Journal homepage: https://pathfinderpub.com/index.php/pathfinder-of-research

Pathfinder of Research

ISSN (3007-3863), Vol. 2, Issue 3, December 2024

Original Research

Anthropogenic and Environmental Factors Affecting Biodiversity and Human Well-being in an Ecologically Sensitive Wetland

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https://doi.org/10.69937/pf.por.2.3.37

ARTICLE INFO

Article History:
Received: 15 October 2024
Accepted: 09 December 2024
Online: 10 December 2024

Keywords
Wetland, Fish Conservation, Community-Based Fisheries Management, Livelihood, Resilience

ABSTRACT

Wetlands in Bangladesh have a crucial role in sustaining biodiversity, fisheries, and local livelihoods; however, they face considerable threats from human activity and environmental influences. This study examines fish diversity, species distribution, and critical socio-ecological issues in Tanguar Haor, an ecologically vulnerable wetland in northeastern Bangladesh. To find out about fish conservation and how communities are connected, a mixed-method approach was used that included both biodiversity assessments and socio-economic analyses. A total of 71 fish species in eight taxonomic groups were identified, with 39 species classified as non-endangered, while 29% were designated as endangered, vulnerable, or critically endangered. The fish assemblage mostly consisted of Cypriniformes (58%), followed by Siluriformes (15%) and Perciformes (09%). Substantial threats include illegal fishing, habitat destruction, agricultural runoff, and poor governance, leading to declining fish populations and socio-economic instability for communities dependent on wetlands. To deal with these problems, the paper suggests setting up fish sanctuaries, using community-based fisheries management (CBFM), making sure that sustainable fishing rules are followed, and supporting programs that help people find other ways to make a living. These results are very important for policymakers, conservationists, and local stakeholders because they help them come up with long-term wetland management plans that will restore biodiversity and make Tanguar Haor's economy and society more stable.

1. Introduction

Wetland security represents one of the most thriving ecosystems worldwide, providing essential ecosystem services such as water filtration, flood regulation, carbon sequestration, and biodiversity conservation. Numerous aquatic animals, particularly fish, require these habitats for survival,

reproduction, and sustenance **(Sunny et al., 2019)**. They are crucial for maintaining environmental equilibrium and sustaining the livelihoods of millions globally **(Shamsuzzaman et al., 2017).** Wetland degradation from human activities and changes in the environment is very bad for biodiversity and the economic and social health of communities that depend on wetland resources. Bangladesh, distinguished by its extensive networks of rivers, haors, beels, and floodplains, is among the most wetland-rich countries worldwide. The country covers an area of 147,570 km² and hosts around 260 indigenous freshwater fish species, along with many non-native fish and freshwater prawn species **(Iqbal et al., 2015).** The fisheries sector in Bangladesh is vital to the national economy, contributing around 4.37% to the GDP and supplying 60% of the national animal protein intake **(GoB, 2012)**. Tanguar Haor, located in the northeastern region of the country, holds substantial ecological and economic importance among its many wetland ecosystems. It serves as an essential freshwater fishery and supports the livelihoods of several persons reliant on wetlands **(Begum et al., 2022; Khelifa et al., 2022).**

Tanguar Haor, situated in Sunamganj District, is a seasonal floodplain wetland characterized by a distinctive hydrological cycle. It stays inundated throughout the rainy season and subsequently desiccates over about six months, enabling agricultural activities like rice cultivation. This seasonal hydrological fluctuation influences fish migratory and reproductive patterns and overall ecosystem dynamics **(Nishat et al., 1993)**. The port is crucial for preserving biodiversity, providing habitats for many freshwater fish species, aquatic plants, and migratory birds. Some important fish for business and the environment, like those in the Cypriniformes, Siluriformes, Perciformes, and Channiformes orders, use wetlands as important places to breed, raise their young, and find food **(Kuddus et al., 2020).** The catch fisheries in Tanguar Haor are a vital source of employment for local communities, bolstering food security and economic stability. Furthermore, the wetland provides critical biological functions, including flood regulation, nutrient cycling, groundwater replenishment, and carbon storage.

