidly increasing unsustainable economic activity in coastal and marine areas, coastal roads and other mega-infrastructures, military installments, ports, and power plants.

Fishery improvement and enhancement projects failed to remove structural barriers to procedural and distributive justice despite external threats and systematic deprivation of land rights and tenures of artisanal fishers. For more than a decade, I have closely observed Bangladesh's politics and natural resources governance. Clearly, the rural poor, whose lives and livelihoods are most intricately related to open-water fisheries, have very few meaningful democratic ways to change the state's economic programs and development priorities to change this course. But still, justice in artisanal fisheries has yet to be widely discussed on the national level. For instance, civil society groups are not concerned that fishers are being arrested and jailed after summary trials during fishing ban seasons (TROSA, 2018).

Where to start?

Late in 2020, I facilitated a series of dialogues about equity and justice in Bangladesh's fisheries. *OXFAM in Bangladesh* organized the events as part of the Transboundary Rivers of South Asia (TROSA) program. Many stakeholders —fishers, fisheries managers, fisheries practitioners in NGOs, leaders of civil society organizations, environmental NGOs, members of academia, journalists, and other communicators—participated in the events. Due to public health concerns amid the ongoing COVID-19 pandemic, we hosted the events online and the number of participants was insufficient to represent all stakeholders in fisheries adequately. Fisheries are only sustainable when the well-being of fishing communities is guaranteed; small-scale fisheries stakeholders are now aware of that. However, stakeholders are yet to determine how they can influence related policies to deliver environmental justice for artisanal fishers. In line with those discussions, I share my observations about scenarios in Bangladesh's small-scale fisheries. These observations will help stakeholders willing to engage in policy advocacy for equity and justice for artisanal fishers.

The main strength of fisheries in Bangladesh is small-scale artisanal fishing. Annually, the artisanal fishers bring most of the catch. And these artisanal fishers in Bangladesh are clear-eyed about what must be changed to remove structural barriers to equity and justice in fisheries. The colonialist British administration de-commonized open-water fishery habitats. And the process of decolonizing water and fisheries governance is yet to run its' course. The land reform that started with the East Bengal State Acquisition and Tenancy Act of 1950 largely excluded restoring customary tenures of traditional artisanal fishers. Abolishing riverine *jolmahals* in 1995 did not protect the exclusive rights of traditional artisanal fishers. Consequently, Bangladesh's existing water and fisheries governance regime does not recognize traditional artisanal fishers' customary tenure rights or does not accommodate customary fisheries governance practices.

Influential actors in Bangladesh's development and conservation sectors consider small-scale fisheries a classic example of the *tragedy of the commons*. Unfortunately, the fundamental problems with colonial water and fisheries governance and tenure rights are generally not acknowledged. Instead, the dominant narrative is centered on the assumption that small-scale fisheries are challenging to manage because of data limitations. This narrative also uses *wicked problems* of small-scale fisheries as justifications for prioritizing intensive aquaculture (often by encroaching open-water fishery habitats) as an alternative to open-water fisheries. Many small-scale fisheries researchers and practitioners in Bangladesh still believe in the debunked myth of the 'tragedy of the commons.' Many often use this narrative to undermine any discussion about the necessity of equity and justice in fisheries. Discussing the futility, irrelevance, and racist roots of *the tragedy of the commons* myth is something we should do more.

The supposed lack of *data* should not be a massive challenge either. Western science is not the only system of knowing. Despite external adversity and the absence of the policy-support, a small number of traditional artisanal fishing communities still use local ecological knowledge and wisdom for effective and ecologically sustainable fishing. A few cooperatives of traditional fishers are still functioning, even if limited in scope. But fishers' knowledge and customary governance practices are poorly documented and not reflected in fisheries governance. Facilitating inter-generational learning among fishing communities is also not happening. Positive changes in policy framework and tenures will enable many other fishing communities to revive their Indigenous and local fisheries governance systems.

At least half of the people in small-scale fisheries are women. Particularly women are leading shore support in fishing, post-harvest, and processing activities. In the post-harvest sector, particularly in fish-drying yards and shrimp processing plants, women fish workers work in hazardous conditions with slave wages risking their health. There is a significant number of women fishers too. But women are not acknowledged as a part of small-scale fisheries in the national public sphere. The government, NGOs, CSOs, and the media exclude women fishers from conversations on fisheries.

Fishers think they are not getting a fair share of income from the river fisheries. The lion's share of the fisheries sector's income goes to the traders because they own the capital, and the fisherfolks need to borrow from them to finance fishing operations. Traditional artisanal fishers say they have valid grievances about corruption in distributing food-grain rations for fishers during fishing ban seasons. But in final consideration, they prefer public investment to build and own boats and gears and self-finance fishing operations. Traditional fishers want to abolish private-access fishing and reform open-access fisheries to secure the exclusive fishing rights of artisanal fishing communities. On the other hand, fishers who work as labourers in small-scale commercial fisheries want good job opportunities. Because, to begin with, they are not formally recognized as labourers and are not employed as per the labour laws. But these opinions of fishers are rarely heard in relevant forums as almost all the time, people who are not genuine traditional and artisanal fishers get invited to participate in such discussions related to fisheries.

There is virtually no representation of traditional artisanal fishers in fisheries governance and management institutions or processes run by the state or the NGOs. Small-scale commercial fishers and fish workers are not represented in small-scale fisheries associations. Small-scale fisheries associations are led by and consist of owners of fishing boats and businesses. Structurally, it is nearly impossible for artisanal fishers to participate in the existing fisheries governance regime. Ensuring the inclusion of fishers in policy advocacy programs run by non-government actors for more just and equitable governance is also tricky. The reason behind this is because programs by both government and non-government organizations are designed in a way that, in the long-term, is only suitable for local political leaders, informal moneylenders, fish traders, and owners of commercial fishing units to participate. Traditional and small-scale commercial fishers lack organizing capacity due to poor economic situations and political powerlessness. Hence, the fishers need to be enabled to organize at a minimum level necessary for representation.

The public agencies responsible for water, fisheries, and wildlife management are yet to take equity and justice for small-scale fishers seriously. For instance, the fisheries agency – the Department of Fisheries – does not have any policy framework, capacity, or resources to ensure the participation of artisanal fishers in fisheries policy-making. The 'production volume' is the only indicator of success for the Department of Fisheries. Environmental justice is not a mandate for the department, and it has no activity designed to ensure equity and inclusion in fisheries. The fisheries agency is heavily focused on aquaculture expansion. Most activities with conservation components are concentrated on the ilish fishery and constrained by project-based time and limited resources. Fishers say the stories of increased income of artisanal fishers due to ilish conservation needs to be more evidence-based. Because of inflation and the rising cost of fishing trips associated with fuel, engine, boat building, and fishing gear, the net income of fishing families still needs to grow in the best-case scenario. The existing temporal measures for ilish conservation did not consider the diversity of fishing gear and indiscriminately ban all fishing gear during ban season even if those gears are not harmful to juvenile ilish. Even after rising catch effort, if individual fishing units can catch more fish (ilish, for instance) than before, that means less income. The income distribution in fisheries has stayed the same and, in many cases, is skewed against the artisanal fishers.

These are my observations as a practitioner. I believe it is necessary to start thinking about environmental justice in Bangladesh's small-scale fisheries. A better understanding of the current scenario in Bangladesh's small-scale fisheries is a prerequisite for finding the most suitable leverages for stakeholders to push for changes.

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About the author

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34. Securing a Just Space: Positioning Small-Scale Fisheries in Marine Spatial Planning of Bangladesh

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Artisanal fishing boats anchored in near the Inani beach of southeastern coast of Bangladesh (Photo: Mahmudul Islam, 2022).

This chapter explores the current practices of Marine Spatial Planning with the rest to small-scale fisheries and calls for a just and equitable space for traditional small-scale coastal fishers, one of the oldest users of the marine space in Bangladesh. For hundreds of years, millions of traditional fishers, including both men and women, have been using marine space and resources for sustaining their livelihoods and income while also making contribution to the national economy. They also use coastal beaches for fish landing and processing activities such as fish drying. Thus, they are legitimate users of coastal and marine spaces for generations and hold the rights and tenure to access and use marine space and resources. Their tenure rights, therefore, are equivalent to an entitlement of land that can be sold or transferred to the next generation. Blue Economy and Blue Growth initiatives see the ocean as the new economic frontier, thus encouraging more use of ocean resources for different economic activities. Various Marine spatial planning (MSP) activities are underway, particularly in the Bay of Bengal towards promoting more extensive and commercial activities. However, small-scale fishers are socio-economically marginalized and lack a voice, for their rights are not positioned to be considered as an equal partner. In this context, small-scale fishers may face difficulties in safeguarding and securing their fishing space and rights against the that are being promoted. This situation calls for an urgent need to secure a just and equitable space for small-scale fishers in MSP of the Bay of Bengal. This call is also aligned with the United Nation's Sustainable Development Goals (SDG). Treating small-scale fishers equitably and fairly as legitimate users of coastal and marine space is crucial towards supporting sustainable development. Neglecting them will undermine the progress towards achieving SDGs by 2030.

Introduction

Both living and non-living resources of the Bay of Bengal can significantly contribute to Bangladesh's economy and the livelihoods and well-being of its population. Particularly in light of the International Tribunal for the Law of the Sea (ITLOS) decision on the Bangladesh-Myanmar maritime boundary in 2012 and the decision of the United Nations Convention on the Law of the Sea (UNCLOS) Arbitral Tribunal on the India-Bangladesh maritime boundary in 2014, Bangladesh has sovereign rights on more than 118,813 km^2 of 200-nautical mile Exclusive Economic Zone (EEZ). This area, as well as the continental shelf up to 154 nautical miles from the coast, provides habitats for diverse living and non-living resources (MoFA, 2014).

