Bangladesh
Climate Change Impacts & Small-scale Fisheries

A Case Study of Adaptation and Resilience

Written by
Md. Mujibul Haque Munir

International Collective in Support of Fishworkers
ICSF

Fisherwomen drying fish at Cox's Bazar, by Din M. Shibly

Bangladesh: Climate Change Impacts & Small-scale Fisheries
A Case Study of Adaptation and Resilience in Bangladesh

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Front Cover
Fishermen in Cox's Bazar load ice into the fish reservoirs on their craft, ensuring cold storage conditions during their upcoming sea fishing trip, by Md. Mizanur Rahman Bahadur

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Climate Change

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Map courtesy: Perry-Castañeda Library Map Collection, University of Texas at Austin.
https://maps.lib.utexas.edu/maps/middle_east_and_asia/txu-pclmaps-oclc-742924775-bangladesh_pol-2011.jpg

Contents

Introduction

In the wake of escalating climate change, nations around the globe are grappling with the consequences of environmental degradation, sea-level rise, and extreme weather events. Among these, Bangladesh stands as a poignant example of vulnerability, despite its minimal contribution to global greenhouse emissions. This case study investigates the intersection of climate change impacts and the small-scale fisheries (SSF) sector in Bangladesh, with a specific focus on the adaptive strategies employed by the fisherfolk of the districts of Cox's Bazar and Bhola.

This case study's urgency emanates from the palpable and accelerating impacts of climate change on Bangladesh's SSF communities. The research zeroes in on the pivotal role of the fisheries sector—in the national economy and food security—and the frontline struggles of small-scale fishers. The case study documents the technologies and adaptation initiatives in Cox's Bazar and Bhola districts, recognizing the unique challenges for SSF communities. Through a nuanced examination of climate-related challenges—sea-level rise, cyclones and salinity intrusion—the case study unveils the impacts on these communities and sheds light on the adaptive strategies they employ to enhance their resilience.

The initial section reviews related literature to contextualize the urgency of the case study, illuminating the multi-faceted challenges facing Bangladesh. After exploring the indispensable role of the fisheries sector, the section paints a detailed picture of the current situation of the national SSF sector, accentuating the unique vulnerabilities of small-scale fishing communities.

The subsequent section investigates the specific impacts of climate change on the fisheries sector to define such climate-related challenges as sea-level rise, extreme weather events like tropical cyclones, and salinity intrusion; all of which portray the harsh realities that SSF communities confront. Shifting to the human aspect, the case study further delves into the nuanced perspectives of small-scale fishers; it highlights their insights into how climate change directly affects their access to fisheries resources and livelihoods. Complementing this is a comprehensive review of existing literature on climate adaptation among Bangladeshi fishers. Drawing from various sources, the section presents evidence that showcases successful climate adaptation measures employed by these communities, bridging academic knowledge with lived experiences.

The case study contributes not only to academic discourse, but also to the practical realm of climate change adaptation. By providing an in-depth examination of climate change impacts, adaptation strategies, and community resilience, this case study offers actionable insights for policy makers, practitioners, and communities alike. In addition, it contributes towards sustainable adaptation.

Objectives

The case study's objectives are to:

a. Document the dynamics of climate change adaptation measures and their tangible impacts on fishing communities in Bangladesh. Specifically, the nuanced ways in which climate change disrupts their access to fisheries resources and jeopardizes their livelihoods

b. Understand how these measures resonate at various levels and how they translate into tangible benefits for SSF communities

c. Provide recommendations for building resilience and empowering these communities in the face of environmental challenges

Methodology

Data Collection

- **Primary Data:** The case study employed semi-structured interviews and Focus Group Discussions (FGD) to obtain first-hand information from fisherfolk to document their perceptions of climate change, its ramifications on fisheries and SSF communities, and the strategies adopted by these communities to enhance their capacity for climate change adaptation.

A total of 16 FGDs were conducted across the country's three districts. Originally, the plan was to conduct FGDs exclusively in Bhola and Cox's Bazar districts. However, acknowledging the unique attributes and significant contribution of the northern regions to inland fisheries, two additional FGDs were arranged in Rangpur district. Their distribution is as given in Table 1.

Table 1. FGD numbers and total participants

Sl.	Area	Total FGDs	Total Participants		
			Male	*Female*	*Total*
1	Bhola	7	50	10	60
2	Cox's Bazar	7	60	10	70
3	Rangpur	2	50	4	54
Total		**16**	**160**	**24**	**184**

In addition to the FGDs, discussions were held with fisheries officers of Bhola district and its sub-district Charfasson, as well as Cox's Bazar. The researchers also conducted interviews with boat owners, prominent fish market entities, and leaders of the fishing communities of the two districts.

- **Secondary Data:** The case study reviewed government reports, academic literature, reports from non-government organizations (NGOs), and news media articles.

Sites

The districts of Bhola and Cox's Bazar highlight the SSF communities' vulnerability to climate change and the importance of their fisheries in the broader national context:

- **Vulnerability to natural disasters:** Bhola, the country's largest island, is prone to natural hazards across the year. It has a long history of suffering—directly and indirectly—from catastrophic weather events. Bhola experienced the world's deadliest tropical cyclone on record; originating from a depression in the south-central Bay of Bengal, it struck what was then East Pakistan on November 12-13, 1970. The storm surge killed an estimated 300,000 to 500,000 people on low-lying islands and tidal flats along the bay.[1]

Figure 1. Case study sites highlighted in red: Bhola district (left) and Cox's Bazar (bottom right)

- **Fisheries Contribution:** Both Bhola and Cox's Bazar are renowned for their marine fisheries, specifically for their significant contribution to the total catch of Bangladesh's national fish, the hilsa or ilish *(Tenualosa ilisha).* These districts contribute 33 per cent of the nation's total hilsa production.[2]

  Cox's Bazar is predominantly agricultural, with 49 per cent of the total population engaged in fishing and salt production.[3] Fishing aboard trawlers or craft provides sustenance to 18 per cent of rural households. The harvest here is distributed across thecountry and also exported.[4] One study in 2023 found that 71 per cent of the people of the Sadar area in Cox's Bazar are fishers.[5] The district is a significant SSF hub, boasting a concentration of 356,601 individuals engaged in artisanal fishing and related activities. This figure represents 39.3 per cent of the country's total artisanal

1 World Meteorological Organization. https://wmo.int/media/news/worlds-deadliest-tropical-cyclone-was-50-years-ago. Retrieved on March 8, 2024.

2 Bangladesh Sangbad Sangstha, September 5, 2022. 'Target set to produce 192,000 metric tons of hilsa in Bhola', BSS from Bhola. https://www.bssnews.net/bangla/trade/57010

3 COX'S BAZAR Upazila Profiles, https://www.acaps.org/fileadmin/Data_Product/Main_media/20200917_acaps_coxs_bazar_analysis_hub_upazila_profiles.pdf. Retrieved on 8 March, 2024.

4 Bangladesh National Portal, Cox's Bazar District. https://shorturl.at/dsVY6. Retrieved on March 31, 2024.

5 Akter, Aklima & Akash, Armanul & Sultana, Tahsin & Tamzi, Nafisa Nawar & Afroze, Shama & Faisal, Dr. (2023). Socio-economic status of fishermen in cox's bazar district of Bangladesh. International Journal of Fisheries and Aquatic Studies. 11. 208-213. 10.22271/fish.2023.v11.i5c.2865.

fishers.[6] As per the Department of Fisheries (DoF), Cox's Bazar alone accounts for 21.09 per cent of the nationwide registered fishers. The district has over 100,000 fishers, but only about 63,000 are registered.[7]

The DoF has identified Bhola district as one of the major inland fish producing districts. The department's data for 2019-2020 showed a total nationwide annual fish catch of 331,793 metric tonnes (MT) across all rivers. Bhola district made a significant contribution to this production—accounting for about 88,344 MT or 26.61 per cent of the total catch.[8] About 80 per cent of the district's population relies on fisheries for their livelihood.[9] The total number of registered fishers is 164,886.[10] There are 53,230 people engaged in fish aquaculture.

- **Vulnerability to climate change:** The Nationwide Climate Vulnerability Assessment (https://climatefinance.erd.gov.bd/publications/16) reveals high vulnerability scores for both Bhola and Cox's Bazar in terms of risk from natural disasters and changes in fish aquaculture. The Climate Vulnerability Index (CVI) for both districts reveals higher vulnerability indices in terms of capture fisheries compared to other factors like the number of people affected by natural disasters, heat stress, land availability for livestock, and water availability. In Cox's Bazar, the average vulnerability index for capture fisheries, calculated across all eight sub-districts, stands at 0.39. In the seven sub-districts of Bhola, it is slightly higher at 0.44. When it comes to fish culture, the vulnerability averages for Bhola and Cox's Bazar are 0.39 and 0.37, respectively. (In such an index, a 1.0 score indicates the highest level of vulnerability.) The two districts' standing on these indices points to a considerable level of vulnerability, specifically in the domain of capture fisheries, which directly affects the primary livelihood of 65 per cent of fishers in these districts. The higher vulnerability in this sector implies increased risks and challenges.

  The economic implications of this vulnerability are substantial. In Bhola, any disruption in fishing operation not only affects the fishers, but also the total fish production of the country and its capacity to meet the seafood needs of its population. The vulnerability indices also highlight the susceptibility of capture fisheries operations to alterations in their traditional practices due to climate change. Notably, both regions exhibit high vulnerability across various factors. For instance, in Bhola, the average vulnerability for people affected due to natural disaster is 0.61; heat stress is 0.36; land availability for livestock is 0.46, and water availability is 0.47. Meanwhile, in Cox's Bazar, these figures are 0.61, 0.34, 0.42, and 0.49, respectively.

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6 Bangladesh Fisheries Development Corporation. 2023. Preparatory Survey on the Project for Improvement of Bangladesh Fisheries Development Corporation Fish Landing Center, Cox's Bazar.

7 The Business Standard. 2022. Fishermen all geared up as marine fishing resumes after 65 days. https://www.tbsnews.net/economy/fishermen-all-geared-marine-fishing-resumes-after-65-days-463762. Retrieved on March 6, 2024

8 DoF. 2020. Yearbook of Fisheries Statistics of Bangladesh, 2019-20. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries and Livestock, 2020. Volume 37: 141p.