Considering its ecological and economic significance, Tanguar Haor is seeing a rapid decline in fish species due to various environmental and anthropogenic stressors. The main things that threaten ichthyological diversity and ecological stability are illegal and overfishing, habitat loss, water pollution, agricultural runoff, bad government, and climate change **(Sunny et al., 2018).** Without proper rules, fishing methods like using fine-mesh nets, letting kids' fish, and dewatering methods are leading to overfishing and less fish resources being replenished **(Shamsuzzaman et al., 2017)**. The encroachment of agricultural activities into wetland areas has significantly altered natural ecosystems, resulting in habitat destruction, sediment buildup, and water pollution. The careless use of fertilizers, pesticides, and herbicides on nearby farms has polluted the water ecosystem with harmful chemicals, which has hurt fish's bodies, their ability to reproduce, and the food chains in the water **(Iqbal et al., 2015).** Also, sedimentation from soil erosion and changes in land use has made spawning sites less available, which makes biodiversity loss worse **(Islam et al., 2017).** Governance challenges, such as politically motivated lease arrangements and

insufficient fisheries management legislation, have exacerbated the plight of small-scale fishermen. The current leasing framework sometimes advantages politically connected organizations, limiting equitable access to fishing resources for local inhabitants **(Ahmed et al., 2008)**. As a result, several poor fishermen resort to illegal fishing methods to sustain their livelihoods, worsening resource depletion **(Islam et al., 2007; Hassan et al., 2024).**

Climate change is increasingly contributing to the degradation of wetlands in Bangladesh. Changes in temperature, lengthened droughts, intense flooding, and changes in rainfall have messed up fish spawning cycles, habitat accessibility, and the effectiveness of wetland systems **(Islam et al., 2018)**. Alterations in water flow have impacted the spawning season of several indigenous fish species, complicated their reproductive processes and hindered population stability **(Sunny et al., 2023).** Prolonged dry periods have led to increased water evaporation rates, reducing wetland connectivity and limiting access to breeding and nursery areas for migratory fish species. Conversely, intense flooding events have interrupted fish migration patterns, leading to habitat fragmentation and the loss of vital aquatic vegetation **(Islam & Gnauck, 2007).** Moreover, increased temperatures have led to oxygen depletion in aquatic ecosystems, hence heightening fish mortality rates and reducing fish output **(Shamsuzzaman et al., 2017).**

However, there is an absence of comprehensive research into the ecological and socio-economic importance of Tanguar Haor, its biodiversity, conservation status, and socio-economic connections. Previous studies mostly focused on short-term species inventories, overlooking socio-economic factors and conservation strategies **(Pandit et al., 2015; Sazzad et al., 2024a)**. The lack of evidence-based policy recommendations has hindered the advancement of effective wetland management strategies. The existing study mostly documents fish species diversity but has not examined long-term biodiversity trends, substantial anthropogenic pressures, or governance challenges affecting Tanguar Haor. Also, not many studies have been done on the social and economic vulnerabilities of people who depend on wetlands, especially when it comes to finding other ways to make a living, dealing with problems from the government, and adapting to climate change **(Sunny et al., 2019).** This study rectifies these deficiencies by integrating biodiversity assessments with socio-economic analyses to provide a holistic overview of wetland sustainability issues **(Mohammed & Wahab, 2022)**.