The Blue Economy is a new emerging economic growth concept based on the sustainable use of ocean resources through technological inputs to improve livelihoods and meet rising job demands while also protecting the environment. Globally, rational use and governance of marine resources have attracted unprecedented attention in recent years, as evident by the United Nation's declaration of the Decade of Ocean Science for Sustainable Development (2021-2030). Simultaneously, in recent years, ocean governance and Blue Economy have also attracted significant attention from the policymakers in Bangladesh (Islam & Shamsuddoha, 2018). As a result, the Bangladesh government has established an inter-ministerial coordination unit referred to as 'Blue Economy Cell' to oversee the implementation of Blue Economy (Sarker et al., 2018).

Marine and coastal zones are not empty spaces for the unchecked implementation of any development plan but an arena for activities for multiple stakeholders who often compete and conflict to ensure their interests. In the absence of rational management initiatives, unorganized anthropogenic activities and unsustainable resource exploitation endanger the long-term sustainability of marine resources and habitats (Islam & Shamsuddoha, 2018; Roy et al., 2022). In this context, MSP emerged in the 1980s as a systematic process for managing and using marine resources through a spatial and integrated plan among multiple stakeholders for long-term use and development (Day, 2002). MSP can be defined as a "*public process of analyzing and allocating the spatial and temporal distribution of human activities in marine areas to achieve ecological, economic and social objectives that are usually specified through a political process*" (Ehler & Douvere, 2009, p.18).

Small-scale fisheries are a significant stakeholder group in marine space, contributing to the national economy while also promoting the socioeconomic well-being of impoverished coastal fishing communities. Small-scale fisheries employ approximately 1.5 million people in Bangladesh, with an additional 10 million living in households that indirectly depend on fisheries. In particular, small-scale fisheries in the Bay of Bengal account for approximately 95 percent of total marine fish production in Bangladesh (DoF, 2019). Among fish species, hilsa shad (*Tenualosa ilisha*) is the largest single fishery in Bangladesh, accounting for approximately 16.4 percent of total fish production. The hilsa fishery merely has a total annual value of USD 1.3 billion, accounting for more than 1 percent of Bangladesh's total GDP and directly and indirectly employing approximately 2.5 million people (DoF, 2019). Thus, small-scale fisheries are too large to ignore in any management and development plan, including MSP in the Bay of Bengal. Therefore, small-scale fishers need to consider equal and just partners in MSP. They are the oldest users of coastal and marine zones and associated landscapes and should be considered equal partners. The SDG 14b on Life Under Water is also aligned with this goal, as it urges the governments to secure access to resources and markets for small-scale fishers.

MSP activities in Bangladesh

Bangladesh is still in an early stage of MSP development. Among several phases the country is now advancing the second phase — Analysis for Planning (Frazão-Santos et al., 2019). As existing marine conservation legislative framework does not mandate MSP, there is also a lack of dedicated provisions for MSP development although legal support is critical to the development of MSP (Sarker et al., 2018). Nonetheless, several important legislations exist in relation to conservation of the maritime environment more broadly. These include Territorial Waters and Maritime Zones Act of 1974 and the associated regulations of 1977, the Environment Conservation Act of 1995, the Environment Conservation Rules of 1997, and the Biodiversity Act of 2017 are all important pieces of (Islam et al., 2017). In particular, the Territorial Waters and Maritime Zones Act of 1974 requires conservation measures to be implemented in 'Reservation zones' (areas) within the EEZ to protect the sea's living resources from indiscriminate exploitation, depletion, or annihilation. These zones are defined by the Maritime Zones Rules (Sarker et al., 2018). The primary goal of the Environment Act and Environment Rules are to reduce and regulate pollution in the environment although there are no specific rules for marine conservation in these Acts. There is a significant potential for expanding these existing environmental conservation laws to include both marine environment conservation and MSP development (Islam et al., 2017; Sarker et al., 2018). The Department of Environment is well positioned to lead and shape these adjustments and the expansion of MSP (Sarker et al., 2018). The Biodiversity Act emphasizes the identification of biodiversity heritage site and provide guideline for management of biodiversity both in terrestrial, aquatic or marine environment but contains no provisions related to marine biodiversity conservation; however, it does contain several regulations relevant to protecting marine biodiversity and developing MSP in Bangladesh (Sarker et al., 2018). The newly enacted Marine Fisheries Act of 2020 (which repealed and replaced the Marine Fisheries Ordinance, 1983) has provisions for establishing mariculture zones to enhance blue growth. Although mariculture is a key area coming under MSP, there is no provisions in the new Fisheries Act for the protection of the marine environment. Particularly, the Act does not recognize the need for consulting local communities such as the small-scale fishing communities) who are likely to be affected by expanding mariculture activities (Al Arif & Karim, 2022).

The marine space in the northern Bay of Bengal is becoming a busy sea space for multitude of maritime activities, which will likely increase further in the near future. In recognition of this, the government established a Blue Economy Cell within the Energy and Mineral Resources Division

(EMRD) of the Ministry of Power, Energy and Mineral Resources to explore, conserve, and manage natural and mineral resources in Bangladeshi territory of the Bay of Bengal. The cell is tasked with a range of activities, including collecting saltwater fish resources, exploring hydrocarbon resources or fossil fuels, and researching tourism opportunities (Sarker et al., 2018; Roy et al., 2022). However, rapidly expanding maritime activities require a full-fledged maritime institution for overseeing all maritime activities. These activities range from commerce and trade (e.g., seaport, beach and recreation, passenger traffic route, commercial shipping corridor, anchoring, and mooring sites, ship-breaking yards, and offshore Liquid Natural Gas (LNG) terminals) to living resources harvesting (industrial and artisanal fishing), exaction and use of non-living marine resources (hydrocarbon and other marine minerals), potential for renewable energy (wind, tidal), and sub-marine communication and supply (telecommunication, gas supply, and LNG supply line). In addition, there are conservation related activities such as conservation sites (e.g., critical hilsa fisheries habitat, sanctuaries, marine reserve, marine protected area, ecologically critical area, national parks, wildlife sanctuaries) and preservation of underwater heritage (shipwreck, underwater obstruction) (Roy et al., 2022). With all these maritime activities, small-scale fisheries will likely face intense competition.

Small-scale fisheries in marine space

The 1983 Marine Fisheries Ordinance primarily governed marine fisheries. This law was replaced by the Marine Fisheries Act of 2020, which distinguishes between industrial and artisanal fishing. This Act also made it mandatory for all artisanal fishers to have a license for fishing in the Bay of Bengal. The previous Act permitted small-scale coastal fishers to fish in coastal waters up to a depth of 40 meters at high tide. Additionally, small-scale fishers may utilize the adjacent beach area for fish landing and auxiliary operations. Even while small-scale coastal fishers have historically had unrestricted access to fisheries resources, this access is now at risk due to expanding coastal economic activities.

Small-scale coastal fishers operate a range of fishing gear and crafts in the Bay of Bengal below the 40-meter depth. Currently, a 32,440 km^2 area in the Bay, from the coast to 40 m depth are open to approximately 67,669 unlicensed fishing boats, with approximately 51 percent being non-motorized (Shamsuzzaman et al., 2017). Fish resources are extracted in three stages in Bangladeshi marine waters: (1) up to 40 m in depth from the coastline where artisanal fishing boats operate; (2) from 40 to 200 m in depth where mid-water trawlers operate; and (3) from 200 m in depth to the end of the EEZ where long-liner trawlers run (Islam et al., 2017). There are only 242 trawlers that are allowed for fishing in those regions by the government with around 68 thousand mechanized and non-mechanized boats are in operation in the marine waters of Bangladesh (MoFA, 2014).

Many traditional coastal fishers retain socially structured, locally enforced, and inherited rights to fishing areas, for example, to set stationary fishing gear such as the estuarine setbag net. This method, locally referred to as *Pata*, has been utilized to prevent confusion and conflict among fishers over access to and usage of fishing areas. A *Pata* area is split into smaller sections called *Faar*. A Faar gives fishing privileges to the fisher, a tradition that dates back centuries. While this right to access and use fisheries resources is transferrable and may be sold for cash, it is not legally recognized by the state. Additionally, enforcement of this fishing right is experiencing challenges because of population growth with many new entrants to fishery along with the expansion of industrial fishing (Jentoft et al., 2010).

Globally, the Blue Growth and Blue Economy agendas appear to ignore small-scale fisheries, with little or no reference in the discussion, which makes them more disadvantaged and marginalized (Chuenpagdee, 2020). While Bangladesh is yet to achieve fully-functional Blue Growth initiatives, coastal small-scale fishing communities are already facing pressure from coastal development interventions. The Bangladesh government has emphasized the development and sustainable use of marine and coastal resources for achieving Blue Growth and the UN SDG 14. However, given that coastal fishing communities are most socially excluded, with very poor political representation, they are at risk for being left behind or even further marginalized as a result of ongoing coastal developments (Islam et al., 2020).

Securing a just space

Despite being a useful technique for managing various uses, MSP and its implementation has significant political risks, such as excluding small-scale fishers from decision-making processes (Cohen et al., 2019). To avoid these risks, in all strategies toward achieving the SDGs, the government must promote efforts that properly acknowledge the importance of coastal ecosystem services and support the current and future contributions of small-scale fisheries towards development (Chuenpagdee, 2020). To address power imbalances and equity, small-scale fishers should be involved as stakeholders in setting Blue Growth agendas with implications on small-scale fisheries operations and spaces (Jentoft, 2019). This is where procedural equity should be ensured to allow small-scale fishers with access to decision-making, especially when they are vulnerable to the adverse effects of potential development interventions (Islam et al., 2020). However, policymakers are responsible for making coastal ecosystem services more equitable to all coastal residents. To create a more equitable and just space for coastal resource-dependent communities, it is essential to recognize the existing injustices and inequalities people face on the ground (Chuenpagdee, 2020). Furthermore, the disproportionate effects increasingly experienced fishing communities such as industrial pollutants, hazards, or waste disposal threaten the health and well-being of fishers (FAO, 2015). This raises environmental justice concerns calling for the need to protect small-scale fisheries from the negative consequence of other maritime activities while also creating a just space for them.