9 Bangladesh National Portal, Bhola District. https://bhola.gov.bd/en

10 Department of Fisheries, Bhola. 2024. Fish Sector Information and Activities.

A fleet of small and medium-sized craft, fully equipped with nets and supplies, prepares to depart for fishing in Char Kukri Mukri, Bhola district, by Md. Mizanur Rahman Bahadur

- **Displacement and Erosion:** On Bangladesh's islands, where the dependence of many residents on fishing is high, the challenges are exacerbated by river erosion—with the retreating riverbanks displacing fishers from their homes. The Kutubdia sub-district of Cox's Bazar, situated in the Bay of Bengal, is predominantly reliant on farming and fishing for subsistence. Between 1880 and 1980, Kutubdia Island experienced a significant loss of landmass: almost 65 per cent lost over that century. The once expansive 250-square kilometre area had dwindled to less than 60 sq km by 2007, forcing more than 60 per cent of its population to seek refuge in urban areas.[11] Similarly, Manpura Island, a sub-district located 80 km from Bhola town, is home to approximately 125,000 people engaged in fishing as their primary livelihood. Over a 37-year period, from 1973 to 2010, the total land area of Manpura Island has steadily decreased from 148 sq km to 114 sq km.[12] Both cases further attest to the deleterious impact of fast-moving environmental changes on these island communities.

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11 Shamsuddoha, M., and R. K. Chowdhury. 2007. Climate change impact and disaster vulnerabilities in the coastal areas of Bangladesh. COAST Trust, Dhaka, Bangladesh

12 Ali, Md & Haque, Fazlul & Rahman, Shah & Iqubal, Kazi & Nazma, & Ahmed, Ashfaque. 2013. Loss and gain of the land of Manpura island of Bhola district: An integrated approach using remote sensing and GIS. Dhaka University Journal of Biological Sciences.

1. Climate Change and Bangladesh's Fisheries

The fisheries sector: An overview

Known as the 'Land of Rivers', Bangladesh evolved into a prime region for fisheries thanks to its picturesque riverine landscape. One of the world's largest deltas, featuring the planet's most extensive flooded wetland, it has an intricate network of approximately 230 rivers.[13] Over the past few decades, fisheries has emerged as one of the country's most productive sectors—consistently playing a pivotal role in the national economy. It contributes 2.41 per cent to the national GDP[14] and accounts for 60 per cent of the nation's animal protein production.[15] About 19 million people—10-12 per cent of whom are women[16]—are directly involved with the sector.[17]

In a report titled 'The State of World Fisheries and Aquaculture 2024' by the Food and Agriculture Organization (FAO), Bangladesh was ranked second in inland open water capture production and fifth in world aquaculture production.[18] Moreover, Bangladesh was ranked first among eleven hilsa producing countries in the world; as well, it was ranked fourth in tilapia production in the world and third in Asia.[19] Bangladesh's fisheries industry extends to international markets; its exports reaching 52 countries. In 2022-23, fish exports amounting to roughly 70,000 MT generated Bangladeshi Taka (BDT) 47.9 billion (1 BDT = 0.0082 USD).

The sector is divided between inland fisheries and marine fisheries. While marine fisheries feature industrial (trawler) and artisanal fisheries (wooden craft), inland fisheries are

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13 The UNESCO, Courier (2019-1), Https://En.Unesco.Org/Courier/2019-1/Land-Wild-Rivers. Accessed On 19th October 2010.

14 Finance Division. 2023. Bangladesh Economic Review 2023. Ministry of Finance Government of The People's Republic of Bangladesh

15 Department of Fisheries (DoF). 2022. Yearbook of Fisheries Statistics of Bangladesh, 2021-22. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries, 2022. Volume 39;139p

16 Bangladesh Government and World Fish, Fishing for A Future Women in Community Based Fisheries Management, Accessed the Softcopy on 18th October 2020 Via: http://Pubs.Iclarm.Net/Resource_Centre/Fishing%20for%20Future%20-%20Women.Pdf

17 Dhaka Tribune. 2023. Minister: Govt set target to produce 8.5 million tons of fish by 2041. July 24, 2023 https://www.dhakatribune.com/bangladesh/319546/minister-govt-set-target-to-produce-8.5-million

18 FAO. 2024. The State of World Fisheries and Aquaculture 2024 – Blue Transformation in action. Rome, FAO. https://doi.org/10.4060/cd0683en

19 DoF, 2022 Annual Report 2020-21 Department of Fisheries, Bangladesh

further split into capture fisheries and culture fisheries. Inland capture encompasses rivers, estuaries, beels (wetlands with static water), floodplains, the Sundarbans, and Kaptai Lake. Meanwhile, inland culture accounts for ponds, seasonal cultured water bodies, baors (oxbow lakes), shrimp/prawn farms, crab cultivation, pen culture, and cage culture.

Inland fisheries contribute 85.16 per cent of Bangladesh's total fish production, while marine fisheries account for the remaining 14.84 per cent.[20] Inland culture fisheries are spread across 797,851 hectares; this includes 391,753 hectares of ponds (about half the total area), 136,622 hectares of seasonal cultured waterbodies, 5,488 hectares of baors, 258,681 hectares of shrimp/prawn farms, and 5,294 hectares of pen culture.[21] In 2017-18, pond aquaculture production accounted for 1.9 million MT, which was 44.43 per cent of the country's total inland culture fisheries production. This was followed by shrimp aquaculture, which contributed 254,367 MT, and then seasonal culture with 216,353 MT. [22]

Two fishermen in Char Kukri Mukri prepare their fishing nets against the backdrop of anchored craft, readying for the next catch, by Md. Mizanur Rahman Bahadur

20 Department of Fisheries (DoF). 2022. Yearbook of Fisheries Statistics of Bangladesh, 2021-22. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries, 2022. Volume 39;139p

21 DoF, 2018. Yearbook of Fisheries Statistics of Bangladesh, 2017-18. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries, 2018. Volume 35

22 DoF, 2018

Bangladesh has about 260 freshwater fish species and two freshwater shrimp species.[23] The main species in inland fisheries include major carps, large catfishes, minor carps, small catfishes, river shads, snakeheads, freshwater eels, feather backs, perches, loaches, anchovies, gobies, glass fishes, mullets, minnows, barbs, and flounders. Three Indian major carps are the target species for inland aquaculture: rohu (Labeo Rohita), catla (Catla catla), and mrigal (Cirrhinus mrigala). Silver carp, grass carp, and some minor carps are also traded. Tilapia is widely cultured.

Bangladesh's 710-km coastal and marine environment supports a rich fisheries ecosystem. The marine fisheries sector, governed by the Marine Fisheries Ordinance of 1983, emphasizes responsible fishing practices. As major export products, hilsa and shrimp are integral to marine fisheries. Following the verdict of the International Tribunal for the Law of the Sea (ITLOS) in the Bangladesh-Myanmar maritime delimitation case, the marine fisheries sector garnered increased attention. The 2012 judgement granted Bangladesh exclusive economic and territorial rights over a vast sea area, leading to initiatives for resource assessment and management.[24] A 2016 survey identified 349 marine species under the FAO-funded project 'Technical Support for Stock Assessment of Marine Fisheries Resources in Bangladesh'.[25]

Inland capture fisheries are regulated through a leasing system initiated after the abolition in 1951 of the colonial-era zamindari system of land revenue. Under the Ministry of Land (MoL), the leases are auctioned for periods ranging from one year to nine years. In addition, the Ministry of Fisheries and Livestock (MoFL) oversees the relevant policy formulation. The fisheries sector's institutional framework is led by MoFL, overseeing bodies like DoF, Bangladesh Fisheries Development Corporation (BFDC), Bangladesh Fisheries Research Institute (BFRI), and Fisheries and Livestock Information Department (FLID). Each institution has distinct roles in policy formulation, research, development, marketing, and information dissemination. In addition, the National Aquaculture Development Strategy and Action Plan of Bangladesh 2013–2020 guides the management of closed water fisheries, focusing on poverty reduction, employment creation, and sustainable development.

Co-management initiatives, particularly Community-Based Fisheries Management (CBFM), have gained prominence as means of dealing with mismanagement and resource depletion. Several projects demonstrate the success of collaborative approaches in sustainable fisheries management; they include Haor Infrastructure and Livelihood Improvement Project (HILIP), Enhanced Coastal Fisheries (ECOFISH) in Bangladesh, Climate Resilient Ecosystems and Livelihoods (CREL), Community-Based Sustainable Management of Tanguar Haor (CBSMTH), and Community-Based Fisheries Management in South and South East Asia (CBFM-SSEA).

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23 Khan, S. M. Munjurul Hannan, Khan, M. Monirul H., Ahmed, Rashiduzzaman, Joarder, Nargis Banu, Pavel, Shameem, Neela, Ismot Ara, Ameen, Mahmud-Ul, Islam, M. Anwarul, Nishat, Ainun. 2000, Red Book of Threatened Fishes of Bangladesh, International Union for Conservation of Nature (IUCN).

24 Rear Admiral Md. Khurshed Alam, (Secretary, Department of Maritime Affairs, Ministry of Foreign Affairs, Bangladesh. 2012. Delimitation of Maritime Boundary Between Bangladesh and Myanmar by ITLOS, The Northern University Journal, Volume III.

25 Department of Fisheries, Ministry of Fisheries and Livestock. 2018. Annual Report 2017.

Women fishing in the wetlands of Bhola district, Bangladesh, by Atikur Rahman

The impact of climate change

Bangladesh faces significant challenges from the impacts of climate change. Despite its greenhouse emissions being among the lowest, Bangladesh stands as one of the most severely affected countries. A report from the World Bank predicts a temperature increase between 1°Celsius and 1.5°C in Bangladesh by 2050, leading to approximately 134 million people being adversely affected. The projected loss for the country during this period is estimated at around US $167 billion. The anticipated reduction in life expectancy of its population is 6.8 per cent by 2050.[26] According to the NGO Germanwatch, Bangladesh ranks as the ninth most affected country globally from climate change.[27]

Figures from 2015 reveal that 13 per cent of households and 12.65 per cent of the population reside in disaster-prone areas. Bangladesh faces a range of major disasters, including floods, cyclones, tornadoes, and earthquakes. It is estimated that 70 per cent of Bangladesh's landmass is susceptible to flooding.[28] The government projects that

26 Mani, Muthukumara, Sushenjit Bandyopadhyay, Shun Chonabayashi, Anil Markandya, And Thomas Mosier. 2018. South Asia's Hotspots: The Impact of Temperature and Precipitation Changes on Living Standards. South Asia Development Matters. Washington, DC: World Bank.