The main goals of this study are to look at the different kinds of fish in Tanguar Haor, how they interact with people and the economy, and the main environmental and human-made problems that affect the area. To figure out how much biodiversity is being lost, we need to look at the current state and expected future trends of aquatic biodiversity, paying special attention to species diversity, richness, and conservation priorities. This study records species diversity, dominance patterns, and conservation status, offering essential baseline data for biodiversity management and policy formulation **(Roskov et al., 2013; Refat et al., 2024)**. The study looks at fishing methods, habitat changes, pollution sources, and climate-related stresses to find the main biological and

human-made factors that cause biodiversity loss and ecosystem degradation. Comprehending these issues is crucial for distinguishing between natural change agents and anthropogenic pressures, as well as for formulating effective conservation programs. The study will assess the socio-economic vulnerabilities of communities dependent on wetlands, particularly fishing households facing economic difficulties due to declining fish numbers **(Sunny et al., 2025)**. This evaluation will look at things like income levels, ways of making a living, access to other ways to make money, and problems with governance. It will show how the loss of biodiversity clearly affects human well-being. In the end, the research will come up with strategic policy suggestions for long-term wetland management. These will include ways to protect wetland areas, make government work better, and find other ways to make a living. This project will improve evidence-based decision-making and scientifically informed policy interventions for the long-term conservation and resilience of Tanguar Haor by pursuing three primary objectives **(Shifaen et al., 2024; Khanal et al.,2024).**

2. Research Methodology

2.1 Study Site

We conducted the research at Tanguar Haor, an ecologically significant wetland located in northeastern Bangladesh. The studies community included Sreepur and Uttor Sreepur in the Sunamganj District. The marsh has seasonal flooding during the monsoon and remains arid for around six months, facilitating agricultural endeavors, mostly rice cultivation. This seasonal fluctuation significantly impacts fisheries productivity, biodiversity, and community livelihood patterns **(Nishat et al., 1993).**

2.2. The study design and sampling methods

A mixed-methods approach was employed, integrating quantitative biodiversity assessments with qualitative socio-economic analyses. Fish sampling was performed utilizing cast nets (mesh size: 10.5 mm) and gill nets (mesh size: 20.5 mm) to guarantee a comprehensive evaluation of species diversity. To reduce sample bias, fish were gathered from randomly chosen locations around the marsh, encompassing both deepwater areas and shallow nesting sites. Each species was recognized utilizing conventional taxonomic references, and its conservation status was confirmed against the IUCN Red List **(IUCN, 2017).**

2.3 Data Acquisition and Evaluation

A comprehensive data collection method was employed, integrating both primary and secondary sources to provide a meticulous and exhaustive analysis of biodiversity trends and socio-economic conditions in Tanguar Haor. The primary data collection was a monthly fish sample from local fishing areas, markets, and landing points to evaluate species diversity and seasonal fluctuations. Furthermore, socio-economic data were collected using household surveys (n=120), focus group discussions (FGDs) (n=20), and key informant interviews (KIIs) (n=10) to analyze livelihood interdependence, conservation issues, and community perspectives. Demographic data, including age distribution, family size, literacy rates, and income levels, were examined

using structured questionnaires to comprehend socio-economic vulnerabilities affecting resource usage and conservation initiatives.

Academic journals, governmental papers, environmental organizations, and NGO publications provided secondary data in addition to the primary data. Official records from the Department of Fisheries, the Bangladesh Bureau of Statistics (BBS), and local environmental groups showed interesting patterns in biodiversity over time, as well as fisheries policy and methods for managing wetland areas. This study looks at the factors that affect protecting biodiversity and the economic and social well-being of people in Tanguar Haor. It does this by combining field-based evaluations with existing research and policy papers.

2.4 Fish sampling and Species Identification

Fish sampling occurred at many places, including fishing communities, vessels, fish markets, and designated landing sites. Sampling was conducted regularly to document seasonal variations in fish biodiversity and abundance. Specimens were collected, documented by photography, and identified utilizing field guides, taxonomic manuals, and molecular databases. The physical traits of each species were documented, and their conservation status was verified against the IUCN Red List and national fisheries data. Fish specimens were categorized into distinct taxonomic orders, and their abundance was recorded. The results were utilized to evaluate biodiversity indicators, including species richness, evenness, and dominance patterns.