Conclusion

Small-scale fisheries in Bangladesh face many stresses and require more resources in tackling them. Small-scale fishers are a significant consumer of ocean space and resources and should be recognized as equal players in maritime area distribution. They have used coastal and marine resources for hundreds of years, yet they still are confronted with poverty and lack voice in upholding their rights. They are also under increasing stress for conservation or other activities such as commercial fishing fleets. As a result, they struggle to secure access to fishing spaces. MSP provides an approach to solving problems among different ocean uses. Any decision-making regarding MSP of Bangladesh in the Bay of Bengal should treat small-scale fisheries as a partner, especially in recognition of their contributions to achieving SDGs by 2030.

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35. Social and Technological Changes in Coastal Fishing Villages of Bangladesh

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Shifts in fishing vessels from traditional non-mechanized boats (front) to mechanized ones (back) (Photo: Reashan Ujjaman, 2022).

This study aims to investigate the social and technological changes in the traditional coastal fishing villages of Moheshkhali Island in Cox's Bazar district of Bangladesh. Using interviews and oral history, the study tracks these changes over time from 1972 to 2021. The study participants include veteran and senior fishers of traditional fishing communities involved in estuarine and coastal fishing. Our historical analysis covers the processes and factors that have influenced the transformation of a traditional fishing livelihoods in the village over a fifty-year period. The introduction of mechanized boats and modern fishing gear has been one of the most critical factors affecting traditional fishers, particularly since the mid-1980s. In addition, increased access to physical infrastructure such as electricity, improved education, diversified occupations, and division of labour have changed the livelihood outcomes and wellbeing of fishing communities. Many of these changes have led to positive impacts including increased fishing income, reduced urban-rural gap in terms of connectivity and economic opportunities (e.g. tourism), and improved health outcomes. However, while the fishers reap the benefits of such social and technological advancements, there is a flip side to these changes that often make them vulnerable. Understanding and addressing such implications is crucial to ensuring the betterment of the lives of the local fishers.

Introduction

Urbanization, regional integration, technological advancements, and globalization shape the spatial distribution and fishers' living conditions in the context of developed countries (Woods, 2009; Hu et al., 2022). However, technology transformation is likely to induce unique short-term disruptions eventually leading to long-term societal benefits (Lechman & Marszk, 2019). For example, technological advancements and their adoption in fishing villages have made it possible and convenient to farm fish while significantly increasing the use of fishery resources, and propagated advancements in marketing and commercialization. Moreover, technological advancements such as fish finders, echo sounders, acoustic cameras, geographic information systems (GIS), global positioning systems (GPS) allow commercial fishing fleets to increase their fishing capacity and access to resources, putting even greater pressure on depleting fish stocks and species diversity.

Moheshkhali Island, locally known as Moheshkhali Dwip, is an island off the coast of Cox's Bazar, Bangladesh. This 268-square-kilometer island is unique as it is the only hilly island on the south coast of Bangladesh. It emerged from an earthquake in 1569 and remain fringed by mangroves. It is home to several small fishing and agricultural villages, which have undergone many social, technological, and economic changes over the last decades. Social and economic changes led to a range of changes from demographic characteristics (e.g., educational levels, livelihood status, family size, marital status, employment status, housing and construction materials) to standards of living, women's role in the society, social layers, and changes in cultural and social institutions. Furthermore, the coastal ecosystems and resources on which these villages depend on have been impacted by industrial activities and other anthropogenic drivers such as tourism (Arefin et al., 2017). The technological changes occurred in Moheshkhali Island has tremendously changed the livelihood status of fishing people. For example, the traditional crafts used in artisanal fishing in estuaries and coastal waters changed to mechanized boats in mid-1960s (Khan, 2010). New and improved fishing gear such as estuarine set bag nets (ESBN), marine set bag nets (MSBN), and trawl nets with small mesh sizes have allowed fisheries to expand their operation to high seas with increased fishing power (Ghosh et al., 2016).

Similar to hinterlands, the coastal fishing villages have experienced changes in many forms. However, studies that critically examine the extent of social, technological, and economic changes are still lacking. This chapter focuses on the dynamics of modernization in the fishery sector and associated socioeconomic transformation within fishing villages in the coastal island of Moheshkhali. The study is based on primary data collected from five fishing villages: Thakurtala, Ahmadiaghata, Mudirchora, Khandokarpara, and Gaurakghata Dokhkin (south) Jaldashpara. Data was collected through interviews with fishers and key informants (veteran fishers of the traditional fishing communities) and through participant observation.

Historical analysis of changes in Moheshkhali Island

According to key informants, the number of fishers on Moheshkhali Island was about 10,000 in 1965, which has now reached about 50,000. Historically, people (three-six months) used small boats (locally known as *Dinghi and Sampan*) for fishing in nearby areas on a seasonal basis while they now engage in year-round fishing using engine-driven boats. The fishers also used traditional fishing gear and fished within 5 to 10 km off the coast although now they have started to go to deep sea areas (200 to 300 kilometers away from the coast) and use modernized fishing gear. Table 1 provides a detailed timeline analysis of changes in Moheshkhali Island.

Table 1: Timeline analysis of changes in Moheshkhali Island.

Characteristics	Time frame		
	1965-1980	1980-1995	1995-Present
Number of fishers	5,000-10,000 (Approximately)	10,000-20,000 (Approximately)	Up to 50,000 (Approximately)
Number of boats and fish catches	A relatively small number of fishing boats caught a huge quantity of commercially important full-grown fishing species with less fishing effort.	Boat numbers increased, and catch volumes gradually became low	Small fish catches due to increased numbers of boats.
Introduction of engine boat	Fishing was done by traditional non-mechanized boats.	Fishing was done by both traditional non-mechanized and mechanized boats.	Most are mechanized boats although some non-mechanized boats still are used for fishing.
Fishing competition	Less competition for fishing.	Less/medium competition for fishing.	High competition
Fishing season	The active fishing period was limited to 3-6 months.	The active fishing period was about six months.	Year-around fishing.
Fishing area	Fishing was done within 5-10 km off the coast.	Fishing was done up to 50 km off the coast.	Both onshore and offshore (200- 300 km off the coast) fishing is done.
Mangrove	Prevalence of q thick mangrove forest along the coast.	Mangroves started to decrease due to anthropogenic and natural causes.	Mangrove forest has decreased remarkably.
Shrimp and prawn postlarvae (PL) collection	PL collection was limited or none.	PL collection increased than before.	The fishers use destructive fishing gear (Small meshed fixed bag net, push net, drag net) for PL collection.
Impact of fishing gear	Fishing gear was not much harmful.	Use of destructive fishing gear began.	Indiscriminate use of harmful fishing gear stated to threaten the fisheries.
Legacy of ancestral occupation	Almost all family members engaged in fishing.	Children were moved for schooling aiming for alternative occupations in future	Traditional fishers are not interested in bringing their kids to the occupation.
Embankment	No embankment.	No embankment.	Embankments were built while hampering fish breeding grounds.

Social changes

Most people of Moheshkhali Island are natives while the others are internally migrants from different district who came for business purposes and later settled permanently. The technological innovations and associated socioeconomic improvements caused significant changes in the livelihoods of the island's local community (Table 2).

Fishing is the primary employment and income source for the islanders. Income levels, however, vary depending on the fishing season, gear type used, and the market price of harvested fish. The low-caste Hindu fishers were the traditional fishers of the island, who believe that the island and their main occupation (fishing) are spiritual linked. They used to depend entirely on fishing for livelihoods in past decades and are highly skilled professional fishers. They found peace and comfort in the profession of their forefathers. They also consider it as a high profit with less investment. At present, most fishers are involved in a range of other activities, including agricultural work, fish trading, betel cultivation, salt cultivation, dry fish trading, retail trading, day labouring, net weaving, shopkeeping, and other petty business as a secondary earning option to support livelihoods.

Around 1965 to 1985, most members of a fishing household used to go fishing, including seven- or eight-year-old children who continued family traditions. Now, parents are concerned about their children's future in face of the vulnerabilities associated with the fishing-based livelihoods. Most fishing households in the past were illiterate (there were no any schools nearby), lacked awareness about education, and poor. However, most households have more access to schools (there are government-run primary schools in every 3–4-kilometer distance) and fishers also value the opportunities that education brings. However, many children who attend school also work part time to supplement their family income. Therefore, child labour is widespread on this island.

The fishing households also experienced improvements in housing. Most fishers used to have thatched houses of straw and bamboo. Now most fishers live in tin shed houses relatively better off fishers live in tin-roofed brickwalled houses. Earlier, due to the remoteness, this island was not connected to the national electricity grid; now, most houses have access to electricity and use small appliances such as rice cookers, microwave ovens, fans, and televisions. Transportation and mobility also became much easier due to paved roads and fueled vehicles. Battery-driven rickshaws and easy bikes ('locally called auto') are now the primary means of transport. However, they still use speed boats and mechanized boats to transport critically ill patients from the island to government hospitals on the mainland (Cox's Bazar). Patients often fail to reach the hospital on time during the night due to poor connectivity and thus face a life-threatening risk.