27 David Eckstein, Marie-Lena Hutfils and Maik Winges. 2018. Global Climate Risk Index 2019: Who Suffers Most from Extreme Weather Events? Weather-Related Loss Events In 2017 And 1998 To 2017, Germanwatch

28 General Economics Division (GED), Bangladesh Planning Commission. 2020. Sustainable

about 20 million people residing in coastal areas face displacement.[29] Severe floods, submerging approximately 60 per cent of the country's land area, occur every four to five years.[30] According to a 2015 report, an estimated 8.3 million Bangladeshis live in high-risk cyclone zones.[31] According to data released by Bangladesh's Ministry of Disaster Management and Relief (MoDMR), the rate of death (as calculated per 100,000 population) due to climate-related disasters had increased slightly between 2016 and 2019. Meanwhile, 14.6 million coastal residents are vulnerable to widespread natural disasters; this number is anticipated to rise to 18.5 million by 2050.[32]

Climate change poses a significant threat to food security, impacting crop—especially rice—production. The shortage of irrigation water, particularly during the pre-monsoon period, is already constraining the production of high-yield rice, which constitutes about 36 per cent of the total rice output. Recent assessments suggest that under a moderate climate scenario, the country may face a loss of 0.2 million tonnes of crops due to salt intrusion. However, in a severe climate scenario, various water-related risks, such as floods, cyclones, storm surges, and both surface and groundwater salinity, are likely to adversely affect communities.[33]

About 40 per cent of the population comprises impoverished individuals, for whom a variable and unpredictable climate can critically limit livelihood options.[34] According to the World Health Organization (WHO), over 7.1 million Bangladeshis were displaced by climate change in 2022.[35] This number is expected to increase to 13.3 million by 2050. The Association for Climate Refugees (ACR) estimated that 6 million people have already been displaced by climate hazards in the country—half of them due to coastal and riverine issues like tidal floods and riverbank erosion.[36]

Development Goals: Bangladesh Progress Report 2020. Ministry of Planning, Government of The People's Republic of Bangladesh.

29 Ministry of Environment, Forest and Climate Change, Bangladesh Climate Change Strategy and Action Plan (2009), (Government of Bangladesh)

30 Displacement Solutions, Climate Displacement in Bangladesh: The Need for Urgent Housing, Land and Property (HLP) Rights Solutions, May 2012.

31 World Health Organization. https://www.who.int/bangladesh/news/detail/16-11-2015-climate-change-threatening-human-health-make-focused-efforts-to-mitigate-risks-who. Retrieved on March 31, 2024.

32 World Bank, Bangladesh and Maldives Respond to Climate Change Impacts (7 December 2012). https://www.worldbank.org/en/news/press-release/2012/12/07/bangladesh-maldives-respond-to-climate-change-impacts

33 Huq, S and Rabbani, G. 2011. Climate Change and Bangladesh: Policy and Institutional Development to reduce vulnerability. Journal of Bangladesh Studies. Volume 13, no, pp 1-10]

34 Manoj Roy, Simon G, David Hulme, Ferdous Jahan. 2011. Poverty and climate change in urban Bangladesh (CLIMURB): an analytical framework/ Brooks World Poverty Institute, BWPI Working Paper 148. May 2011

35 The Daily Star. 2022. Over 7.1m Bangladeshis displaced by climate change in 2022: WHO. Retrieved on 6 March, 2024. https://www.thedailystar.net/environment/climate-change/news/over-71m-bangladeshis-displaced-climate-change-2022-who-3181851

36 Displacement Solutions. (2012, May). Climate Displacement in Bangladesh: The Need for Urgent Housing, Land and Property (HLP) Rights Solutions.

Fishermen preparing their nets on Manpura Island, Bangladesh, by Atikur Rahman

Thus, Bangladesh faces an alarming convergence of climate challenges, with its coastal communities bearing the brunt of tropical cyclones, storm surges, changes in salinity levels, sea-level rise, changes in water temperature, and changes in rainfall and drought patterns.[37] The FAO has recognized tropical cyclones and coastal erosion as compounding threats to both capture fisheries and aquaculture. These manifest in disrupted biological processes, altered habitats, and shifting species distributions.[38] As the country grapples with drying water bodies, hampered breeding cycles, and aquaculture disruptions, the resilience of fishing communities is severely tested.

Numerous studies paint a concerning picture of climate change's negative impacts on the fisheries sector. These range from disruption in fish habitats and breeding cycles, to disease outbreaks. Already, such effects as drying water bodies, unfertilized eggs, lower hatching rates, late fry availability, and disrupted breeding cycles have been felt.[39] Aquaculture remains the primary driver of Bangladesh's fish production. However, the sector remains vulnerable to climate change-induced disruptions of fishpond operations. A study in 2010 revealed high temperatures triggering disease outbreaks and decreasing dissolved oxygen levels.[40] This gets coupled with reduced rainfall, stunting the fish, and

37 Islam MA, Wahab MA, Alam ABMS. Effect of temperature on the monosex tilapia (Oreochromis niloticus) egg production in a private hatchery and nursery system. Aqua-internship program Asia link project, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. 2010.

38 Food and Agriculture Organization (FAO) of the United Nations. 2009. The State of Fisheries and Aquaculture 2008.

39 Islam and Wahab, 2010.

40 Muhammad Tanvir Hossain Chowdhury et al, 'Climate Change and Its Impact on Fisheries Resources in Bangladesh' (Conference Paper, International Conference on Environmental Aspects of Bangladesh, 2010) ,95–97.

seasonal fluctuations—leading to lower fish production.[41]

Seasonal fluctuations, in the realm of climate change, refer to the regular variations in weather patterns experienced annually. These fluctuations bring about unpredictable changes in temperature, precipitation, and other meteorological elements from one season to another. Climate change disrupts these established patterns, altering traditional seasonal cycles and intensifying extreme weather events. For instance, in Bangladesh's agriculture and fisheries sectors, reliance on seasonal norms is paramount. However, recent shifts, like unexpected rainfall during the typically dry winter months, have damaged crops traditionally cultivated during this period. Similarly, fishermen face challenges as erratic rainfall and untimely cyclones disrupt their traditional seasonal planning. These disruptions epitomize the impact of seasonal fluctuations exacerbated by climate change.

According to the DoF, historical fisheries trends reveal climate variability as a significant contributor to the declining catch of hilsa between 1970 and 1990.[42] A 2017 report also highlights fish mortality triggered by erratic or incessant rain.[43] In April 2017, early incessant rain caused a flash flood that resulted in large-scale fish death in Haor (a wetland ecosystem in north-eastern Bangladesh). Brood fish migration, crucial for breeding, is significantly affected by a lack of regular rainfall and water scarcity. Heavy rainfall, intensified by climate change, fills migration routes with sand, boulders and silt that obstruct breeding migration, causing a decline in capture fisheries production.[44]

Meanwhile, fishing communities are forced to relocate to higher ground for survival.[45] The FAO predicts a severe negative impact on the lives and livelihoods of millions in Bangladesh, with a projected 18.69 per cent reduction in fish catch by 2100.[46] Bangladesh stands 18th globally in terms of susceptibility to climate change impacts on marine fisheries.[47] SSF communities situated close to the coast may have easy access to fishing grounds,

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41 Alam, Edris & Mallick, Bishawjit. (2022). Climate change perceptions, impacts and adaptation practices of fishers in southeast Bangladesh coast. International Journal of Climate Change Strategies and Management. ahead-of-print. 10.1108/IJCCSM-02-2021-0019.

42 DoF. 2020. Yearbook of Fisheries Statistics of Bangladesh, 2019-20. Fisheries Resources Survey System (FRSS), Department of Fisheries. Bangladesh: Ministry of Fisheries and Livestock, 2020. Volume 37: 141p.

43 Deshwara, M., 2017. Fish dying at Hakaluki haor after flood. Daily Star, Bangladesh. https://www.thedailystar.net/country/fishes-dying-hakaluki-haor-after-flood?1392235.

44 Akhter, J.N., Rahman, M.K., 2016. Impacts of climate change on fish and aquatic resources of Bangladesh. In: National Fish Week Compendium 2016 (In Bengali). Department of Fisheries, Ministry of Fisheries and Livestock, Dhaka, Bangladesh, pp. 120–123.

45 Md Monirul Islam et al, 'Migrating to Tackle Climate Variability and Change? Insights from Coastal Fishing Communities in Bangladesh' (2014) 124(14) Sustainability Research Institute, School of Earth and Environment, University of Leeds, UK 14,733-46.

46 Manuel Barange, Tarûb Bahri, Malcolm C.M. Beveridge, Kevern L. Cochrane, Simon Funge-Smith, Florence Poulain (Eds). 2018. Impacts of climate change on fisheries and aquaculture: Synthesis of current knowledge, adaptation, and mitigation options. FAO, Rome. 2018

47 Blasiak, R. et al., 2017) Spijkers, J.; Tokunaga, K.; Pittman, J.; Yagi, N.; Österblom, H. Climate change, and marine fisheries: Least developed countries top global index of vulnerability. PLoS ONE 2017, 12, e0179632.)

but they often find themselves in a precarious position. As a sector dependent on climate-sensitive fisheries resources, they remain among the underprivileged.[48]

Fishers face mass destruction of their resources; lacking alternative income sources, they often have to resort to migration.[49] Economic losses in the fisheries sector are staggering. The southern part of the country is experiencing the highest economic loss of over US $17.65 million. The entire region is hit by losses attributed to storm surges, waterlogging, cyclones, floods, drought, and erosion.[50] Simultaneously, crops rot, pushing people reliant on agriculture and fishing into a cycle of misery.[51] Studies have identified severe losses in aquaculture stocks, crops, livelihoods, and biodiversity. The complex network of communication in the fish trade gets disrupted, and infrastructure, aquaculture facilities, fishing craft, and equipment suffer damage and destruction.[52]

A 2018 study emphasizes the far-reaching consequences of altering climate and marine ecosystems.[53] Fish reproduction, growth, and migration—intricately linked to physical factors such as temperature, rainfall, and hydrology—are disrupted. The Ministry of Environment, Forest and Climate Change (MoEFCC) recognizes the threat, stating that sea-level rise leads to saltwater intrusion, impacting soil salinity and decreasing the availability of freshwater. The ministry has identified some impacts of climate change on the country's fisheries sector described in detail in the Third National Communication of Bangladesh to the United Nations Framework Convention on Climate Change (UNFCCC).[54]

Government initiatives to mitigate the impact

According to the Government of Bangladesh's Voluntary National Review (2017) on the implementation of Sustainable Development Goals (SDGs), the conservation of fish biodi-

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48 Israt Jahan, Dewan Ahsan & Md Hasan Farque, 2017. "Fishers' local knowledge on the impact of climate change and anthropogenic interferences on Hilsa fishery in South Asia: evidence from Bangladesh," Environment, Development, and Sustainability: A Multidisciplinary Approach to the Theory and Practice of Sustainable Development, Springer, vol. 19(2), pages 461-478, April.)

