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Challenges of Sustainable Haor Management in Bangladesh: A Study on Hakaluki Haor

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Abstract

The objectives of the study were (i) to sketch the current haor management practices in Bangladesh; (ii) to identify the challenges of sustainable management of haor resources; and (iii) to explore the scope of such management which can be helpful in achieving SDGs in Bangladesh.

The study was qualitative primary data focused. Based on judgement 10 KII were selected. They are related to haor management, local government, media, and research. Based on the KII opinion and secondary data, an open-ended questionnaire was developed. Then 20 stakeholders were selected for an in-depth interview. Respondents were fishermen, farmers, local community members, traders, government officials and NGO representatives. A focus group discussion has also been conducted to understand the overall management scenario of Hakaluki haor area. Collected data have been analyzed for thematic contents and compared between KII and FGD by using triangulation in terms of data reliability. Water contamination of the studied area impacts plant and animal life in recent years. Lessening of natural resources causing harm of haor biodiversity. Increasing number of pollutants, unplanned expansion of agricultural activities, overfishing, use of insecticides and pesticides are damaging the wetland ecology. The degradation of marsh wetlands also impacts on livestock feed availability. Other issues are encroachment of upstream dams, undue influence of regional groups, drying up water sources, filling out wetland areas, uncontrolled hunting, unplanned constructions, reluctance of the concerned authorities, multifaceted corruption, and lack of awareness among the active stakeholders. To improve the current scenario and using haor as a tool of achieving SDGs, some policy suggestions have been given. Findings of this study can be used in further policy formulation. To minimize the challenges community empowerment and proper collaboration can be applied. Evidence-based decision making, and adaptive management approaches can be helpful in our overall sustainable development. This study has been conducted based on qualitative data of a limited number of respondents. Incorporating a large number of respondents and quantitative data could present a wider scenario. Moreover, comparing the realities of other hoar areas could explore different dimensions of sustainable haor management.

Key words: SDGs, Sustainable haor management, Hakaluki haor, Haors of Bangladesh

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Introduction

Hakaluki Haor is an extensive marshland that sustains a wide variety of fish species, now recorded in 64 species belonging to different genera and families (Imran et al., 2023). (Aziz et al., 2021) has identified overfishing, habitat degradation, and water pollution as the primary threats to the vital ecological services provided by the wetland, particularly its habitat for aquatic biodiversity. The Haor region is marked by persistent poverty, as seen by its lower household earnings in comparison to other rural regions in Bangladesh. The quality of life for women is significantly impacted, since it is rated as excellent or very good by just 30% of respondents (Hiramoni 2023). Environmental issues such as floods and low winter temperatures limit agricultural production, thereby requiring the creation of cold-tolerant crop varieties and other agricultural advances to improve food security and livelihoods. Climate change presents substantial obstacles to fish production, mostly due to variations in temperature, unpredictable rainfall patterns, and the accumulation of silt. The reduction in fish populations and biodiversity is further aggravated by human activities, including the use of damaging fishing gear and agricultural intensification. Potential remedies include enhanced water management techniques, expansion of fish species diversity, and implementation of climate-resilient fisheries management. To improve fish species abundance and guarantee sustainable lifestyles for residents, it is advisable to implement community-based wetland conservation and management. Kabir and Siddiqua (2023) describe the Haor Eco-Interpretation Center as an exemplary example for advancing sustainability via the use of environmental education and eco-sensitive design concepts. The incorporation of sustainable methods is essential for expanding agricultural output, improving fish farming, and raising the standard of living, especially for women, while also addressing wider environmental and economic objectives. Despite its importance as an economic activity in the haor areas, fish farming has obstacles with market access and infrastructure. Achieving sustainable practices in fish farming requires the implementation of efficient support systems, substantial expenditures in education, and necessary infrastructural enhancements. The use of these strategies may effectively reduce market losses and enhance the quality of life for local populations (Acharjee et al. 2023). The integration of agricultural, forestry, and livestock systems may have synergistic effects across many Sustainable Development Goals (SDGs), including poverty eradication and climate action. Nevertheless, there are trade-offs arising from the limitations in technical proficiency and financial resources. To optimize sustainable development in the haor areas, it is crucial to tackle these issues by

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implementing specialized loan facilities, insurance programs, and enhanced market linkages. In comparison to other rural areas, the haor regions exhibit a notably worse standard of living for women. Facilitating women's involvement in economic decision-making and enhancing their socio-economic circumstances are essential for attaining Sustainable Development Goals (SDGs) pertaining to gender equality and poverty reduction. The haor areas have difficulties in maintaining water quality and accessibility, which requires the implementation of enhanced infrastructure, educational initiatives, and governance systems to guarantee the provision of clean water and sanitation for all inhabitants. Although the emphasis on sustainable management practices is crucial, it is also vital to contemplate the possible compromises and difficulties linked to these actions. To effectively tackle problems including fragmented land ownership, gender imbalances, and insufficient market possibilities, it is necessary to implement holistic plans that prioritize economic, social, and environmental goals. Unique constraints posed by the haor environment include floods and low winter temperatures, which limit agricultural output. Implementing techniques such as cultivating short-duration, cold-tolerant crop types and using higher landscapes for vegetable agriculture may greatly improve output. These advancements are in line with government strategies aimed at enhancing agricultural, livestock, and seafood output, thus contributing to the achievement of food security and the alleviation of poverty. The promotion of agricultural mechanization and agribusiness development has the potential to significantly improve production and lives in haor areas. Microcredit schemes are a vital component in reducing poverty in haor areas. An analysis, comparing formal and informal microcredits, shows that informal sources are favored because of their lower interest rates and more flexible conditions. Modifying formal credit systems to align more effectively with the socioeconomic circumstances of haor inhabitants may improve financial inclusion and contribute to the achievement of sustainable development objectives. The market decisions of fish farmers are influenced by their access to credit facilities, underscoring the importance of implementing effective financial systems to encourage sustainable fish farming methods. An exemplar of environmental education and sustainable design is the Haor Eco-Interpretation Center in Moulvibazar. The centre promotes knowledge and conservation of the haor environment by effectively integrating visitor education with eco-sensitive architecture concepts. The effort highlights the need of integrating environmental education into sustainable management strategies (Kabir & Siddiqua 2023). The implementation of a capability framework for child development in haor regions highlights the