Socioeconomic changes of the traditional fishers are also reflected in fishers' ability to use a wide variety of fishing gear. The estuarine setbag net was the traditional gear. Now many fishers use gillnets, seine nets, cast nets, monofilament gill nets, and hooks and lines. Most fisher own boats and catch fish near the coast. Others rent boats from other fishers or borrow boats from fishing entrepreneurs called '*Bahaddar*' locally. In the past, most fishers worked under middlemen for fishing capital and provided a percentage of fishing income or sold fish to them at a reduced price while middlemen used to reap much of the benefits. Nowadays, dependency on middlemen has been drastically reduced, mainly due to the availability of different soft credit schemes with lower interest rates. In the past, most fishers took advance money for labouring for the whole season's fishing and thus were debt-tied to the owners of fishing teams, locally called Bahaddar or other companies. This patron-client relationship was extractive although some still exists. Many fishing labourers can now exercise much economic freedom as they can take loans from other sources with better terms and conditions and sometime also able to fish as partners rather than labourer. Due to the massive expansion in power-driven fishing boats and better economic conditions, the relationship between boat owners and fishing crew also got interrupted. As a result, the former crew who had no boats now own fishing teams, which have led to an overcapacity that brings negative consequences (Table 2). Along with overcapitalization, other anthropogenic causes, such as the use of destructive fishing gear, catching of brood fish, overfishing, pollution, oil spillage, and siltation have become salient reasons that have caused the loss of fish feeding, breeding, and spawning grounds eventually leading to loss fish biodiversity in fishing grounds closer to Moheshkhali Island.

Table 2. Social changes that took place in fishing communities in Moheshkhali Island over last five decades.

Dimensions	What changes happened	Consequences of this change
Societal level changes in the village	Changes in socioeconomic dimensions, increased education institutions, human behaviour, diversified occupations, and medical facilities.	Significant changes in the urban-rural gap, power structure, leadership patterns (from group fishing to individual fishing), socio-political activities, health and life span improvements, transportation improvements, socioeconomic condition and increased education rates and daily income levels.
Strain on fishery resources	With the increase in coastal population and technology, fishing pressure increased.	Many important fish species have declined in numbers while some become extinct while impacting fish catch levels, incomes, and livelihoods.
Dependency between fishers and fishing entrepreneurs (patron-client relations)	Fishing labourers worked as bonded labour and lived by taking advance money from fishing entrepreneurs (*Bahaddars*). Many fishers now take loans from microcredit organizations for their fishing ventures.	Improvements in socioeconomic conditions.
Change in fish catching techniques	Fishing techniques changed over time, including high-speed motorboats, increased trawling, new technology such as GPS, as well as the increased use of small-meshed nets that are illegal.	Destructive fishing activities impact fish stocks and catch levels leading to rising fish prices.
Changes in the division of labour	Group fishing was common. However, the labour force and fish stocks are now reduced due to destructive fishing gear use. Working as labour on board fishing boats is has become an activity that does not get paid properly. Many fishing labourers have started their own fishing activities using their own boats and fishing nets) or have left fishing altogether.	Overcapitalization of fisheries occurred. With availability of alternative income sources, some have managed to achieve economic prosperity.

Technological changes

Over the past 50 years, fishing activities in Moheshkhali Island, Bangladesh has undergone significant technological changes (Table 3). These changes profoundly impacted the livelihood outcomes of the local communities. One of the most significant changes has been the introduction of new fishing gear. Gill nets and estuarine/marine set bag nets (*Behundi*) manufactured by machines are widely used nowadays. In the past, fishers used simple equipment such as bamboo rods and nets made of cotton or nylon. Due to modern technology, fishers now have access to more sophisticated equipment such as hooks, mechanized boats, and multifilament nets. The use of estuarine set bag nets, marine set bag nets, and trawl nets with small mesh sizes have allowed fishers to expand their fishing power.

The introduction of the boat engine in the mid-1980s also significantly impacted fishing operations. Fishers can now venture into deeper sea and cover longer distances to access remote fishing grounds. They use manually operated traditional wooden boats (locally known as *Dinghi and Sampan*) for day trips in nearby areas and small to medium mechanized boats for more lengthy voyages in the sea. The capacity of the motorized boat engines typically vary from 12 to 65 horsepower. Boats with smaller engines are used for hook and longlines and for set bag net operations. These boats range in size from 7 to 15 meters. However, the coastal fishers who cannot afford to buy the equipment work as seasonal paid labourers on the boats of more wealthy owners. The boat engine has also made fishing more accessible and efficient, increasing fishers' income.

Modern technologies such as GPS, fish finders, echo-sounders, and radar are also commonly used now to locate fish abundant areas in the sea. These technological advances have increased fishing power, making commercial fishing fleets more efficient. However, mechanized trawlers with small-meshed nets have led to overexploitation of fishing resources. Fishers now use mobile phones to improve their incomes, expand their markets, receive weather updates in addition to listening to FM radio and staying in touch with families and other fishers. The use of mobile phones has not only improved the quality of life but also the efficiency of marketing activities through communications over the phone. Radio is another technology that has proven to help to fishers, especially in receiving weather updates and entertainment news.

The use of ice boxes for fish storage and preservation on board fishing vessels have also significantly increased in recent years. Fishers now use ice to preserve fish caught during medium and long-range fishing trips, allowing for extended storage periods and better preservation that led to better prices. Despite these technological advancements in the fishing industry, water supply and sanitation facilities still remain poor. The water is salty and unsafe for drinking, and toilets are generally unhygienic and unsanitary. Poor sanitation is linked to transmission of diseases such as cholera, dysentery, typhoid, and other water-borne diseases. Contamination from waste therefore remain a risk to the community's land and water resources.

Table 3. Technological changes among the fishing communities in Moheshkhali Island.

Dimensions	What changes happened	Consequences of change
Introduction of new fishing gear	Development of hooks, boats, multifilament nets (estuarine set-bag-net, marine set-bag-net, and trawl net with small mesh size).	Expanded fishing operations and increased income.
Introduction of boat engine	Diesel engine was introduced in 1985/86.	Offshore fishing in high seas became possible because of vessel technology.
Change in boat engine capacity (horsepower)	Engine power improved allowing for long-range fishing.	With the development of boat engines, long-distance fishing is now possible.
Technologies to locate fish schools	GPS, and fish finders (radar) are used.	These technological advances led to commercial fishing fleets with enhanced fishing power.
Use of Mobile Phones	Mobile phones are used for communication and business.	Improved fishing incomes, getting weather updates and news, FM radio for entertainment at sea, and the ability to remain in touch with families and other fishers.
Use of Radio	Radio is used for communication, news, weather updates, emergency help, and entertainment.	Created a favourable situation where fishers have access to more information.
Use of icebox or other modern storage facilities	Short-range fishing does not include any ice boxes, while medium- and long-range fishing often involves 50–70 pieces and 100–200 pieces, respectively.	The use of ice improved fish storage and preservation on board fishing vessels.
Better forecasting and protection from rough weather	Use of internet for weather updates, radio, life jackets, navigational light equipment, and other means of protection.	Fishers who have relied on traditional knowledge may need to learn new skills and adapt to modern technology. Additionally, the cost of purchasing and maintaining these technologies may be a barrier for some fishers.

Challenges and a way forward

While small-scale fishers mostly appreciated the positive aspects of technological and socioeconomic changes, some unfavourable consequences also emerged from these changes. First, there are several destructive methods of fishing, such as trawling, shrimp and prawn post-larvae collection using fine-meshed gears that threaten fish biodiversity, upon which they are intimately connected for livelihoods, culture, and income. Second, easy access to fishing technology invited many more new entrants that led to intense competition for resources. Third, economic activities on both land (e.g., shrimp farming) and seascape (e.g., oil spills from merchant ships) deteriorate coastal water quality that drives away fish and destroy the delicate coastal habitats. Fourth, climate change is a global crisis that manifests local menace to coastal fishers of Moheshkhali Island through frequent extreme weather events, for example: flood, waterlogging, storms, cyclones.

Recommendations for scaling up positive transformation while minimizing negative impacts can be made in following ways. Firstly, promoting sustainable fishing methods such as using alternative fishing gear and regulating fishing seasons and quotas. Secondly, community-based resource management strategies can be adopted to ensure that the are shared fairly and equitably in collaboration with local people and thereby reduce the demand for additional resource collection. Thirdly, the government should implement water quality monitoring and reforestation programs to ensure safer water quality levels and restore damaged habitats. Finally, the government can integrate climate adaptation plans with local development practices while also encouraging climate-resilient fishing practices.

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36. Fisher Organizations in Bangladesh: A Safety Net against Crises?

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A fisher casting a net at Amritkundo Beel in Habiganj, Bangladesh (Photo: Tanvin Yeasin Tanay, 2023).

Fisheries organizations are important in involving fishers and their communities towards sustainably managing small-scale fisheries. Using a case study approach, this chapter discusses how fisher organizations contributes to improving fishers' wellbeing and better fisheries management. The findings suggest that fisher organizations can strengthen social bonding among fishers and raise voices against injustice and deprivation. However, these organizations achieved only partial success in terms of ensuring participatory resource management. Given that small-scale fishers mostly remain unorganized and lack a collective voice, they continue to face challenges such as livelihood insecurity and socioeconomic deprivation and are more vulnerable to various shocks such as extreme weather events. Such vulnerabilities are most often about the weak organization and poor institutions that leave small-scale fishing people without bargaining power or insurance mechanisms, thus, leaving them defenseless. The chapter suggests that strengthening traditional fisheries organizations is a way forward to empowering the fishers, through collective action in face of vulnerabilities and shocks.

Introduction

Fisheries organizations are important in ensuring the participation of fishers and their communities in sustainably managing small-scale fisheries. Such organizations are deemed essential for the long-term viability of small-scale fisheries, as they help build social capital, strengthen agency, and promote fishers' empowerment and stewardship of fisheries resources. The fisheries sector in Bangladesh is vast and approximately employ 15 million people involved. In particular, traditional small-scale fishers in Bangladesh are confronted with poverty, and remain largely unorganized and vulnerable to both internal and external shocks and pressures. Social capital often plays an important role with or without government intervention as small-scale fisheries of Bangladesh are anchored in social relations and networks. Thus, strengthening social capital in the form of fisher organization has the potential to significantly lower vulnerabilities associated with small-scale fisheries (Islam, 2011).