49 Islam, M.M.; Islam, N.; Habib, A.; Mozumder, M.M.H. Climate Change Impacts on a Tropical Fishery Ecosystem: Implications and Societal Responses. Sustainability 2020, 12, 7970.

50 Jatish C. Biswas, M. Maniruzzaman, M. M. Haque, M. B. Hossain, M. M. Rahman, U. A. Naher, M. H. Ali & W. Kabir. 2019. Extreme Climate Events and Fish Production in Bangladesh. Environment and Natural Resources Research; Vol. 9, No. 1; 2019

51 Kabir, Russell & Khan, Hafiz & Caldwell, Kay & Ball, Emma.2016. Climate Change Impact: The Experience of the Coastal Areas of Bangladesh Affected by Cyclones Sidr and Aila. Journal of Environmental and Public Health. 2016.10.1155/2016/9654753.

52 Mostafa A R Hossain, Climate change adaptation of Fisheries Sector in Bangladesh. Retrieved from http://gobeshona.net/wp-content/uploads/2014/09/Climate-Change-Adaptation-of-Fisheries-Sector-in-Bangladesh.pdf

53 Hussain, M.G. and Hoq, M.E. (eds.). 2010. Sustainable Management of Fisheries Resources of the Bay of Bengal- Compilation of national and regional workshop reports. Support to Sustainable Management of the BOBLME Project, Bangladesh Fisheries Research Institute. SBOBLMEP Pub./Rep. 2. 122 p.

54 Ministry of Environment, Forest and Climate Change Government of the People's Republic of Bangladesh. 2018. 'Third National Communication of Bangladesh to the UNFCCC' the impact of climate change on fisheries and aquaculture

Non-mechanized fishing craft anchored on the riverbank in Char Kukri Mukri, Bhola district, Bangladesh, by Md. Mizanur Rahman Bahadur

versity and healthy fish stocks is crucial for long-term success in fisheries. The report includes plans to establish Marine Protected Areas (MPAs) for the conservation and protection of fish spawning, development, migration and ecosystems, among others. The report also talks about control under the Strategic Environmental Assessment (SEA) to avoid the loss of fish habitats, the destruction of mangroves, and the depletion of fish stocks. The following represents glimpses of the initiatives of several government entities involved in projects that specifically contribute to adaptation and mitigation in coastal areas:

- At the forefront of climate change mitigation and adaptation is the Department of Environment (DoE), which is spearheading initiatives like the Community-Based Adaptation in the Ecologically Critical Areas through Biodiversity Conservation and Social Protection (CBA-ECA). Through this project, communities are empowered to take ownership of their environment by implementing measures to safeguard biodiversity, while bolstering social safety nets against climate-induced challenges

- The Bangladesh Climate Change Resilience Fund has been pivotal in financing several projects aimed at fortifying resilience. From the construction of multi-purpose cyclone shelters to innovative endeavours like spatial and temporal down-scaling of climate data, their efforts span the spectrum of adaptation and mitigation

- Parallel to these, the Bangladesh Climate Change Trust Fund (BCCTF) stands as a testament to the government's commitment to addressing climate change. With a substantial allocation of funds and hundreds of approved projects, the BCCTF serves as a beacon of hope, channelling resources where they are needed

- The Forest Department has embarked on ambitious projects like Climate Resilient Afforestation and Reforestation, aiming to mitigate the adverse effects through massive reforestation efforts. These green corridors not only serve as carbon sinks, but also as vital habitats for countless species, fostering biodiversity and ecological stability

- Meanwhile, the Institute of Water Modelling (IWM) and the Bangladesh Water Development Board (BWDB) are working hand in hand to assess the impacts of climate change on water resources. Through advanced computational modelling and on-the-ground interventions, they strive to safeguard the lifeline of the nation, ensuring access to clean water even in the face of adversity

- The Department of Disaster Management (DDM) has been unwavering in its commitment to protect lives and livelihoods. It advances initiatives from early warning systems to post-disaster directives to minimize the human cost of climate-induced disasters. Cyclone and flood shelters offer a sanctuary for vulnerable communities during disasters

- The Bangladesh Bureau of Statistics (BBS) plays a crucial role in monitoring and evaluating the impact of climate change on various sectors. Armed with data and insights, they inform policy decisions and allocate resources where they are most urgently needed, ensuring a coordinated response

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The crucial, but often unseen, role of women in post-harvest activities is highlighted at a group discussion on Kutubdia Island, Cox's Bazar, by Md. Mizanur Rahman Bahadur

2. FGDs and KIIs

The impact on the fisheries sector

1. Perception of Fishers

Although fishers tend to have low levels of education, the respondents were still able to relate to the impacts on their lives when specific characteristics of climate change were introduced; for example, changes in weather patterns or the sea level. In response to a question on the changing climate in his region, M. Jasim Uddin, a 29-year-old fisher from Cox's Bazar, asked: "I've heard about climate change, but exactly what is it?" The FGDs made it apparent that all fishers possessed some knowledge or experience of climate change. Discussions confirmed that the fisher community had observed changes in temperature, rainfall patterns, seasonality, tropical cyclones, inundation patterns, and sea-level fluctuations. Rahamat Ullah, 40-year-old fisher from Cox's Bazar, observed: "We note an increase in warm days and nights, along with heatwaves, and a decrease in cold days and nights. Furthermore, we identify a rise in the frequency and intensity of cyclones." This perception aligns with several reports. Additionally, there are forecasts suggesting that the incidence of cyclones is likely to increase in the next five to seven years in the coastal areas. This is consistent with studies forecasting a potential for increased heavy rain, drought, and high temperatures due to climate change.

2. Education and Income: Key Determinants

Insights gleaned from the FGDs with fishing communities unveil nuances in perceptions of climate change and the level of education. They showed a significant correlation between levels of education and income with attitudes towards the effects and susceptibilities linked to climate change. All FGDs were attended exclusively by individuals directly engaged in the fishing industry, including fishermen and fisherwomen. Participants had limited formal education, with the highest reported level being a higher secondary school certificate (HSC), equivalent to the grade XII in the Bangladeshi education system.

Despite directly experiencing the impacts of climate change, many fishers struggled to define the term itself. However, when prompted to discuss its characteristics and impacts, they demonstrated a clearer understanding. This suggests tha education plays a crucial role in shaping the perception of climate change, with lower levels of education potentially hindering articulation of complex concepts. A 2012 study supports this finding; it reported that only a small fraction of respondents, about 10 per cent, were well-informed about climate change, particularly among predominantly uneducated or minimally educated fishers and farmers.[55]

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55 Anik, S.I., &Khan, M.A.S.A. (2012). Climate change adaptation through local knowledge in the north

Along the banks of the Naf River in Cox's Bazar, Bangladesh, fishermen engage in a focus group discussion, sharing insights and concerns, by Md. Mizanur Rahman Bahadur

Participants with higher incomes or greater access to resources showed lower concerns about the impacts of climate change. In contrast, those with lower incomes and fewer resources expressed heightened apprehension. In the FGDs conducted in Cox's Bazar, two participants were initially dismissive of the problem, displaying a casual disregard and expressing unwavering confidence in their own ability to navigate any potential impacts. However, subsequent discussions unveiled that, apart from their involvement in fish culture, these individuals had other sources of income. They also benefited from family members employed in urban areas, ensuring a relatively secure financial footing. This finding aligns with research indicating that low-income families in vulnerable areas tend to be more cognizant of climate change risks, reflecting the influence of socio-economic factors on perception. This finding is further supported by a 2007 study; it highlighted that low-income families in flood-prone areas are more vulnerable to disasters and, therefore, more likely to be concerned about the impacts of climate change.[56]

These findings underscore the need for interventions tailored to address the intersecting dynamics of education, income and vulnerability. Efforts to empower these communities with education and resources can enhance resilience and foster a deeper understanding of climate change complexities. Additionally, initiatives aimed at bolstering adaptive capacity among vulnerable groups can help mitigate unequal impacts of climate change. Central to these efforts is the concept of income diversification as a linchpin strategy. It offers a pathway to economic resilience by enabling communities to buffer against the uncertainties posed by environmental shifts. By limiting reliance on fishing, communities can mitigate the risks associated with climate change-induced fluctuations in fish stocks and environmental conditions.

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eastern region of Bangladesh. Mitigation and adaptation strategies for global change, 17(8), pp.879-896.

56 Brouwer R, Akter S, Brander L, Haque E. Socioeconomic vulnerability and adaptation to environmental risk: a case study of climate change and flooding in Bangladesh. Risk Anal. 2007 Apr; 27(2):313-26.

3. Digital Revolution: Social Media and Mobile Phones

In terms of the origins of the respondents' perceptions and knowledge concerning climate change, the majority cited social media platforms, particularly Facebook, as the primary source of information. In Bangladesh, the arrival of mobile phones revolutionized the sharing of information and learning. The Internet subscriber base had grown to a staggering 131 million by the end of December 2023, covering about 40 per cent of the total population, with 118.49 million mobile internet users and 12.88 million broadband internet users.[57]

All fishers participating in the FGDs used mobile phones and mobile internet services, with the majority using Facebook. As one of the respondents, Jaynal Abedin of Bhola, said, "Nobody here lives without Facebook! We can go without food, but Facebook is indispensable." After social media, the most prominent sources of information were television and newspapers. In Cox's Bazar and Charfasson municipality areas, participants also pointed to FM radio as a crucial source of information regarding climate change, weather and environmental updates. Several FM stations like Radio Today and community platforms like Radio Saikat operate in Cox's Bazar; while Radio Meghna operates in Charfasson. These allow fishers to access programming conveniently via their mobile phones. FM stations are proving invaluable to fishers in several ways. Hasan Majhi from the Char-

Two fishermen in Cox's Bazar display their government-issued ID cards, essential assets that signify their legitimacy in Bangladesh's SSF sector, by Md. Mizanur Rahman Bahadur

57 Dhaka Tribune. 2023. Internet users in Bangladesh reach 131m as of 2023 https://www.dhakatribune.com/bangladesh/339218/internet-users-in-bangladesh-reach-131m-as-of-2023. Retrieved on 31 March, 2024.

fasson area of Bhola attested to this: “During the last cyclone, we lost our mobile network and were missing updates on the storm. It was Radio Meghna that provided us with updates day and night. It was incredibly helpful.”