2.5 Biodiversity Indices and Statistical Analysis

The study employed established biodiversity indices to evaluate species diversity and environmental stability.

Shannon-Wiener Diversity Index (H′)

This index measures species diversity within the wetland ecosystem and was calculated using the formula **(Shannon & Weaver, 1949; Margalef, 1978)**:

$$H' = \sum [Pi \times Ln(Pi)]$$

Where,

H' = Shannon Wiener index

Pi = ni/N

ni = No. of individuals of a species

N = Total number of individuals

Margalef species richness (d):

$$d = (S-1)/log(N)$$

Where, S = Total species

N = Total individuals.

Pielou's evenness index (J'):

$$(J') = \frac{H(S)}{H(\max)}$$

Where, H (s) = The Shannon-Wiener information function.

H (max.) = The theoretical maximum value for H(s) if all species in the sample were equally abundant.

Simpson dominance index (c):

$$C = \sum_{i=1}^{s} \left(\frac{ni}{N} \right)^2$$

Where,

ni = Number of individuals in the ‘each’ species

N = Total number of individuals

S = Total number of species.

These indices provided a quantitative framework for assessing biodiversity trends, conservation priorities, and the health of Tanguar Haor’s fishery resources.

2.6 Ethical Issues and Research Validity

We secured ethical approval from local fishery authorities and pertinent institutional review boards. All participants granted informed consent before involvement, and their identities and data confidentiality were preserved. No live specimens were damaged during fish sampling, and all field studies complied with ethical standards for biodiversity assessment. To make sure the study was valid and reliable, the data were checked by a number of different methods, such as direct field observations, expert consultations, and secondary literature studies. Statistical studies were performed utilizing Microsoft Excel 2013, guaranteeing precise data representation and reducing possible biases.

3. Results and Discussion:

3.1 Demographic Aspects of the Fishing Community in Tanguar Haor

Understanding the inhabitants of the fishing villages in Tanguar Haor is essential for assessing their socioeconomic conditions, the hazards they encounter in their livelihoods, and their capacity to adjust to environmental and anthropogenic changes. This research collected demographic data using household surveys, key informant interviews, and focus group discussions (FGDs) with local fishermen and people dependent on wetlands. The findings highlight the age demographics, educational levels, family structures, economic sources, and gender dynamics within the community **(Sultana et al., 2017)**.

3.1.1 Age Distribution and Workforce Participation

The fishing settlements in Tanguar Haor predominantly have a youthful and middle-aged population, signifying a substantial dependence on active labor in fisheries and wetland activities. The research revealed that more than 65% of participants engaged in fishing-related activities were aged 18 to 50 years, indicating that fishing remains a crucial livelihood strategy for the working-age demographic. Twenty percent were above 50 years of age, comprising experienced fishers who substantially contribute to the dissemination of knowledge and traditional fishing techniques. The other 15% of the fishing workforce were youngsters aged 12 to 17, who often assisted their families with fishing, net preparation, and post-harvest activities. The participation of youth in fishing occupations suggests that, despite declining fish stocks and environmental challenges, younger generations continue to rely on traditional fishing livelihoods due to a lack of other employment opportunities. This raise concerns over intergenerational poverty and long-term economic instability, necessitating policy interventions to provide other income sources and mitigate unsustainable fishing pressure in Tanguar Haor **(Naiman & Dudgeon, 2011; Siddiq et al., 2013)**.