Fisher organizations cater to fishers and their activities, including rules and efforts to ensure their welfare. Globally, effective organization and collective action among fishers plays a vital role as a buffer against crises and help them survive in the face of adversity (Cyert & March, 1963). Furthermore, fisher organizations support various activities towards the betterment of the membership. These activities include protecting fisher rights, helping them better respond to crises, encouraging their participation in fisheries management, informing government policy-making activities, fighting corruption and conflicts among the fishers, coordinating activities with other organizations, raising a voice and making claims in favour of fishers, and in arising awareness among fishers on rights and responsibilities in fisheries management. In other words, these institutions are "*indispensable when organizing, communicating, representing, negotiating, managing, leading, governing, or researching*" (Jentoft, 2003, p. 138).

Given the vast number of fishing people, it is not surprising that there are a good number of fisheries-based organizations in Bangladesh — some are locally operated, some are affiliated with political parties while some others are national-level organizations that have local affiliates at the grassroots level. Though fisher organizations should be considered an indispensable part of any fisheries-related discussion, scientific study of fisher organizations is relatively rare in Bangladesh. Despite the many fisher organizations across different levels, only three organizations are registered with the government: Bangladesh Khudra Matshyajibi Jele Samiti, Bangladesh Matsyajibi Samabay Samity, and Bangladesh Khudra Matsyajibi Samabay Samity. The latter two are registered with the Department of Cooperatives. This chapter focuses on the activities of the Khudra Matshyajibi Jele Samiti to explore the activities, potentials, and challenges in face of fisher organizations in Bangladesh.

Case study of a fisher organization

A case study on Bangladesh's Khudra Matshyajibi Jele Samiti (Bangladesh Artisanal Fishers Association) was developed based on key informant interviews and a review of literature. This organization was founded in 1985 with only seven members. Now more than 200,000 members are involved with the organization, which covers all of Bangladesh and across 47 districts out of 64. The highest number of members is found in the Barisal division, as it is the hub of capture fisheries in Bangladesh. Their division-level organization continues to run with a committee elected once every three years. The positions in the committee are fixed according to government guidelines. This organization arranges three to four national meetings every year. At the local level, meetings are arranged once a month or once in every two months.

The apex national executive committee is based in Dhaka that consists of 31 members, including a president, three vice presidents, one general secretary, three joint secretaries, one organizing secretary, one treasurer, one office secretary, one publicity secretary, one sports secretary, one legal secretary, one fisheries secretary, two women's affairs secretaries, eight organizing secretaries, and five executive members. The organization has a four-tiered administration structure that includes divisional, district, upazila (sub-district), and union levels. The organization sets specific conditions for new members to ensure that only genuine fishers are included. Accordingly, a potential member should be involved in fishing and fisheries-related activities, including selling or owning a water body. The members pay nominal membership fees. According to an office bearer, they maintain transparent and well-documented financial records. The money collected through membership fees and donations are deposited in a bank at regular intervals and the spending is restricted only to organizational needs.

Contributions to fishers' wellbeing

The organization sets its mission and vision to ensure both fishers' wellbeing and protection of fisheries resources. The organization lead and organize four different kinds of activities. First, the organization aims to maintain good cooperation and communication among its members. Second, it serves as a platform for rural and remotely located fishing communities to raise their voices and demands in jointly solving problems with local authorities. Third, they regularly arrange seminars, protests, press conferences, and collective action against different matters and pressing issues although they appreciate the various positive government initiatives. For example, this organization is influential in navigating issues in relation to the implementation of any new regulations or conservation measures concerning small-scale fishers, such as the imposition of fishing bans without consulting fishers. In such cases, they organize protests or rallies or try to find a way to negotiate with the implementing authority although such efforts may not always succeed. Finally, the organization often works with local government administration to identify genuine fishers in implementing compensation schemes during fishing bans. This is due to the concerns among the fisheries that the government's compensation scheme for fishing bans often includes non-fisheries and excludes genuine fishers from receiving in-kind support (rice bags). The local union council (the lowest tier of local government administration) makes the list of eligible fishers. Fishers allege that local government administration was biased due to partisan politics, and many genuine, poor and vulnerable fishers are excluded from receiving compensation, which led to fisher organizations involvement in the selection process.

The organization focuses on a range of coastal and marine fishing activities. The intrusion and illegal fishing of foreign trawlers is a key concern for all fishers. The illegal fishing intensifies particularly during fishing bans when local fishers stay ashore. Fisher organization recognizes the detrimental impact of illegal fishing to the fisheries resources of the Bay of Bengal and often stage rallies and petition the local authority to act against illegal fishing by foreign trawlers. It is often the case that Bangladeshi fishers are imprisoned in neighbouring countries due to trespassing jurisdictional boundaries, particularly in India. In such situations as well the organization speaks on behalf of fishers and provides legal help to get them released.

In addition, the organization facilitates communication and coordination in responding to various risks and dangers fishers face while fishing such as unfavourable weather in the Bay of Bengal. One key informant from the apex committee said that better communication and coordination with government law enforcement and maritime surveillance agencies are necessary to decrease causalities during extreme events.

Furthermore, the organization raises awareness among membership on fishing rules, regulations, boundaries of sanctuaries, and banning periods. This reduces the number of fishers engaging in illegal and destructive fishing, such as using monofilament gill nets or fishing during ban seasons, which often result in imprisonment, fines or confiscation of gear by the law enforcement agencies.

The organization sometimes collaborates with other fishers organizations in collectively making various demands for ensuring fellow fishers livelihoods, wellbeing, and security. Some local committees are also found to be active across fish value chain activities such as processing and trading. They exercise their collective influential power to ensure that fishers get fair prices for their catches. With support from the government and non-government organizations (NGOs), this organization also support the rehabilitation of the fishers' houses, destroyed fishing crafts, or equipment affected by cyclone events.

There are different categories of fisheries actors involved in the organization. They include fishing labour, skippers, owners of fishing boats (productive assets owner), and fisheries entrepreneurs (e.g. *aratders*). For day-to-day expenses for living and operating fishing activities, most fishers depend on loans through informal money lenders (often at higher interest rates). Due to lack of collateral assets, most fishers do not have access to formal banks. Although the organization raised concerns in the past to ensure fishers access to loans through formal banks, there has been not any progress yet in this regard.

Different fisher organizations work together to arrange different programs seeking to help fishers. Although the organization has involved women in small numbers as fishing is a male-dominant occupation, most members agree that women's roles are increasingly becoming important, and that their participation needs to increase further. Another area needing attention is the poverty and illiteracy among fishers as well as lack of access to formal education among their children. Although the office bearers of the organization often get invited to meetings arranged by government agencies such as the Department of Fisheries (DoF), Bangladesh Fisheries Development Corporation (BFDC), and Bangladesh Fisheries Research Institute (BFRI) to discuss collaborate programs to make progress in addressing such issues, there have been less progress so far.

Participation in fisheries management

The organization and its members support the management of country's fisheries resources. In doing so, they collaborate with various levels of government, including catch data collection through *aratders* at landing sites, attending joint meetings and programs arranged by institutions such as DoF and BFRI as well as by the association. This allows the members to share their ideas, issues, and suggestions with government officials. During data collection and surveys by NGOs or the government, the organization helps by providing data, including fish catches, income levels of fishers, and their livelihood status.

Hilsa shad (*Tenualosa ilisha)* is the most important fish species on which most coastal and estuarine small-scale fishers depend for a good income. To conserve hilsa juveniles (*Jatka*) below 25 cm of body size, the Government of Bangladesh has introduced a Conservation Program with the involvement of four governance tiers. The National Task Force or Central Jatka Task Force Committee (CJTFC) is the top governance body, headed by the Fisheries Minister. The next tiers include the District Jatka Task Force Committee, the Upazila Jatka Task Force Committee, and the Union Jatka

Task Force Committee. All these committees include representatives from various stakeholder groups, including representatives of two fishers' organizations: the Jatiyo Matshyajibi Samity (National Fishers Association) and the Bangladesh Khudra Matshyajibi Jele Samity (Bangladesh Artisanal Fishers Association) in addition to the representatives of above-mentioned government bodies (Islam, 2021).

As an example, the members of the fisher organization in Amritkundo Beel, in Nabiganj sub-district of Habiganj district shared their conservation initiatives that reflect their resource stewardship. This is a leased waterbody, and the members comply with self-imposed ban periods for different species, particularly snakehead fish. Through this process, the organization directly supports the conservation of biodiversity and in ensuring fish availability in the future. However, the fishers do not receive any subsidy or other support help from the government to sustain their livelihoods during these self-imposed ban periods despite their requests for support.

According to key informants at the head office in Dhaka, the organization forbids the fishers to use destructive fishing gear while also making them aware of different extinct species prioritized for conservation efforts. The organization also often communicates fishers' perceptions and experiences that can shape ban periods, specially when they are not appropriately timed. Such efforts to knowledge sharing are crucial to ensure fisher wellbeing as prolonged fishing bans strain fishers' livelihoods due to income loss.

The Government's Jalmahal Management Policy of 2009 has provisions for involving fisher organizations in leasing out open waterbodies (locally known as *jalmahal*). The Department of Fisheries is required to consult with a government-approved fisher organization in the bidding process to verify the applicant's fisher identity as a 'genuine fisher'. The term genuine fisher refers to those who make a living by catching and selling fish from natural ecosystems for their livelihoods. Only verified genuine fishers are approved for leasing a waterbody such that the only legitimate fishers can benefit. However, this legislation does not allocate any community user rights. The organization therefore works to secure leases for its members. One must pay 20 percent security money and 5 percent tax to access open water bodies, which is difficult for the fishers to afford, and therefore only some manage to secure leases to waterbodies. They then permit other fishers to also access these water bodies for fishing. The rural fishers control only a few water bodies and get 25 percent of the profit from the water body. Many conflicts also arise in the process between fishers, rural people, government, and other stakeholders and the organization actively works to solve these conflicts.

Challenges fisher organizations face

Local partisan politics often influence the flow of benefits that are intended for rural genuine fishers. Many influential local people form fisher organizations also bid for leasing government-owned waterbodies to help sustain fisheries-based livelihoods. However, in many cases, non-fisher local elites and influential people manage to lease waterbodies while marginalizing genuine fishers from accessing waterbodies.