4. Impacts on Communities: Insights from Fishers

The FGDs provide a vivid insight into the impact of climate change on fishing communities. Abul Kalam of Cox’s Bazar said: “I don’t know why, but it seems nowadays the gap between storms is very small; they are coming quickly. The met office is giving weather updates frequently now. Additionally, it is getting very hot and even the off-shore breeze cannot cool things down.” The perceptions of fishers regarding the rise in temperature, increased frequency of tropical cyclones, and sea level rise align with scientific studies. Data from 1978 to 2016 indicates a notable escalation in major cyclones in Bangladesh, with an average of 3.6 tropical cyclones forming annually in the Bay of Bengal.[58] Interviews and FGDs revealed that the fisher community also observed changes in rainfall, seasonality, inundation pattern and its type, and the sea level. They observed temperature changes as increased warm days and nights, heatwaves and a decrease in the number of cold days and nights.

Given the increasing availability and affordability of scientific instruments, there exists a promising opportunity for community science initiatives or partnerships between SSF groups and academic institutions. By leveraging scientific instruments such as weather stations, water level sensors, and satellite imagery, these collaborations can validate and augment community observations of environmental changes. For instance, SSF members can contribute their on-the-ground knowledge and observations, while academic institutions can provide technical expertise and access to advanced monitoring equipment. Together, they can design and implement research projects to collect empirical data on parameters like temperature, precipitation, sea level and storm events.

By integrating local knowledge with scientific methodologies and instruments, these partnerships can enhance the accuracy and reliability of observations. This not only strengthens the validity of community insights, but also generates valuable datasets for scientific research and policy making. Such collaborations also foster mutual learning and capacity building. SSF members gain exposure to scientific methods and technologies, empowering them to better understand and adapt to changing environmental conditions. Academic researchers, meanwhile, benefit from the fishes’ rich contextual knowledge and real-world experience. Increased access to digital information may lead to an overlap in knowledge and observation within the community, potentially influencing perceptions of environmental changes.

- **Impact on Fishing Livelihoods:** The FGDs shed light on the profound impacts of climate change. Traditionally, fishers could rely on certain weather patterns and sea conditions. However, according to Joynal Abedin of Cox’s Bazar, “These patterns are shifting rapidly. In the past, the Bhadra month (of the lunar Bangla calendar, falling in August-September) offered favourable weather for fishing in the sea. But now, storms and rough seas have become common occurrences. Low tides, once infrequent, now plague the ocean annually, making fishing treacherous.” Abul Momen, another fish-

58 Md. Rashed Chowdhury. 2018. Tropical cyclones in Bangladesh in changing climate. The Financial Express. May 10, 2018.

Coastal fishermen in the Bay of Bengal at Bhola, Bangladesh, by Din M. Shibly

er, added, “The abrupt onset of turbulent seas forces fishers to abandon their trips prematurely, resulting in reduced or non-existent income. The consequences are dire. Fishing expeditions, lasting seven to ten days, often end abruptly, leaving fishers with diminished pay or nothing at all.” With dwindling incomes, fishers are forced to take out personal loans or resort to selling their labour in advance, perpetuating a cycle of debt and poverty. The impact of climate change extends beyond the sea. Decreased rainfall leads to increased salinity in drinking water sources during the dry season, posing additional challenges.

- **Salinity, scarcity and native fish:** The respondents in Bhola and Rangpur provided stark evidence of the effects of climate change. They cited the erratic rainfall and salinity intrusion experienced in 2023 as a significant change and emphasized that climate change is directly impacting native fish species. Saltwater intrusion during tides causes significant harm to reproduction of certain species, leading to a decline in their populations. The reduced water flow decreases the navigability of canals and rivers, diminishing new fish stocks in open water bodies. While the loss or shrinking of habitat impairs reproduction, increased sedimentation disrupts natural migration patterns. The abnormal fluctuations in water levels in reservoirs, coupled with extreme temperature variations, further deteriorate the water’s physico-chemical and biological properties.

  Minar Rashid from Rangpur said: “The fishers noted a deviation from the usual pattern of water increase during the April-June rainy season, which typically facilitates fish reproduction. The lack of rain during this period has impacted fish breeding

cycles, with reduced reproductive capacity observed in various species." FGD participants noted that the reproduction of tilapia has been significantly affected by a combination of heatwaves and insufficient rainfall. This disruption in reproduction has led to losses for nursery and hatchery owners, affecting the entire fishing sector.

- **Escalating Storms:** The frequency and intensity of storms and typhoons have escalated. Previously, fishers had time to react to worsening weather conditions; now, the sea can become tumultuous in an instant, endangering lives and livelihoods. The rising temperatures of the ocean have disrupted the distribution of fish, forcing fishers to venture farther into the sea in search of viable catches.

- **Declining catch:** Inland fisheries are also suffering. Rivers, once teeming with fish, now yield meagre catches. Indiscriminate practices such as the use of gas tablets and electricity in rivers are decimating fish populations, exacerbating the crisis.

- **Marine ecosystems:** The FGDs in Bhola and Cox's Bazar shed light on the significant transformation occurring within marine ecosystems. Specifically, participants emphasized the changes in migration patterns of hilsa from rivers to marine environments. This migration is implicitly linked to changes in salinity and increase in water temperature. Hilsa has a geographical indication (GI) tag (a form of intellectual property right that identifies a product as originating from a specific geographical area). Worldfish reported that a staggering 86 per cent of the world's hilsa is produced in Bangladesh.[59] Both rivers and seas serve as crucial breeding grounds for the coveted fish.

  Fishers in Bhola, who traditionally catch hilsa from nearby rivers, have reported reduced catches. They have observed the migration of hilsa from rivers to marine areas, although they did not directly attribute this shift to climate change. Instead, they implied its connection to the negative impacts of environmental changes. This observation finds support in various reports, with some highlighting a decline in hilsa production within rivers. Some reports reference government research suggesting that water pollution in rivers may contribute to this.[60]

- **Livelihood strategies:** Climate change and associated extreme events have impacted the fishing communities' life and livelihood strategies. In response to a question regarding the effects of summer temperature rises, decreased seasonal rainfall and late onset of the rainy season, most fishers cited the decrease in fish in the Bay of Bengal. The other problems include increased heatwaves causing sickness; decreased fish in large areas; and decreasing numbers of popular fish species including baghair, pipla shoal (or bakka), mahashoal, nandila, chanda, bhanga bata, kharki, black pabda and chenua.

  Due to increasing intensity and frequency of tropical cyclones, fishers have to stop fishing in the bay. When the weather is particularly bad during the period prone to cyclones, turbulent seas force the fishers to return to the coast. They also reported experiencing damage to houses and roads during tropical storms. Farid Alam of Cox's Bazar summarized the fishers' plight: "We can't find the same number of fish as we did previously."

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59 Zillur Rahman. 2023. Hilsha breeding, production at risk. Dhaka Tribune. August 21, 2023.

60 Zillur Rahman. 2023.

A fishing craft in Bhola district, Bangladesh, bringing in the catch from a successful fishing trip, by Md. Mizanur Rahman Bahadur

- **Riverbank erosion:** The FGDs suggest that constant riverbank erosion in Bhola island has significantly reduced the fishing community's land area, inducing landlessness and the need to relocate their houses. The fishers experienced damage to houses, nets, craft, crops and vegetation during the tropical cyclone period. During vigorous cyclone periods, coastal communities experience destruction to their houses, craft and nets. Roads get submerged in rain and tidal water and plantations are destroyed. Cattle deaths and increased risks were also mentioned. Meanwhile, the lack of an evacuation centre puts certain communities at a greater risk.

- **Household savings:** In terms of household expenditure, about half the participants observed a significant increase in expenditure, corresponding to the increasing prices of commodities. A majority of FGD participants also reported a decrease in household savings. This decline was attributed to the reduction in income from fishing, coupled with increasing expenditure.

- **Broodstock:** Respondents from Bhola who were primarily engaged in fish culture spoke of the difficulties in collecting broodstock. Fish farms and hatcheries in Bangladesh heavily rely on broodstock sourced from natural habitats like the Halda River. The respondents emphasized the sensitivity of the broodstock to environmental conditions, particularly erratic rainfall patterns that pose serious obstacles to gathering broodstock from open water bodies.

  Excessive rain and flash floods lead to inundation and decomposition of immature rice plants and grains, resulting in reduced oxygen levels in the water and the production of toxic gases. This often led to the death of a significant number of fish and

broodstock. Wild broodstock breeding and spawning, commonly utilized in hatcheries, are adversely affected by temperature variations. The lack of regular rainfall and water scarcity in rivers and linked channels prevent broods from migrating to reach their breeding grounds in a timely manner.

While fishers cannot provide scientific evidence to support their claims, the observations are consistent with scientific studies. Studies have documented how temperature changes, abrupt rainfall patterns, and extreme climatic events such as cyclones and floods impact the hatching rate of fish and the size of larval yolk.[61] These insights point to the relationship between environmental conditions and sustainable fish culture practices; they emphasize the urgent need for further research and evidence-based solutions to mitigate the impact of climate change on fisheries.

5. Adaption Strategies

- **Maximizing Income:** Bellal Majhi of Bhola offered this telling statement: "Sometimes, it feels like we have arrived in this world with a stroke of bad luck. Many times in the year, we can't go fishing due to adverse weather. Agriculture could be our means of livelihood, but even that is threatened by river erosion, devouring our lands. How do we survive? Not just by believing in Allah (God), but by holding onto hope and resilience in the face of adversity."

  During discussions on adaptation, the fishers' immediate concern centred around their livelihood, particularly ways to supplement their income. Nearly every participant linked the impacts of climate change to their family's financial well-being. Families were actively seeking additional sources of income. Participants lamented the blows inflicted by erratic weather, climate change, and fishing bans imposed for specific periods. Heavy rainfall, cyclones, and adverse weather repeatedly disrupted fishing, while fishing moratoriums are a further constraint. Bangladesh implements two annual fishing bans aimed at safeguarding juvenile hilsa and the fishing resources of the Bay of Bengal: from March 1 to April 30, and in October. While these bans aim to benefit the sector in the long term, they exact a significant toll in the short term.