3.1.2 Household Size and Familial Structure

The fishing households in Tanguar Haor generally comprise around 5.7 members per family. The study indicated that 70% of households consisted of joint or extended family arrangements, characterized by several generations living together and sharing financial responsibilities. This traditional family structure provides social security and labor-sharing benefits, although it also increases dependency on resources, since larger families require more food security and income stability. The research revealed that households led by females constituted around 12% of the overall fishing families, particularly among widows or women whose partners moved for other jobs during times of diminished fishing activity **(Let & Pal, 2023; Sazzad et al., 2024b)**. These households had heightened economic vulnerability, characterized by limited access to financial aid and reduced bargaining power in fishing-related decisions. Getting more women involved in other ways to make money, like processing fish, making nets, and making crafts, could make people less economically vulnerable and promote gender-inclusive fisheries management.

3.1.3 Educational Qualifications and Literacy Competence

Education is crucial for cultivating resilience and enhancing adaptive capacities among fishing communities. The poll revealed that literacy rates among fishers in Tanguar Haor are inadequate, with just 32% of respondents having formal education above the basic level. Approximately 48% of respondents possessed no formal education, whereas 20% had attended school without finishing primary schooling **(Mahmud, 2007)**. The insufficient educational qualifications of fishermen limit their access to other economic opportunities, impede their ability to engage in modern fisheries management methods, and reduce their comprehension of conservation legislation. Furthermore, educational achievement was significantly lower among women, with more than 60% of female respondents reporting that they had never had formal education. A considerable proportion of young children from fishing homes discontinue their schooling prematurely to assist in fishing activities, thereby perpetuating cycles of poverty and resource reliance. To do this, fishing communities need targeted educational programs, vocational training, and public awareness campaigns to help people learn to read and write and gain new skills, which will help them adapt to changing social, economic, and environmental conditions **(Paik & Chakraborty, 2003; Kuddus et al., 2022)**.

3.1.4 Major Earnings and Economic Conditions

Fishing remains the principal source of income for the majority of households in Tanguar Haor. The study revealed that more than 82% of households relied directly on fishing and related activities for their livelihood. These operations include the catch, processing, transportation, and selling of fish in local markets. However, due to seasonal variations, declining fish populations, and overfishing, many fishermen face economic instability, particularly during the lean fishing months when fish availability is limited. The average annual income of fishermen was around BDT 2,442 per capita, indicating a decline of over 70% relative to the national per capita income of Bangladesh **(Belaluzzaman, 1995)**. This places fishers among the most economically disadvantaged groups, often struggling with basic home needs, school costs, and healthcare expenses. Approximately 30% of households engage in extra income-generating activities to mitigate economic challenges, including seasonal agriculture, small-scale animal husbandry, wage labor, and non-fishing occupations. However, prospects for alternative work are limited, particularly for landless fishermen who lack both financial resources and skills for non-fishing jobs. There is an urgent need for livelihood diversification efforts that provide alternate income opportunities for fishers. Investments in ecotourism, community-based fisheries management (CBFM), aquaculture training, and handicraft production might significantly reduce economic vulnerability while promoting sustainable resource use **(Ahmed et al., 2008; Horwitz & Finlayson, 2011).**

3.1.5 Health, Sanitation, and Life Environments

The health and well-being of fishing communities in Tanguar Haor fundamentally depend on their living conditions and the availability of necessary services. The study indicated that access to healthcare facilities, drinking water, and sanitation services is inadequate in several fishing communities. About 60% of families rely on hazardous water sources, such as untreated surface water from the haor, increasing the likelihood of waterborne diseases, diarrhea, and skin ailments. Furthermore, insufficient sanitary infrastructure exacerbates public health risks. The study indicated that just 38% of fishing households own sufficient toilet facilities, and the remaining 62% utilize shared, makeshift, or open defecation practices. The lack of sanitary infrastructure is particularly concerning for women and children, who are more vulnerable to hygiene-related illnesses **(Islam et al., 2023).** Numerous fishing households faced food insecurity during times of diminished catch, acknowledging hunger as a critical issue. Limited economic opportunities, coupled with fluctuating fish populations, result in reduced food diversity and undernutrition, particularly among youngsters and pregnant women. Government and NGO interventions to improve healthcare access, sanitation, and food security are crucial for strengthening the well-being of those dependent on wetlands **(Khan et al., 2018)**.