Lack of sufficient funds is another challenge, which compromises the capacity to run programs such as capacity building and in responding to crisis situations. Lack of funds also impact the fisher organizations' ability to secure leases to open waterbodies as a large sum of money is needed to participate in the bidding process. Therefore, wealthy local people use these organizations to secure leases for themselves. These elites also sometimes form fisher organizations to serve their needs while excluding fishers with weaker levels of agency. These issues pose a big challenge in ensuring the rights and proper livelihoods for genuine fishers who live closer to waterbodies.

The study respondents suggested different strategies for improving better resource management. According to them, improved participation in organizational activities is important for better capacity building among rural fishers. Further, they should get involved in the market chain of fish and fisheries products to ensure fair prices for harvests and fish products such as dried fish. Fishers also need to plan and implement coordinated efforts to ensure rights to lease and access waterbodies as well as in the management of user activities.

Discussion and conclusion

Despite the large numbers of fisher population, vulnerability to poverty and other stressors of both natural and anthropogenic origins, characterize small-scale fishers in Bangladesh. In face of these overwhelmingly disadvantaged situations, traditional fisher institutions have a greater potential to serve as a safety net during crises. Many existing fisher organizations already support fisheries in many ways at the grassroots level (Cyert & March, 1963; Islam, 2011). At the same time, these organizations support the livelihoods and wellbeing of their members while also protecting crucial fisheries resources. With focus on the history, formation, and activities of fisher organizations, this study provides evidence that collective action among fishers play a meaningful role in fisheries management and livelihood development within fisheries-dependent communities in Bangladesh, especially in responding to crisis situations.

With limited self-organization and lack of voices small-scale fishers remain vulnerable without any bargaining power or defense mechanisms. These vulnerabilities are often related to weak organization and poor institutions that leave small-scale fishing people defenseless. Strengthening traditional fisheries organizations, therefore, is essential to empower the fishers at the local level. Although traditional social ties, networks, or social capital can support people's ability to survive in times of crises, they alone are not capable enough to lift them out of poverty or in enhancing their capacities to survive and flourish. They also have the potential to improve access to financial resources and help reduce the dependency of small-scale fishers on middlemen of value chain and informal credit markets (Chuenpagdee & Jentoft, 2011). With appropriate management and training initiatives, these traditional community institutions can also play a vital role in resource conservation and stewardship.

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37. Vulnerability and Responses: Towards Viable Livelihoods of Small-Scale Fishers in Bangladesh

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A small-scale fishing team repairing their nets on the riverbank before embarking on a fishing trip using traditional boats and a seine net on the Shibsa River, which flows through the Sundarbans (Photo: Mohammad Mosarof Hossain, 2022).

This chapter investigates the threats, stressors, and vulnerabilities that small-scale coastal fishers face in Bangladesh and their responses to addressing those. Our chapter is based on a comprehensive review of literature in the context of small-scale fisheries in Bangladesh. The findings revealed that multiple anthropogenic stressors in combination with climate-related hazards have caused a significant decline in fisheries resources and physical assets owned by fishers while putting coastal fishers livelihoods at risk. In response to these threats and shocks, fishers have devised a variety of coping strategies, including both short- and long-term measures. For examples, short-term responses include taking loans and reducing family expenses. Long-term responses include planting trees and compensating for income loss during fishing bans. However, we found that many short-term coping mechanisms have a detrimental impact on the resource base that coastal communities heavily depend on. This exacerbates the threats to coastal small-scale fisheries and further aggravates the vulnerabilities. In responding to these issues, our study emphasizes the need to restructure the governance approach with attention to context-specific resource management practices. We suggest co-management as an effective tool in this regard and in alignment with the Voluntary Guidelines for Securing Sustainable Small-Scale Fisheries in the Context of Food Security and Poverty Eradication. Such an approach will help address vulnerabilities, secure viable fishing livelihoods, and strengthen fishers' social resilience.

Introduction

Vulnerability is an inseparable characteristic of small-scale fishing communities and livelihoods from local to global scales. Vulnerability is often described as a result of a blend of extraneous exposure of individuals or groups or ecological systems to a hazard, where these is an inherent sensitivity to that risk and an inability to alter the exposure. There is also a lack of capacity to absorb and recover from the losses caused by the risk or to take advantage of any new opportunities that arise while responding (Adger et al., 2005; Smit & Wandel, 2006). The notion of vulnerabilities to environmental hazards is often understood across natural and social sciences disciplines as a three-dimensional phenomenon: exposure (presence/ effects of vulnerable scenarios), sensitivity (weaknesses to vulnerable consequences), and adaptive capacity (ability to respond with context-specific measures (Adger et al., 2006; Morzaria-Luna et al., 2014). In the context of small-scale fisheries, these vulnerabilities are determined by the interactions of exposure to risk, susceptibility to stress and shocks, and inability to handle those. Adaptive capacity, or the ability to adjust to potential harm, seize opportunities, and cope with changes, influences a community's ability to respond and minimize potential damage (Pachauri et al., 2014). Furthermore, high adaptive capacity leads to better adjustment and a higher possibility of transformation towards resilience while low adaptive capacity results in vulnerability (Folke, 2006; Joakim et al., 2015; Schinko et al., 2019). However, adaptive strategies may also reverse or worsen current vulnerabilities or create new ones (Eriksen et al., 2021). The relationship between hazard exposure, susceptibility, adaptive capacity, and response behaviour is complex and requires further investigation that this chapter aimed to address.

Small-scale fisheries make critical contributions to food and nutrition security, local livelihoods, national economies, and poverty alleviation. They are also strongly anchored in local communities where fisheries represent a way of life, especially in developing countries (FAO, 2015). Yet, small-scale fishers are vulnerable to a wide array of interlinked and complex environmental, economic, social, technological, and governance challenges (Islam & Chuenpagdee, 2022). In Bangladesh, livelihoods of small-scale fishing communities are particularly threatened by inherent vulnerabilities that operate across inland, marine, and coastal ecosystems. Understanding vulnerability and conducting vulnerability assessments can help increase awareness of risks and opportunities, develop policies and actions to improve targeted adaptation efforts, and promote scientific research (Patt et al., 2012). For instance, how can better management contribute to addressing vulnerability? How can the adverse consequences be minimized? What are the management implications in building adaptive capacity of small-scale fisheries and associated ecosystems? In doing so, vulnerabilities of small-scale fisheries are often classified as an approach to lessen the complexity of vulnerability assessment processes (Johnson, 2006) by offering deep insight to inform decision-making and management. Small-scale fisheries can become viable and sustainable if vulnerabilities are fully acknowledged and appropriate actions are taken in responding (Islam & Chuenpagdee, 2022). In supporting these efforts, however, limited attention from the scientific community and lack of community awareness about the importance of record keeping remain challenges in developing a better understanding on the specific vulnerabilities, adaptation responses, and risk management strategies in the context of Bangladesh. In particular, scattered and poorly documented response strategies implemented by small-scale fisheries in Bangladesh during previous risk events have resulted in challenges in assessing the success (or failure) of earlier adaptation response strategies. This undermines the ability of policymakers to make informed decisions on how to effectively address the vulnerabilities. Furthermore, the vulnerability classification currently used in Bangladesh is limited, overlapping, or unclear, particularly at the local scale. For example, the classification often don't include community's input about how they view and experience different vulnerability factors and the particular coping responses they adopt. This calls for in-depth research to address the scarcity and gaps in literature and scientific knowledge on the vulnerability factors and responses of small-scale fishing communities in Bangladesh. To address this gap, we used the qualitative narrative review methodology to assess available literature (n=37). This chapter aimed to critically examine fishers' vulnerability factors and key coping strategies of small-scale fishing communities in Bangladesh.

Vulnerability of coastal fishery-based livelihoods in Bangladesh

Our review highlighted that the small-scale fisheries sector in Bangladesh is vulnerable to various biophysical, environmental, social, economic, technological, and governance factors (Table 1). These factors, for example, include the effects of climate change (environmental), illiteracy and poor awareness among fishers (social), high fishing costs and market price instability (economic), inadequate preservation and processing facilities (technological), and mismatching regulations and top-down decision-making (governance) contribute to the vulnerability of small-scale fisheries in Bangladesh (Table 2).

Biophysical drivers

Small-scale fishing communities in the disaster-prone Bay of Bengal area face major climate variability and challenges. The frequency and severity of climate events (e.g., cyclones, flooding, erosion, and salinity intrusion) differs among the 19 coastal districts of Bangladesh. Fishing operations during unsafe conditions such as cyclones, turbulent tides, and rough seas lead to significant human fatalities (Islam et al., 2014). Fish stocks and species diversity is impacted by the use of fine-meshed fishing nets that result in increased levels of bycatch, including juvenile finfish and shellfish (Islam et al., 2017). Coastal and marine fishing habitats are also impacted by certain fishing practices like shrimp post-larvae (PL) fishing, widespread use of estuarine set bag net (ESBN), and shrimp bottom trawl fishing (Islam et al., 2018). This is evident by the decline in catch per unit effort (CPUE), which is about 50 percent lower than the CUPE levels of early 90s.

The inland waters in Bangladesh are also facing threats due to siltation, rising river basins, and sandbars resulting in habitat destruction. In particular, the country's hilsa fishery has already shown changes in terms of spawning times and areas (Islam et al., 2020a). The Ganges-Bhramaputra river delta has 735 million metric tons of sediment in its river systems, which may contribute to the divergence of fish migration routes. The inland and marine waters are also facing pollution from industrial, agricultural, and other land-based sources as well as from shipbreaking activities (Islam et al., 2018; Islam et al., 2020a). These activities release hazardous materials causing direct harm to the growth and abundance of aquatic biotas such as plankton, fish, and other sea creatures (Siddique, 2004). River water flow has also significantly decreased as a result of the construction of various flood control, drainage, and irrigation projects such as the Farakkah barrage on the Ganges-Padma river system. This has resulted in decreased water flow and increased siltation. This poses a threat to the hilsa fishery by disrupting the patterns and migratory routes of the anadromous fish (Mozumder et al., 2019).