  Participants in FGDs also highlighted the lack of adequate alternative livelihood support from the authorities. The government does provide rations, but they are insufficient; besides, they are only given to registered fishers. Several studies corroborate such claims. For instance, a 2020 study by the COAST Trust NGO revealed how a recent 65-day ban on fishing in the Bay of Bengal had deprived 70 per cent of the fishers of their jobs. Prior to the ban, 95.8 per cent of fishing families enjoyed three meals a day, but this figure was reduced to only 49 per cent after the imposition of the ban. Although the government provided 43 kg of rice to each fisher family affected by the ban, the NGO reported that 34.2 per cent of the families were yet to receive this assistance.[62]

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61 Munday, P.L., Donelson, J.M., Dixson, D.L., Endo, G.G.K., 2009. Effects of ocean acidification on the early life history of a tropical marine fish. Proc. R. Soc. B Biol. Sci. 276, 3275–3283.

62 COAST Trust. July, 2020. About 50% of Coastal Fishermen are in Food Crisis, 45% Borrowed at High-Interest Rates, Dhaka, Bangladesh. Press Release July 7, 2020. https://coastbd.net/about-50-of-coastal-fishermen-are-in-food-crisis-45-borrowed-at-high-interest-rates-coast-study-finds-70-fishers-unemployed-during-65-days-fishing-ban-in-the-bay-of-bengal-alternative-employment-r/

Fish freshly landed at a local station in Cox's Bazar, Bangladesh, are being transported for processing, ensuring they are prepared for distribution and sale, by Md. Mizanur Rahman Bahadur

Thus, creating alternative or additional income sources emerged as the foremost adaptation strategy from the FGDs in both districts. As Malek Majhi explained, "We understand that we can't halt river erosion, so we're adapting by exploring additional sources of income." In many cases, fishers and their family members have turned to operating auto-rickshaws (locally called Tom-Toms), easy bikes, or mechanized rickshaws. These modes of transportation have become ubiquitous, serving as vital means of commuting for both urban and rural populations. It is estimated that there are about one million easy bikes and 240,000 motorized rickshaws in Bangladesh, transporting up to 250 million people nationwide.[63]

Bangladesh has made significant strides in rural road infrastructure development. The country's total road network spans nearly 380,000 km, with an astounding 94 per cent comprising rural roads.[64] More than 70,000 villages out of 87,223 are considered well-connected through a network of rural roads. Electricity has significantly eased the operation of easy bikes and auto-rickshaws. Notably, the power generation capacity has increased from about 5,500 megawatts (MW) in 2009[65] to about 24,911 MW now.[66]

Over the past decade, the Bhola municipality has witnessed remarkable improvements. Approximately 84 km of road repair and paving across nine wards, along with the construction of 38 km of drains, seven bridges, and 6.65 km of canal excavation

63 Dr. Taskin Jamal. 2023. Exploring the Battery Driven Electric Vehicle Sector in Bangladesh and Our Inclusive Roles. Ahsanullah University of Science & Technology Dhaka, Bangladesh

64 Adnan Zillur Morshed. 2022. Rural Bangladesh needs next-generation village roads. The Daily Star, Sept 15, 2022

65 Badrul Inam. 2021. Power Generation in Bangladesh: Important facts to look at. The Daily Star, February 28, 2021.

66 Bangladesh Power Development Board. 2024. The Annual Report

have been completed. Embankment conservation and the establishment of three kilometres of walkways have been undertaken. Amenities and entertainment facilities have been introduced, such as sports infrastructure for children, and beautification projects like fountains. Investments in 10.50 km of footpaths and drains, 39 km of water supply lines, and slum development have contributed to the area's development.

The total cost of these developments is about BDT 2,880 million.[67] While such measures are not directly targeted towards SSF communities, they have an all-round positive impact. This becomes especially important given that discussions on adaptation highlight the urgent need for safeguards to fisher livelihood. In the face of erratic weather patterns and inadequate government support, fishers remain resilient, opting to diversify their income streams rather than abandoning their profession.

- **Forced adaptation:** While FGD participants were determined to face the adverse effects of climate change without abandoning their professions, the ground reality tells a different story. Nationwide, about 15 per cent of fishing communities have already begun exploring alternative livelihoods.[68] In Bhola and Cox's Bazar, migration is one such crucial adaptation.

  The relentless erosion of rivers has compelled people to seek refuge in other locales, often in urban centres. A 2009 report highlighted that since 1995, half of Bhola Island has been engulfed by erosion induced by heavier river flows and rising sea levels, resulting in the displacement of half its population, many of whom have sought shelter in the overcrowded slums of the capital Dhaka.[69] With its population dwindling from 3,500 families to just 1,000 families, Dhal Char, once a thriving island in Bhola district, is now on the brink of disappearing.[70] Dhaka's Bhola Slum stands as a testament to this mass exodus.

  In Cox's Bazar, Kutubdia Para (translated to neighbourhood) harbours an estimated 60,000 refugees from the island searching for safer ground.[71] Erosion and strong waves continue to submerge Kutubdia Island, prompting an exodus of fishers and salt workers. About 40,000 have fled from six villages since 1991, pointing to the stark realities of climate change.[72]

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67 Hasib Rahman, Daily Janakantha, October 7, 2021. 'Field Visit to Habiganj Tomorrow for Implementation of Bhola-Barishal Bridge: Bhola on the Path to Transformation'. https://www.dailyjanakantha.com/national/news/605357

68 Dr. Ali Mohammad Omar Faruque, Senior Assistant Director, Department of Fisheries. https://shorturl.at/ehjEG

69 Nicolas Haque. 2009. The 'ground zero' of climate change. Al Jazeera.com https://www.aljazeera.com/news/2009/12/7/the-ground-zero-of-climate-change

70 Rafiqul Islam Montu. 2022. Why Thousands Are Fleeing the River Islands of Bangladesh. https://www.indiaspend.com/climate-change/as-bangladeshs-river-islands-erode-people-struggle-for-a-stable-life-and-livelihood-829569

71 Abdul Kuddus, 2024. Kutubdia shirking, people rushing to cities. https://en.prothomalo.com/bangladesh/local-news/p2ai3r1v3m.

72 Shakhawat Hosen Tanim & Dipok Chandra Roy. 2013. Climate Induced Vulnerability and Migration of the People from Islands of Bangladesh: A Case Study on Coastal Erosion of Kutubdia Island. Bangladesh Institute of Planners.

- **Innovation and financial resilience:** FGD participants from both districts emphasized the importance of modernizing fishing, while acknowledging their reliance on formal and informal loans. Modernization efforts, including the provision of life jackets for safety and the use of mobile phones and radios for weather forecasts, have instilled some confidence.

  However, these are insufficient. Dwindling incomes force fishers to return prematurely from fishing trips. This increases the pressure to take loans for everyday expenses. Limited access to formal banking channels drives them towards NGOs for loans, while local lenders called dadan charge high interest rates. Once ensnared in the net of debt, fisher families struggle to break free. This reality has been echoed in a national-level discussion leading to a declaration by marginalized fishers that there was no way out of the debt trap.[73]

- **Traditional knowledge:** Fishers affirm that their inherited knowledge remains a crucial tool. Passed down over generations, this intuitive skill guides them through unpredictable waters. They rely on cues from nature; for example, observing the sky or lightning striking in the northeastern sky for signs of impending inclement weather. They recognize ominous sea conditions through indicators like red water circling

73 The Daily Star, Staff Correspondent, November 30, 2021. 'No way out of the debt trap'. https://www.thedailystar.net/news/bangladesh/news/no-way-out-the-debt-trap-3183196

Fisherman repairing a boat engine in Cox's Bazar, Bangladesh, by Reaz Hossain

and brewing in specific areas. They observe marine life for signs, like the impatience of the churi fish to alert them to potential dangers at sea.

There appears to be a dichotomy between the fishers' traditional knowledge and the limitations mentioned earlier. While fishers struggle to predict specific shifts in weather patterns, their inherited knowledge remains valuable. Observing the sky, unusual water conditions, and fish behaviour does provide clues as to the state of the weather, even if it does not offer an exact forecast of such.

This traditional knowledge complements scientific understanding, although it is no replacement. The effectiveness of traditional methods might be reduced due to climate change. Some methods may require adaptation, while others might become less reliable.

- **Government efforts:** The government has committed to developing a fisheries sector tolerant of climate change. This announcement came amidst a series of initiatives launched by several governmental and non-governmental organizations aimed at enhancing the resilience of fishing communities.

  Major ongoing projects include the DoF-led Climate Smart Agriculture and Water Management Project (CSAWMP-DoF). Its objective is to boost fish production by 20 per cent through climate-smart fisheries technology. The Sustainable Coastal and Marine Fisheries Project (SCMFP) aims to establish co-management of coastal and marine fisheries, providing alternative livelihood options for poor fisherfolk.

  However, concerns loom large over the effectiveness of these programmes. The FGD participants said fishers who spend the majority of their time at sea find it challenging to participate in training programmes arranged by fisheries offices. The distribution of safety equipment, fishing nets, and relief goods post-disaster is inconsistent. This leaves many fishers without essential resources. Illiteracy among fishers complicates matters because they often remain unaware of the support and assistance available to them.

  Local governments and NGOS have tried to raise awareness through radio broadcasts and publicity campaigns. But many fishers remain uninformed about disaster preparedness and available resources. With limited access to training and information, fishers struggle to engage in adaptation efforts.

- **Livestock as adaptation:** In Bhola district, erosion is hitting agriculture. One adaptation among fishers has been to adopt livestock rearing: mini-hatcheries, poultry farming, rearing goats and ducks have gained popularity. This provides additional income while requiring minimal land area—as well as offering additional employment opportunities for women.

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3. An Assessment of Adaptive Strategies

A nuanced landscape characterizes the efforts of fishers in Bhola and Cox's Bazar to adapt and cope with the escalating tide of climate change. Income diversification emerges as a critical adaptation for livelihood and survival. Activities like operating easy bikes offer some respite for both fishers and the fishery resources, particularly in areas with enhanced infrastructure like Bhola.

Nevertheless, there are significant hurdles. Foremost among them are: the limited nature of government assistance and the persistent problems from erratic weather and fishing bans. In Cox's Bazar, while there is a partial intervention involving the distribution of GPS trackers

A fisherman in Bhola district, Bangladesh, repairs his nets, by Md. Mizanur Rahman Bahadur

for some craft, it appears to be a limited effort and not part of a comprehensive project aimed at addressing the broader challenges. Such are the harsh realities of climate change. Migration offers an escape from the relentless erosion of riverbanks, but it frequently leads to overcrowding of urban slums and the attendant social hardships. Likewise, the pursuit of alternative livelihoods presents avenues for building resilience but also flags the vulnerability of traditional fishing occupations to environmental degradation.