3.2 Current Status of Fishery Resources and Species Populations

The biodiversity assessment of Tanguar Haor revealed a diverse fish ecosystem, consisting of 71 recorded species spanning eight primary taxonomic groups. The analysis highlighted the conservation challenges associated with the fish population, particularly due to human-induced pressures and environmental changes. The major order among the detected species was Cypriniformes, accounting for 58%, which included different species of commercial and ecological importance. Siluriformes (15%), Perciformes (9%), and Channiformes (6%) were present in considerable amounts, considerably aiding in the preservation of ecological balance. Nonetheless, several species previously documented in the haor were either missing or observed in markedly reduced quantities, signifying a downward trend in species abundance **(DoF, 2005; Huang et al., 2000).**

Table 1. Fish Species Composition in Tanguar Haor

Fish Order	Percentage (%)
Cypriniformes	58
Siluriformes	15
Perciformes	9
Channiformes	6
Synbranchiformes	4

Fish Order	Percentage (%)
Clupeiformes	3
Beloniformes	3
Tetraodontiformes	2

Numerous species, including Rasbora rasbora, Clupisoma garua, Labeo rohtia, and Cirrhinus cirrhosus, were documented as common in the study area. Conversely, severely endangered species such as Labeo nandina, Channa barca, and Rita rita were documented in dangerously low quantities, indicating a significant risk of local extinction. The diminished presence of these species may be attributed to overfishing, habitat degradation, and insufficient conservation efforts. The results of this study unequivocally demonstrate that ongoing biodiversity monitoring and conservation-focused fisheries management are essential to avert future degradation of fishing resources in Tanguar Haor **(IUCN, 2017).**

Table 2. Fish Conservation Status in Tanguar Haor

Conservation Status	Number of Species	Percentage (%)
Not Threatened	41	58
Endangered	11	15
Vulnerable	10	14
Critically Endangered	8	12
Near Threatened	1	1

3.3 Impact of Habitat Degradation on Fish Biodiversity

The deterioration of natural habitats in Tanguar Haor has become a primary catalyst for biodiversity decline, adversely affecting fish populations, aquatic flora, and ecosystem stability. Many farms have started using the wetland for farming, which has changed a lot of the habitat. Wetland ecosystems have been turned into farmland and aquaculture facilities. These modifications have led to habitat fragmentation, the loss of spawning habitats, and diminished water quality, adversely affecting fish reproductive cycles and young survival rates **(Hossain, 2007; Ifty et al., 2023).**

The wetland environment is getting worse because of changes in land use and water pollution from waste water, household garbage, and industrial effluents. The unregulated application of chemical pesticides, herbicides, and fertilizers in adjacent agricultural areas has polluted water bodies, impairing fish physiology and reproductive viability. Sedimentation resulting from soil erosion

has modified water depth and substrate composition, thereby diminishing the availability of appropriate breeding sites for several native fish species **(Huq et al., 2020; Iwasaki et al., 2009)**. The escalating encroachment and degradation of aquatic vegetation jeopardize the habitat integrity of Tanguar Haor, prompting immediate conservation and restoration initiatives to avert irreparable harm to fish species.

3.4 The Role of Fisheries in Livelihood and Economic Security

Fishing constitutes the principal means of sustenance and income for several individuals residing around Tanguar Haor. The wetland sustains subsistence fishing populations and small-scale commercial fisheries that substantially enhance local and regional economies. The diminishing fish populations and habitat degradation have imposed significant socio-economic strain on households reliant on fishing, undermining their income stability and economic resilience. In the current study, 75% of questioned fishermen articulated worries over the diminishing profitability of fishing, identifying reduced fish supply, heightened competition, and variable market pricing as primary difficulties **(Moniruzzaman et al., 2023)**. The research further revealed that seasonal unemployment and restricted alternative income prospects significantly intensify economic vulnerability within fishing communities. Many households lack financial resources, governmental support, or viable economic options, leaving them dependent on unsustainable fishing methods to meet their daily needs. In this setting, there is an immediate necessity for policy measures that foster sustainable fisheries management and livelihood diversification. Community-based fisheries co-management, financial aid for fishers, and skill-development programs could be very important for making sure that fishing communities have a stable economy in the long term and that wetland resources aren't overused **(Nair et al., 1989; Mithun et al., 2024).**