Social drivers

Fishing communities in Bangladesh face poverty and lower levels of support for education leading to widespread illiteracy and limited job skills that limit their future opportunities to improve their livelihood and socioeconomic status (Ahmed et al., 2021; Miah et al., 2021). Children often skip school for fishing, perpetuating a multi-generational cycle of poverty, and illiteracy (Islam, 2012; Miah et al., 2022). For most coastal fishers, fishing is the only source of income as income diversification options are scarce (Hossain et al., 2018; Sunny et al., 2021).

Small-scale fishing communities suffer from declining fish stocks due to rising demand, overfishing, and population pressures (Islam & Herbeck, 2013; Miah et al., 2021). The open-access nature of water bodies and increased fishing activities, including illegal practices and participation by non-fishers, are putting significant pressure on fish stocks (Mozumder et al., 2019). During migration and spawning seasons, intense fishing pressure and gear use lead to overfishing and jeopardize the livelihoods and food security of those who rely on fishing (Islam et al., 2020a). Illegal use of monofilament gillnets is prevalent in hilsa fishing sanctuaries, contributing to increased catch and high CPUE. Despite the consequences, this practice is driven by the low cost of the net, ease and efficiency of its use (Islam et al., 2017).

Piracy is also a significant threat to Bangladeshi small-scale fishers, especially during the hilsa fishing season in the Sundarbans. Fishers are vulnerable to kidnapping for ransom and are fearful of assaults. During such encounters their boats and nets are at risk of being taken by pirates, who then sell the stolen items back to fishers through intermediaries (Islam, 2012).

Fishing settlements in Bangladesh suffer from poor living conditions, including overcrowding, inadequate sanitation, and a lack of security measures (Islam, 2012; Ahmed et al., 2021; Miah et al., 2021). These conditions lead to health risks and financial hardship, especially in an event of illness or death of a family's primary breadwinner. Weather events and tiger attacks compound these challenges, leaving families vulnerable to loss of livelihood and financial insecurity (Islam, 2012; Islam et al., 2020a;). Women in low-income and female-led households are compelled to work outside the home to sustain their families that are some often conflicting with the social norms and local tradition (Hossain et al., 2018). Fisherwomen face challenges such as wage gaps, earning less than their male counterparts for the same work. In Sundarbans, for example, women's wage rate is 30 percent lower than that of men's for the same type of work (Islam, 2012). Women also have lesser opportunities for work due to lower literacy level and lack of employment skills. They are also burdened by dowry costs. In response, they often resort to loans from non-governmental organizations (NGOs) or moneylenders that lead to debt traps (Islam, 2012; Islam & Herbeck, 2013).

Table 1. Summary of biophysical and social vulnerabilities faced by small-scale coastal fishers in Bangladesh.

Type	Sub-category	Examples of threats/ risk factors	References
Biophysical	Fish and Fisheries	Declining fisheries resources	Islam, 2011 Islam and Herbeck, 2013; Islam, 2012; Islam et al., 2014 ; Islam et al., 2016; Islam et al., 2018; Islam et al., 2020a; Islam et al., 2020b; Islam and Hossain, 2017; Mozumder et al., 2019; Miah et al., 2022
		Changes in fish migratory routes	
	Habitat/Ecosystem	Water pollution	
		Resource degradation	
	Built Environment	Dams and barrier constructions	
		Dredging, sand mining	
		Large-scale infrastructures and spatial fishing restrictions	
	Geophysical	Coastal land erosion	
		River bank erosion	
	Hydrological	Coastal flooding	
		Salinity intrusion	
		Siltation	
	Weather/Climate	Climate change induces extreme cyclonic events	
		Rough sea episodes, tidal surge	
Social	User conflict/resource competition	Population growth and new entrants into fisheries	Ahmed et al., 2021; Hossain et al., 2018; Islam et al., 2020a; Islam et al., 2020b; Islam and Herbeck, 2013; Islam, 2012; Islam et al., 2014 ; Islam et al., 2016; Islam et al., 2017 ; Miah et al., 2021; Mozumder et al., 2018; Mozumder et al., 2019; Rahman et al., 2012; Rouf and Jensen, 2001
		Conflicts among stakeholders	
		Competition with large-scale commercial fishery	
		Conflict with tourism/touristic activities	
		Redistribution and privatization of common property	
	Overfishing/unsustainable fishing practices	Overfishing	
		Illegal fishing during ban/breeding season	
		Destructive fishing practices e.g., monofilament gillnets	
		High fishing pressure	
	Low social capital	Illiteracy/low education	
		Inadequate skills for other alternative works	
		Lack of awareness on capacity development	
		Weak family ties	
		Low to moderate levels of trust	
		Domestic violence, alcoholism, and drug addiction	
		Marginalization and physical isolation of the communities	
		Social inequalities	
		Poor social inclusiveness/Social exclusion	
	High dependency on fisheries	Dependency on fishing	
		Strong affection for jobs or place	
	Poor occupational health and safety facilities	Piracy in fishing	
		Poor health and sanitation	
		Death of an income earning family member	
		Attacks by criminal gangs	
		Absence of basic infrastructure	
		Poor road infrastructure and transport availability	
	Gender issues and bias	Dowry	
		Gender violence	
		Social exclusion due to tiger widowhood	

Economic drivers

The small-scale fishers in Bangladesh face poverty, scarcity, limited resources, and low employment opportunities, leading to a lack of dignity in their public life (Islam & Herbeck, 2013; Islam & Chuepagdee, 2017). Weather events further exacerbate this poverty, putting fishers in a debt cycle and leading to a poverty trap (Islam, 2011; Miah et al., 2022). Many fishers lack land ownership, mostly residing on government-owned lands, called *Khas* (Islam et al., 2020a). Coastal embankments serve as settlement sites and transportation roads for landless people. Lacking indemnity assets like land property hinders fisher's access to formal credit markets. They rely instead on informal micro-credit mechanisms, called *Dadon*, which exploit them through much higher interest rates than formal credit schemes (Islam, 2012; Rahman et al., 2012).

Poverty and debt from microcredit systems profoundly contribute to fishers engagement in unsustainable fishing practices and the resulting non-compliance of fishing regulations (Islam et al., 2017). Many fishers are driven by local microcredit systems, forcing them to continue fishing during banned periods to repay loans. Lenders control the sale of their catches, leading to a loss of control over their livelihoods. A good catch does not guarantee a reasonable price as they are forced to sell to money lenders at low prices (Rahman et al., 2012). The fishing communities face limited alternative income sources. Their main income remains fishing, but they struggle to find other ways to earn during fishing ban periods (Islam & Herbeck, 2013). They also lack the employment skills to be able to find alternative employment (Ahmed et al., 2021).

Technological issues

The mechanization and advancement of fishing technology used by commercial fishers has led to increased fishing intensity in the coastal region while putting additional pressure on the already struggling small-scale fishers. Fishers extend the duration of fishing trips for a better catch, relying on efficient gear. Despite concerns over bottom trawling's impact on the Bay of Bengal's ecosystem, about 100 trawlers continue to use this method, posing a major threat to small-scale fisheries (Islam et al., 2017). Moreover, small-scale fishers in Bangladesh needs proper post-harvest facilities and adequate safety measures, such as lifesaving equipment and improved communication and navigation devices.

Governance factors

Since 2019, Bangladesh has been imposing a fishing ban in six hilsa sanctuaries towards sustainability. During the 65-day ban, all coastal and marine fisheries, including small-scale fisheries, are prohibited (Islam et al., 2021). Ban periods hurt livelihoods and force fishers to engage in illegal fishing and overexploitation during that time, leading to the depletion of juvenile and breeding stocks (Mozumder et al., 2019). The Government of Bangladesh provides fishing households with 40 kg of rice per month during fishing ban periods to compensate for the loss of income and reduce livelihood vulnerability (Islam et al., 2016). However, this support is inadequate as it fails to consider the number of dependents or the other financial needs of the family. Although, while all types of fishing activities are banned in sanctuary areas for a specific period, only the households of hilsa fishers receive incentives. This practice discriminates against non-hilsa fishing households, potentially leading to illegal fishing and overexploitation.

Table 2. Economic, technological, and governance drivers faced by small-scale coastal fishers in Bangladesh.

Type	Sub-category	Examples of vulnerability/ risk factors	References
Economic	Lack of assets	Poverty and debt cycle Low income and financial capacities Inadequate savings (gold, silver, or personal cash savings) Landlessness, lack of land resources, ponds or livestock	Islam, 2012; Islam and Herback, 2013; Islam et al., 2020a; Mozumder et al., 2018; Sunny et al., 2021; Rahman et al., 2012; Rouf and Janesen, 2001
	Little livelihood options	Joblessness and high rate of unemployment Limited alternative employment opportunities	
	Price-taker risk / unfavorable market conditions	Unstable and unpredictable income from fishing Lack of access to markets Unfair pricing, influence of intermediaries on value chain Exploitative patron-client relations Lack of access to formal credit	
Technological	Catching power	Intensifying fishing effort Improved fishing technology/overcapacity- mechanization The decline of traditional harvesting practices	Mozumder et al., 2019; Islam, 2017
	Landing site and processing constraints	Longstanding and neglected infrastructure Poor and unhygienic landing sites Inadequate post-harvest preservation and storage facilities	
	Safety device inadequacy	Inadequate safety at fishing (e.g., lifesaving equipment) Inadequate modern communication and navigation devices	
Governance	Unfair rules/regulations	Imposed long ban period Unequal access rights and ownership Loss of fishing areas by regulation	Islam, 2012; Islam et al., 2014; Islam et al., 2017; Islam and Chuepagdee, 2017; Mozumder et al., 2019; Islam et al., 2020b
	Weak government / Low capacity	Inadequate incentives Non-compliance with regulations Lack of enforcement Improper fishing regulations Insufficient emergency supplies Corruption, nepotism	
	Inadequate stakeholder participation/interaction	Lack of institutional supports Lack of access to the political and local institutions Low participation/ lack of voice- poor involvement of small-scale fisheries stakeholders in management and decision-making Little political attention to small-scale fisheries	

Irregular government compensation for fishers during banned periods have led to non-compliance with regulations (Ahmed et al., 2021). Complex and multi-faceted fishing conflicts are also common in Bangladesh, encompassing resource competition, management disputes, and power imbalances. Seasonal fishing bans inevitably result in reduced income for full-time fishers, while irregularities in compensation schemes generate social friction within fishing communities and with the local government (Islam & Herback, 2013; Mozumder et al., 2019). The tensions between management authorities and beneficiaries' institutions are growing and have led to non-compliance with management decisions during implementation (Islam et al., 2017; Mozumder et al., 2019).