Modernization and the reliance on formal and informal loans offer some degree of support, but also throw into high relief the limitations of current technological solutions and financial aid. There is an absence of projects specifically tailored for SSF communities. The discussions with sub-district fisheries officers in Charfasson, Tazumuddin and Lalmohan point to a lack of non-localized projects that empower fisherfolk. Despite governmental projects targeting broader community welfare in Bhola, there is a noticeable lack of initiatives specifically crafted to address the unique needs of SSF communities. Confirming this observation, officers from all three sub-districts spoke to the need for dedicated projects.

The existing community-initiated adaptation measures demonstrate the resilience and ingenuity of the fishing communities. They also reveal the critical necessity for comprehensive support mechanisms. Effective adaptation demands a holistic approach that integrates traditional knowledge with modern technologies, enhances access to alternative livelihoods, and fortifies social safety nets to ensure the enduring resilience and well-being of fishing communities in the face of growing uncertainty. Both the FGD participants and fisheries officers mentioned the lack of dedicated projects for SSF communities. Several ongoing projects aim to enhance the resilience of fishing communities; yet interviews with fishers and government officials uncover a lack of cooperation and coordination between service providers and the SSF communities.

The SCMFP, funded by the World Bank, seeks to enhance the management of fisheries resources, promote sustainable fishing practices, and bolster the resilience of fishing communities. However, despite its promising objectives, fishers in Bhola and Cox's Bazar report minimal participation and fail to identify any substantial benefits. Activities under SCMFP, like the establishment of marine fisheries co-management committees and the introduction of alternative income sources like seaweed farming and eco-tourism, are disconnected from the daily realities of the fishers.

The establishment of the Blue Economy Cell by MoFL aims to foster sustainable development within the fisheries sector and create new economic opportunities while conserving marine resources. The initiative has failed to resonate with fishers in Bhola and Cox's Bazar who remain largely disengaged and unable to derive meaningful advantages from its implementation. The disconnect between the initiatives like SCMFP and Blue Economy Cell and the fishing communities of Bhola and Cox's Bazar likely stems from a combination of factors beyond just information dissemination. Often, such projects seem designed with a 'one-size-fits-all' approach, overlooking the specific ground-realities. Insufficient involvement of fishers in the design and implementation phases can lead to activities that don't resonate with their concerns and communication habits. The initiatives might not adequately consider their traditional knowledge and experience. Integrating this knowledge could lead to more sustainable and culturally-appropriate solutions.

Proposed alternatives for adaptation like seaweed farming or eco-tourism might require new skills, resources or infrastructure fisherfolk do not have right now, or which are unsuitable for them. The DoF's creation of fish refuge sanctuaries to safeguard spawning

grounds and critical fish habitats is a commendable effort. However, the fishers' lack of involvement and understanding of these sanctuaries perpetuates the gap between governmental initiatives and the realities of the communities they intend to serve.

Despite the provision of various social safety net programmes—cash transfers, food assistance, access to credit, for example—by the government to support vulnerable fishers during crises such as cyclones and floods, fishers in Bhola and Cox's Bazar remain largely disconnected and unaware. While governmental initiatives hold promise in addressing the challenges faced by SSF communities, their effectiveness is severely undermined by the lack of participation and awareness among the fishers. Bridging the gap between service providers and the communities they aim to assist is imperative to ensure the meaningful engagement and equitable distribution of benefits, thereby enhancing the resilience and well-being of fishers in the face of ongoing environmental challenges.

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Fishermen ready their nets amid anchored craft in Char Kukri Mukri, Bhola district, using the downtime for vital maintenance before the next catch, by Md. Mizanur Rahman Bahadur

4. Challenges of Adaptation

SSF communities in Bhola and Cox's Bazar face significant barriers in adapting to climate change. Chief among these is their geographical vulnerability. Living in close proximity to the coast increases their risk of becoming the first casualties of cyclones and rising sea levels. Socio-economic factors exacerbate this issue. Poor housing conditions and limited access to essential services further impede their ability to cope with environmental changes. A lack of scientific knowledge among fishers regarding climate change and effective adaptation strategies is another barrier. These challenges call for targeted interventions to enhance resilience and support the fisherfolk's livelihoods.

- **Environmental Hurdles:** SSF communities in Bhola and Cox's Bazar grapple with formidable barriers in adapting to climate change. Being close to the coast exposes them to frequent natural disasters. Then there is the erosion of riverine and coastal areas. With 283 locations and 2,400 km of riverbank line at risk, displacement is a perpetual threat.[74] Their resourcefulness is severely hampered by poor housing infrastructure. This case study revealed the following types of housing used by SSF communities:

  1) *Jhupri* (shacks); makeshift shelters constructed from materials such as jute sticks, tree leaves, and jute bags, offering minimal protection against the elements

  2) *Kutcha* (temporary); these are made with mud bricks, bamboo, sun-grass, wood, and occasionally corrugated iron sheets for roofing, providing basic—but inadequate—shelter

  3) Semi-permanent housing characterized by walls partially built with bricks, cemented floors, and roofs made of corrugated iron sheets, offering slightly improved durability compared to *kutcha* dwellings

  4) *Pucca* (permanent) structures; these are the most durable housing option, with a lifespan exceeding 25 years. These houses feature brick walls and concrete roofs, providing better protection and longevity

  Despite varying degrees of permanent structures, a significant proportion of houses in both Moheshkhali (in Cox's Bazar) and Bhola are classified as kutcha, indicating

74 Islam, Md & Rashid, A. 2012. Riverbank erosion displaces in Bangladesh: the need for institutional response and policy intervention. Bangladesh Journal of Bioethics. 2. 10.3329/bioethics.v2i2.9540.

their vulnerability to environmental hazards. About 65 per cent of houses in Moheshkhali were found to be kutcha, with another 15 per cent classified as semi-pucca. In Bhola, about 71 per cent of fishing community houses were kutcha, while 23 per cent were categorized as semi-pucca. This prevalence of temporary and semi-permanent housing underscores the urgent need for improved and resilient infrastructure to withstand river erosion and cyclones.

- **Economic and Social Obstacles:** The socio-economic conditions of SSF communities further compound the problem. Fisherfolk often lack the necessary resources and support systems to respond to environmental challenges. An analysis comparing national-level data with the socio-economic indicators of fishing communities reveals stark disparities.[75] While the national per capita income is $2,064, the fishers' income range varies widely, from $235 to $1,176. This highlights their economic vulnerability as compared to the national average. Adult literacy rate among fisherfolk is 37.7 per cent; compared to the national average of 74.4 per cent. This inevitably leads to greater disparities in accessing relevant information about climate change adaptation.

  Primary school completion rates are significantly lower among fishers: 28.33 per cent compared to the national average of 81.3 per cent. Fishers have improved access to drinking water (100 per cent) and sanitation facilities (84 per cent), surpassing national averages in these areas. However, some disparities persist; 82 per cent of fishers have access to electricity, as compared to the national average of 93 per cent.

  Extreme poverty rates remain consistent at 10 per cent for both fishers and the national average. But fishers face higher rates of homelessness (25 per cent) and lower rates of land ownership; only 0.89 decimal of land is owned by fishers on average, compared to the national average of 14.8 decimal (one decimal land unit is equal to one-hundredth of an acre, or roughly 435.6 square feet). Although a substantial proportion of fishers (80 per cent) own their house, this rate is lower than the national average of 95.85 per cent.

  These disparities further stress the need for targeted interventions aimed at enhancing access to education, improve income opportunities, and provide adequate housing infrastructure and land ownership rights, thereby empowering fishers to better cope with the adverse impacts of climate change.

- **Knowledge deficits:** The lack of scientific knowledge or information poses a significant barrier. Despite the availability of the internet, accessing relevant information, particularly regarding weather forecasts, remains challenging for many fishers due to language barriers and technical complexities. There exists a notable gap between the available services and the understanding of these services within fishing communities.

  The overall lack of education exacerbates this. Educational attainment among fishers differs significantly from the national average. Data from a 2019 census revealed a

75 For this comparison, we used data and information from Dhaka Tribune, 11 August 2020, Bangladesh Economic Review, 2020; FAO. 2019. Westlund, L. & Zelasney, J. eds. Securing sustainable small-scale fisheries: sharing good practices from around the world. FAO Fisheries and Aquaculture Technical Paper No. 644. Rome. 184 pp. Licence: CC BY-NC-SA 3.0 IGO, TBS; 29 October, 2019. Ali (2014), The Daily Star, 6 May, 2019. Bangladesh Economic Review, 2020

Fishermen in Cox's Bazar district discuss the absence of official appointments and formal minimum wages for the SSF sub-sector, by Md. Mizanur Rahman Bahadur

primary school cycle completion rate of 82.10 per cent;[76] while the literacy rate was 74.4 per cent.[77] But fisherfolk's children were markedly worse off, notwithstanding numerous government programmes to promote education. While enrolment in primary education has risen to 98 per cent nationally, the dropout rate has decreased from 50.5 per cent in 2006 to 13.95 per cent by 2022.[78] But this improvement has not touched SSF communities. Only 37.7 per cent of children from fisher families have received primary education, and only 34 per cent have obtained a secondary school certificate.[79]

Reports indicate some fishing villages of coastal districts like Bhola have almost no school-going children. Instead, children from the 7-9 year age bracket are often engaged in fishing alongside their parents.[80] This glaring disparity screams for attention. Despite concerted efforts to send to school children from fisher families, dropout rates remain high, compounded by—and contributing to—widespread illiteracy among fishers themselves. The ramifications of this disparity extend way beyond the classroom, hitting the livelihoods of these communities. Education is a gateway to better-paying jobs and an enhanced quality of life, to a secure and prosperous future.

This gap requires targeted efforts to improve educational opportunities in SSF com-

76 Directorate of Primary Education, Ministry of Primary and Mass Education Bangladesh. 2019. The Annual Primary School Census 2019.

77 Ministry of Finance. 2020. The Bangladesh Economic Review 2020. October, 2020.

78 Press Express, 2023. How Bangladesh Revolutionized Primary Education. November 25, 2023.

79 Hossain, Mohammed & Sathi, Shahnaj & Hossain, Sabbir & Akter, Mst. Farzana & Ullah, Mohammad. (2020). Assessing the livelihood status of fishermen at Sunamganj district in Bangladesh. Biometrics & Biostatistics International Journal. 9. 16-20. 10.15406/bbij.2020.09.00295.

80 Banglanews24.com, Bangla news portal, Staff Correspondent. February 19, 2014. 'From Coast to Coast: Fishermen's Children, Skilled Skippers by Sixteen'. https://www.banglanews24.com/climate-nature/news/bd/268836.details

munities. Initiatives that provide accessible and culturally relevant education, that drive the awareness of climate change adaptation strategies. Such efforts are essential to empower fishers to effectively deal with the environmental challenges they face.