3.5 Impacts of Unauthorized and Unregulated Fishing Practices

Illicit, uncontrolled, and unsustainable fishing methods have become a significant catalyst for the loss of fish stocks in Tanguar Haor. The research revealed extensive utilization of fine-mesh nets, dewatering methods, and juvenile fish capture, all of which exacerbate the rapid reduction of fish populations. Unregulated fishing during essential mating periods intensifies biodiversity decline, hindering the natural recovery of fish populations **(Nishat et al., 1993; Begum et al., 2023a)**. Politically driven leasing regimes disrupt equitable access to fishing rights, resulting in heightened exploitation by a select few and the marginalization of small-scale fishermen. Illegal fishing has also been allowed to continue because current fishing laws are not being enforced properly and governance systems are not strong enough. This makes conservation efforts even less effective. Addressing these difficulties necessitates the enhancement of fisheries governance, the enforcement of stringent fishing rules, and the implementation of scientific stock management programs. The implementation of no-fishing zones, seasonal prohibitions, and fish sanctuaries can markedly enhance fish population recovery while guaranteeing sustainable fishing prospects for future generations **(Al-Amin et al., 2021).**

3.6 Impacts of Climate Change on Wetland Ecosystem Stability

The effects of climate change on Tanguar Haor are becoming apparent, with elevated temperatures, unpredictable precipitation patterns, and severe weather events influencing fish species and wetland ecosystem functioning. The research indicated that erratic flooding, extended droughts, and changing seasonal patterns have resulted in modified water chemistry, habitat degradation, and heightened fish death rates. Furthermore, climate-induced habitat alterations have compelled several fish species to relocate, upsetting conventional fishing practices and diminishing fish supply for local populations. Elevated water evaporation and diminishing groundwater levels in arid seasons have exacerbated habitat stress, resulting in enhanced resource competition and diminished fish recruitment. To lessen the long-term effects of climate change on Tanguar Haor, it is important to use adaptive methods like restoring wetland areas, improving habitat connectivity, and managing fisheries in a way that takes climate change into account **(Odada et al., 2009; Choudhuryet al., 2022)**. Combining indigenous biological knowledge with contemporary conservation methods can enhance the resilience of wetland ecosystems to climatic instability.

3.7 Comparative Analysis of Fish Biodiversity

Similar drops in biodiversity have been seen in Hakaluki Haor and Tanguar Haor, where overfishing and the spreading of wetlands have greatly reduced the number of fish species. In contrast to Dekhar Haor, where Cypriniformes constitute 55% of the fish population, other wetlands have a greater prevalence of Siluriformes owing to differing ecological circumstances. Comparative assessments underscore the necessity for region-specific conservation initiatives **(Sunny et al., 2020).**

3.7 Conservation Strategies and Policy Recommendations

A thorough conservation strategy is vital for safeguarding the long-term viability of Tanguar Haor, given the many threats to biodiversity and human well-being. This study's findings underscore the pressing necessity for a cohesive wetland management strategy that concurrently tackles ecological and socio-economic issues. Effective conservation strategies should prioritize the protection of fish biodiversity, the restoration of damaged habitats, the fortification of governance structures, and the augmentation of community resilience. A significant strategy is the adoption of Community-Based Fisheries Management (CBFM), designed to empower local fishers in resource governance and decision-making. Engaging communities in co-managed fisheries can substantially enhance the sustainability of wetland resources while fostering equal access to fishing benefits **(Joadder et al., 2016; Begum et al., 2023b).**