Small-scale fishing in Bangladesh is hindered by poor enforcement or ignorance of legal instruments. For example, wealthy anglers bypass fishing closures and sanction on illegal fishing are ignored based on connections among anglers, boat owners, and political leaders (Islam et al., 2017). Mechanized boats owned by local politicians seem to continue fishing during bans and are supported by local police. Some non-conventional fishery species like elasmobranch, shark and rays, sea turtle, marine mega fauns, crustaceans, molluscs et. are also exploited indiscriminately due to mismatching or inappropriate regulations. Loss of access to fishing areas is also common. Various regulations and restrictions have promoted alternative uses of fishing grounds such as the firing zones, military training areas, commercial navigation routes, port harbours, large-scale industries like liquid natural gas terminals, ship salvaging areas, and other industrial projects. These factors have led to a decrease in fishing activities or even stopping them altogether in certain areas (Islam et al., 2020b). Small-scale fishers are also reluctant to take on local leadership roles, which undermine local organization and collective action such as fishers' associations. Although some associations exist, they are dominated by fish dealers and traders (Rouf & Jansen, 2001; Islam, 2011).

Responses

Our findings showed that coastal small-scale fishing communities in Bangladesh have adopted diverse response strategies in face of vulnerability issues. These responses are largely linked to natural, social, and governance factors (Table 3).

Natural systems

In Bangladesh, the coastal zone, including the islands, has undergone coastal afforestation and mangrove plantation/restoration activities that support natural regeneration of mangroves. Apart from the existing flood control embankments, the Forest Department of Bangladesh emphasizes creating a green belt along the entire coast to provide double protection. This initiative is called 'building back better against natural hazards' (Islam & Jentoft, 2019).

Social systems

Most small-scale fishers in Bangladesh intensify the fishing effort to cope with poverty and adverse conditions, thus increasing fishing pressure and depleting fishery resources (Islam, 2011). Some practices are more common, such as using small-meshed set bag nets, catching undersized fish, and violating legal restrictions on mesh size. Many fishers cope with lower incomes by reducing their daily expenditures and food intake. During fishing bans, the prices of low-value and cultured fish also increases, making it difficult for them to purchase any type of fish for consumption. Instead, they consume more cheaper vegetables and less rice (Islam, 2012). In some cases, they also tend to reduce the number of meals to twice or once a day (Islam et al., 2016). Fishing families in Bangladesh often pass down their trading practices to next generations. To reduce financial vulnerability, some diversify their income by having family members participate in fishing-related activities (as unpaid family labour) or alternative income-generating activities such as gardening. Children and women who commonly work in fishing operations also supplement their income through activities such as fish drying, net making and mending, and poultry and livestock raising (Islam, 2012). However, financial issues can force children to work, which essentially puts a stop to their education. Shrimp PL collection, despite being banned, is also a common practice among women and children (Islam et al., 2016).

Fishers in Bangladesh are often forced to migrate due to changes in fish stocks and fish habitat, including seasonal shifts in fishing grounds and fishing bans (Islam & Herbeck, 2013; Islam et al., 2017). These changes lead to seasonal unemployment, forcing some to seek alternative livelihoods or engage in illegal activities. Some also resort to selling their assets or illegally migrating to neighbouring countries (Islam & Herbeck, 2013). The lack of gainful employment and the absence of alternative income sources can also lead to crime and social unrest among affected communities. Fishers often turn to *dadondar*s (money lenders) for financial assistance, despite these being largely exploitative patron-client relationships (Islam, 2011). Nonetheless, these types of borrowings provide some security for the fishers, as they receive loans without having to provide collateral. *Dadondars* also offer support in social security and legal matters.

Table 3: Coping responses by small-scale coastal fishers.

Systems	Example of small-scale fisheries responses activities	References
Natural	Coastal afforestation (green belt), and mangrove plantation, facilitate the natural regeneration of mangroves Planting trees around the house, along the road, the river bank, dam	Islam and Jentoft, 2019
Social	Getting food aid, incentives, and other relief support from governmental organizations, NGOs, charities, or social networks Reducing the size and frequency of daily meals Cancelling celebrations of social and religious festivals for cost reduction Intensifying resource exploitation- disobedience and violation of fishing regulations Diversification of income by a variety of measures Patron-client relationship -taking loans/microcredit from *Dadonder/ Mohajon*, usually at a high-interest rate Women's involvement in fishing Discontinued child education and involved teenage boys in fishing activities Preventive measures and creating safety buffer- selling jewelry (gold, silver) or household assets - trees and livestock or fishing boat Strengthening and modification of the house Migration (both in and out)	Islam and Chuepagdee, 2017; Islam, 2011; Islam, 2012; Mozumder et al., 2018; Mozumder et al., 2019; Islam et al., 2016; Islam et al., 2017; Islam et al., 2020a; Islam et al., 2021; Rahman et al., 2012
Governance	Restrictions in fishing Compensation for income loss during the fishing ban Disaster warning and cyclone shelter	Islam et al., 2016; Islam et al., 2017; Islam et al., 2021

Governance systems

Bangladesh has enacted various regulations to promote sustainable fisheries by focusing on controlling fishing methods and protecting marine resources. These regulations include restrictions on mesh sizes, fishing gear, and closed seasons or fishing areas (Islam et al., 2017). There are also six hilsa sanctuaries where fishing is prohibited by any means (Islam et al., 2016). In addition, the government has banned destructive fishing gear, such as monofilament gill nets and has recently imposed a fishing ban in the Bay of Bengal to conserve the ecosystem (Islam et al., 2021). These measures aim to ensure the long-term sustainability of the country's fisheries. As compensation for income lost during the ban, the Government of Bangladesh provides 40 kg of rice per month to hilsa fishing families (Islam et al., 2016). However, this incentive scheme is criticized for its inadequacy and mismanagement (Mozumder et al., 2019). Despite the 65-day ban period, the scheme fails to effectively address the dissatisfaction among coastal fishing communities. The government is also working to lessen the potential damage from climatic and weather events in the coastal regions through awareness campaigns. For example, fishers now report seeking shelter during cyclones showing the effectiveness of these initiatives (Mozumder et al., 2019).

Towards viability of fisheries-based coastal livelihoods in Bangladesh

The vulnerabilities of small-scale fishing communities undermine their food security, livelihoods, economy, employment, values, culture, and identity and threatens their viability and sustainability. Coping mechanisms used by fishers provide support to survive in the short-term but are insufficient in the long-term (Islam et al., 2020a). A co-management approach with stakeholder involvement can restore the social resilience of local fishery-based communities (Islam & Chuepagdee, 2017; Mozumder et al., 2018; Islam et al., 2020. As a collaborative approach to managing natural resources, co-management typically involves the government and local communities as partners (Berkes, 2009). The co-management approach is based on the idea that local resource users have valuable knowledge and insights that can complement formal scientific knowledge and enhance the effectiveness and sustainability of natural resource management. This approach work in a manner that resource users and government agencies share power and responsibility for decision-making regarding natural resources, such as fisheries or forests. Establishing local institutions, poverty alleviation programs, self-help groups, conserving mangroves, and village knowledge centres are necessary to promote long-term resilience (Guleria & Edward, 2012). Creating resilience requires risk management and adaptation options integrated with the community's social fabric and vision. Access to credit is a vital indicator of resilience. Traditional banks and cooperatives often fail to provide loans, leaving fishers dependent on moneylenders who exploit them. Cooperatives are recognized for their role in promoting economic progress and reducing dependence on moneylenders (Sharifuzzaman et al., 2018). Additionally, promoting diversification and supplementary income from non-fishing sources such as agriculture and small businesses, is also crucial. For example, craft making, net making, and raising poultry are identified as women-friendly, additional income-generating activities (AIGAs). Institutional support that should be supported by the government and NGOs can further increase the effectiveness of such strategies (Rahman et al., 2012). To improve riverine ecosystems, necessary actions include rehabilitating habitats and migration routes by dredging silted river channels and planting trees to prevent siltation (Islam et al., 2020). Better cooperation among different levels of government, fishers, NGOs, and other stakeholders is necessary sustainable fishery management, including conflict management. Co-management approach can be effective in this regard, particularly towards increasing compliance and legitimacy of fisheries governance (Islam et al., 2016).

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This book is a comprehensive guide for small-scale fisheries in Bangladesh for those interested in learning more about this vital sector. It provides an overview of the importance of small-scale fisheries, the challenges they face, and the opportunities they offer. This edited volume collected contributions from academics, researchers, NGO representatives, and practitioners who have a stake in Bangladesh's small-scale fisheries. The book is designed to provide a thorough introduction to small-scale fisheries in Bangladesh and help readers understand the importance of preserving this valuable resource. We hope this book will be of great use to those interested in learning more about the country’s small-scale fisheries and in supporting the sustainable management of this important resource. We also hope it will raise public awareness and inform policymakers of the need to protect these valuable fisheries and the livelihoods of the people who depend on them.

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