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Conclusion

The voices of Bangladesh's fishing communities speak of the urgent need for targeted interventions to address the impacts of climate change. Incorporating their perspectives and experiences into policy and programme development can ensure that adaptation efforts are effective and equitable. Moving forward, it is crucial to prioritize climate resilience, promote sustainable fishing practices, diversify livelihood options, strengthen community resilience, enhance access to information and resources, foster gender equity and social inclusion, and strengthen policy and governance frameworks. Implementing special safety net programmes for fishing families during lean seasons or fishing bans will provide much-needed support and stability. Through collaborative efforts and inclusive approaches, fishing communities can be empowered to adapt and thrive in the face of a changing climate.

This cannot materialize without greater connection between the programmes offered by the government and NGOs and the lived context of SSF communities. Concerns persist regarding the efficacy and inclusivity of the adaptation strategies offered at present, casting doubt on the potential success of these endeavours. Ongoing projects like CSAW-MP-DoF and the SCMFP strive to enhance the resilience of fishing communities through technological innovations and sustainable management practices. However, their effectiveness is compromised by limited engagement from the fishers, because the programmes have not taken into account the lived context of SSF communities.

Inconsistencies in the post-disaster distribution of essential resources exacerbate vulnerabilities, particularly among illiterate fishers who often remain unaware of available support mechanisms. Despite efforts to disseminate information through radio broadcasts and publicity campaigns, many fishers still lack awareness about disaster preparedness and available resources, impeding their ability to engage in adaptation efforts effectively.

Addressing this gap in information dissemination and enhancing access to training programmes are essential steps in bridging the divide between existing initiatives and the needs of fishing communities. Through collaborative efforts aimed at bolstering awareness and participation, we can empower fishing communities to navigate the challenges of climate change and thrive in a rapidly changing environment.

Recommendations

1. **Strengthening Climate Resilience:** Given the escalating impacts of climate change on fishing communities, there is an urgent need for comprehensive strategies to increase resilience. Governments and relevant stakeholders should prioritize the development and implementation of adaptation plans tailored to the specific needs of SSF communities. As a participant from the FGD in Cox's Bazar said, "We need stronger embankments and shelters to protect us from cyclones and storms. Every year, we face the threat of losing our homes and livelihoods to the increasingly unpredictable weather." Efforts should include investing in infrastructure upgrades and enhancing early warning systems.

2. **Diversifying Livelihood Options:** "During the lean season, when fishing is scarce, we struggle to feed our families. Diversifying our income sources through alternative livelihoods like agriculture or small-scale businesses would provide much-needed stability," said an FGD participant in Cox's Bazar. Given the increasing uncertainty in traditional fishing livelihoods, there is a pressing need to diversify income sources. Governments and development agencies should support initiatives aimed at creating alternative livelihood opportunities, such as agriculture, livestock, eco-tourism, and handicrafts. Micro-finance schemes and vocational training programmes can empower fisherfolk to explore new income-generating activities and reduce their dependence on fishing.

3. **Community networks:** A fisher at the Bhola FGD said, "When disasters strike, we rely on each other for support. Strengthening our community networks and building local institutions would help us better cope with the impacts of climate change." Building community resilience is essential for enabling fishing communities to withstand and recover from climate-related shocks and stresses. This involves fostering social cohesion, strengthening local institutions, and promoting participatory decision making. Community-based adaptation initiatives supported by the government and other organizations, like mangrove restoration projects, coastal zone management, and community-based disaster risk reduction programmes can empower fishing communities to take collective action to address climate challenges.

4. **Access to information and resources:** Access to accurate information and essential resources is critical. An FGD participant in Cox's Bazar said, "We often receive late or inaccurate weather forecasts, leaving us vulnerable to sudden storms and rough seas. Improving access to timely and reliable information would help us make better decisions to protect ourselves and our livelihoods." Governments and NGOs should invest in improving access to weather forecasts, market information, and support services for fisherfolk. This includes leveraging technology, such as mobile phones and radio broadcasts, to disseminate timely information to remote fishing communities. Moreover, efforts should be made to enhance the literacy and numeracy skills of fisherfolk to enable them to access and utilize information effectively.

5. **Gender and social inclusion:** This has a pivotal role. As highlighted by a participant in the Bhola FGD, the invaluable contributions of women within these communities often go unrecognized, despite their indispensable roles. Elevating the voices of women and promoting their active participation in fisheries management not only promotes inclusion but also yields more comprehensive and effective solutions. Gender equity and

social inclusion must be the central tenets of policy making and implementation, with a focus on integrating the perspectives and experiences of women, the youth, indigenous peoples, and marginalized groups into decision making and resource allocation.

A deeper exploration of this approach reveals its profound implications for the resilience and adaptability of fishing communities. Women constitute half of the population; they possess insights and expertise that complement those of their male counterparts. Promoting women's leadership will bring much needed diversity to decision making and the need to innovate. While men may excel in offshore fishing operations, women often hold unparalleled knowledge of coastal and land-based habitat resource management. By harnessing this diverse expertise and ensuring equal access to resources and opportunities, fishing communities can tap into a wealth of knowledge essential for navigating the complexities of climate change.

Empowering marginalized groups fosters social cohesion and strengthens community resilience. Prioritizing gender equity and social inclusion within climate adaptation strategies is not only a matter of justice but also a strategic imperative. By leveraging the diverse perspectives and expertise of all community members, fishing communities can cultivate resilience and chart a sustainable path forward in an ever-changing climate landscape.

6. **Policy and governance:** Effective policy and governance frameworks are essential for supporting adaptation and resilience. Governments should enact and enforce policies that promote sustainable fisheries management, protect marine ecosystems, and safeguard the rights and livelihoods of fisherfolk. Efforts should be made to strengthen coordination and collaboration among government agencies, civil society organizations, and other stakeholders. An FGD participant in Cox's Bazar summarized it thus: "We need stronger laws to protect our rights as fisherfolk and ensure sustainable management of our fisheries. Without proper governance and enforcement, our efforts to adapt to climate change will be hindered."

Lessons for future engagement

While conducting research on the intricate dynamics of climate change impacts and adaptation strategies for SSF communities, it is critical to continually refine methodologies and approaches; this will provide depth and comprehensiveness to the research, effectively capturing the multifaceted nature of climate change challenges and community responses. By integrating diverse data collection techniques and expanding stakeholder engagement, researchers can enhance the robustness and relevance of their findings, ultimately contributing to more informed decision making and targeted interventions.

Here are some specific recommendations to consider for future studies:

1. **Diversified data:** To achieve a more nuanced understanding of climate change impacts on SSF communities, researchers should supplement traditional methods like FGDs and KIIs with individual or family-based surveys. This approach allows for the exploration of household-level dynamics, thereby uncovering community-wide effects and facilitating the development of tailored adaptation strategies.

2. **Stakeholder engagement with experts:** Strengthening the research endeavour in-

volves expanding interviews to include experts on climate change. By tapping into their specialized knowledge and insights, researchers can enrich their understanding of the scientific dimensions of climate change impacts and adaptation, providing a robust foundation for analysis and interpretation.

3. **Policy:** Broaden the scope of stakeholder engagement by conducting interviews with top-level policy makers and implementers. Their perspectives and expertise can offer valuable insights into policy gaps, implementation challenges, and opportunities for enhancing support to SSF communities, thereby ensuring the relevance and applicability of research findings to policy and practice.

4. **Time allocation:** Recognize the importance of allocating a sufficient time-frame for conducting an in-depth study. Extended time-frames allow for thorough data collection, analysis, and interpretation, enabling researchers to delve deeper into the complexities of climate change impacts and adaptation strategies in SSF communities.

5. **Socio-economics:** Conduct a comprehensive socio-economic analysis to fathom the underlying drivers of vulnerability and resilience in SSF communities. Explore factors such as income diversification, social networks, access to credit, and power dynamics within households to provide a nuanced understanding of adaptive capacity.

6. **Cross-discipline:** Adopt an inter-disciplinary approach that integrates insights from fields such as climate science, sociology, economics, and anthropology. This holistic perspective can capture the complex interactions between environmental change, socio-economic factors, and adaptive responses.

7. **Participatory research:** Embrace the methodologies of community-based participatory research (CBPR) that prioritize the active involvement of local communities throughout the research process. Engage fisherfolk as co-researchers, ensuring their perspectives and priorities shape the study design, data collection methods, and interpretation of findings.

8. **Governance:** Evaluate existing policies, governance structures, and institutional arrangements governing SSF and climate change adaptation. Identify policy gaps, barriers to implementation, and opportunities for enhancing coherence and effectiveness in supporting adaptive capacity at local, regional and national levels.

9. **Technology:** Investigate the role of technological innovation, such as mobile apps, weather forecast and information services, and low-cost sensor technologies, in enhancing the adaptive capacity of SSF communities. Promote the co-development and dissemination of user-friendly tools and resources that empower fisherfolk to make informed decisions.

10. **Ethics:** Prioritize ethical considerations in research design, implementation, and knowledge dissemination processes. Address power imbalances, ensure informed consent, and safeguard the rights and dignity of research participants, particularly marginalized groups within SSF communities.

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Fisherwomen casting their nets in the Bhola wetlands, Bangladesh, by Atikur Rahman

In the face of escalating **climate change, Bangladesh** has emerged as a poignant example of vulnerability, despite contributing minimally to global carbon emissions. This case study dives into the intersection of climate change impacts and the small-scale fisheries (SSF) subsector in Bangladesh, focusing on adaptive strategies employed by fishing communities in the Cox's Bazar and Bhola districts. The research underscores the urgent need to address the palpable effects of climate change on SSF communities, which are critical to the nation's economy and food security.

Through an examination of the challenges, such as sea level rise, cyclones, and salinity intrusion, the case study reveals not only the impacts on these communities, but also the innovative strategies they employ to enhance their resilience. It documents technologies and adaptation initiatives, providing a platform for fishing communities to share their stories and aspirations.

Key recommendations include prioritizing the development of tailored adaptation plans, diversifying livelihood options, strengthening community resilience, enhancing access to information, and fostering gender equity and social inclusion. The case study also emphasizes the need for robust policy and governance frameworks to support these efforts.

The findings contribute valuable insights for policymakers, practitioners, and communities, highlighting the importance of inclusive and targeted interventions. The case study not only illuminates the challenges faced by SSF communities, but also empowers them by providing a comprehensive understanding of climate change adaptation and resilience-building strategies.

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