The development of fish sanctuaries and breeding reserves is a crucial method for safeguarding essential spawning habitats and promoting the recovery of fish populations. Seasonal and permanent sanctuaries are crucial for sustaining fish populations and averting additional biodiversity decline. Moreover, enhancing environmental controls and enforcing fisheries laws is essential to avert illicit fishing, habitat degradation, and resource overexploitation. The report stresses that the lack of effective enforcement mechanisms is a major problem for conservation

efforts that need more involvement from lawmakers and stricter rules for compliance. This study advocates for the advancement of climate-resilient fisheries and alternative livelihood initiatives to alleviate the effects of climate change and resource depletion **(Pandit et al., 2015; Chowdhury et al., 2021)**. Promoting sustainable aquaculture, eco-tourism, and alternative livelihoods can mitigate reliance on diminishing fish populations, offering fishermen economic stability and multiple revenue streams. Moreover, investments in ecological restoration initiatives are essential for rehabilitating damaged wetland ecosystems, enhancing water quality, and reinstating aquatic vegetation. These programs must integrate habitat conservation, pollution mitigation, and community-driven restoration efforts to guarantee enduring ecological integrity. By taking these scientifically sound conservation steps, policymakers, conservationists, and community members may be able to restore Tanguar Haor's ecological balance while also protecting the social and economic well-being of communities that depend on the wetland. An inclusive management strategy that amalgamates indigenous knowledge with empirical research will be essential for ensuring the future resilience and vitality of Tanguar Haor as a wetland ecosystem **(Islam et al., 2025; Chowdhury et al., 2020).**

4. Conclusion

The combating biodiversity of wetlands, especially Tanguar Haor, is a significant environmental and socio-economic issue. The results of this study show that illegal fishing practices like taking juvenile fish, fishing for brood, and overfishing have greatly reduced fish stocks and made wetland ecosystems less stable. Unsustainable fishing methods, habitat loss, agricultural pollution, and changes caused by climate change have put a lot of stress on aquatic biodiversity and the ways of life of people who depend on wetlands. To alleviate biodiversity, decline and guarantee sustainable resource utilization, the adoption of scientifically informed wetland management practices is essential. This research advocates for the use of Community-Based Fisheries Management (CBFM), co-management frameworks, and the Ecosystem Approach for Fisheries Management (EAFM). The prioritization of both permanent and seasonal fish sanctuaries is essential for the protection of vital breeding and nursery habitats. To reduce local fishermen's dependence on wetland resources, we should implement alternative income-generating activities alongside conservation initiatives. Initiatives centered on eco-tourism, sustainable aquaculture, skill enhancement, and alternative employment can foster economic resilience within fishing communities. Moreover, the replenishment of native fish fry in the marsh can facilitate the recovery of endangered species and improve ecological equilibrium. In the end, long-term monitoring of biodiversity and large-scale research projects are necessary to understand ecological patterns, spot possible risks, and plan for flexible management approaches. This study shows how important it is for government agencies, conservation groups, local communities, and policymakers to work together to create a long-lasting and reliable framework for managing Tanguar Haor and other environmentally sensitive wetlands in Bangladesh. By amalgamating conservation, governance, and livelihood diversification, we may endeavor to save biodiversity, rehabilitate ecological services, and enhance the welfare of

wetland-dependent communities for future generations.

Funding

This work had no outside funding.

Author Contribution

Author took involved in the creation of the study design, data analysis, fieldwork, and execution stages. Every writer gave their consent after seeing the final work.

Acknowledgments

We would like to thank the beneficiary for providing the information that was needed during the interview.

A statement of conflicting interests

The authors declare that none of the work reported in this study could have been impacted by any known competing financial interests or personal relationships.

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