significance of community involvement and parental competencies. This participatory methodology can be expanded to other research domains, to promote community-led solutions for sustainable development. Although these approaches provide a thorough framework for sustainable haor management, major obstacles such as the creation of infrastructure and the control of risks persist. Resolving these concerns by focused investments and policy measures will further improve the long-term viability of haor areas across Bangladesh.

Literature Review

In Bangladesh, haors play a crucial role in preserving biodiversity and supporting local livelihoods. However, they are also endangered by climate change, unsustainable practices, and socio-economic limitations. Contemporary approaches to haor management prioritize sustainable development, climate resilience, and community engagement. In Bangladesh, management solutions for haor prioritize agricultural growth by introducing short-duration, cold-tolerant crop types such as Boro rice. Furthermore, these approaches include the use of elevated areas for cultivating vegetables and the promotion of automation, livestock husbandry, and fisheries to augment productivity and provide food security (Bokhtiar et al. 2024). The initiative integrates environmental education with sustainable design to foster awareness and preservation of the haor ecosystem. This effort emphasizes the need of integrating environmentally conscious design concepts into the management of habitats (Kabir & Siddiqua 2023). Ramsar site Tanguar Haor is experiencing biodiversity decline because of irresponsible use of resources. The management approaches in this context prioritize ecosystem-based co-management, which include engaging local people in conservation processes. Sultana et al. (2022) proposes the establishment of fish sanctuaries, gene banks, and the use of balanced fishing strategies as measures to mitigate the decline in fish variety. Fishermen in haor regions are responding to the effects of climate change by using different approaches, such as depending on government assistance and pursuing other means of earning a living. To maintain livelihoods in the face of environmental changes, these adjustments are essential (Hossain et al. 2023). The haor area is susceptible to recurrent floods and flash floods, which not only disrupt agricultural production but also modify the aquatic ecology by inducing sedimentation and habitat degradation (Aziz et al. 2023; Bokhtiar et al. 2024). Man-made pressures, Overexploitation, coupled with the use of detrimental fishing equipment, has greatly diminished fish populations. The dehydration of beels, which are depressions in wetlands,

for agricultural use worsens this problem by removing the habitats of fish (Aziz et al. 2023; Habib & Hossain 2023). The rapid development of human settlements and agricultural industries has resulted in a decline in water bodies and the proliferation of thick vegetation. This shift in land use is influenced by population growth and insufficient implementation of regulations, leading to the loss of habitats and deterioration of ecosystems (Polash et al. 2022). This paper emphasizes the significance of microcredit in attaining sustainable development objectives, namely in diminishing poverty and advancing sustainable finance (Islam et al. 2024). Market selection poses obstacles for fish producers in the haor areas, mostly influenced by socio-economic variables like age, education, and loan accessibility. Their selection of market is influenced by these elements, which in turn impact their economic results and the long-term viability of fish farming operations (Acharjee et al. 2023). The importance of infrastructure and transportation facilities in informing market decisions highlights the need for enhanced infrastructure to facilitate economic activity in the haor areas (Acharjee et al. 2023). In the haor areas, the economic engagement and decision-making authority of women inside homes have a strong correlation with their quality of life. The quality of life of individuals may be significantly predicted by their economic contributions and level of control over financial choices (Hiramoni 2023). Strengthening the economic participation of women may result in higher quality of life and contribute to the overall socio-economic progress in the haor regions (Hiramoni 2023). Floods and climate change impose agricultural limitations on the haor ecosystem, therefore affecting it production. Achieving sustainable agricultural growth requires the implementation of strategies such as the creation of flood-tolerant crop varieties and the promotion of agricultural automation (Bokhtiar et al. 2024). Still, inadequate management techniques endanger these ecosystems, affecting several Sustainable Development Goals. The unsustainable management of haor has a detrimental impact on the environment, namely on aquatic ecosystems and biodiversity. This is analogous to the difficulties presented by plastic pollution, which endangers marine life and ecosystems, impeding progress towards Sustainable Development Goal 14 (Life Below Water) (Ka 2024). The inadequate waste management in haor regions worsens pollution, therefore posing further threats to aquatic ecosystems and biodiversity. The haor areas have substantial water management challenges, such as water shortage and inadequate sanitation, which are crucial for attaining Sustainable Development Goal 6.A lack of proper infrastructure and effective administration in water management results in limited availability of clean water, reflecting the difficulties seen in metropolitan regions such as Rajshahi

City Corporation (Hossain et al. 2023).Deficiencies in haor management have a negative impact on the means of subsistence for communities reliant on these ecosystems, so exacerbating poverty and economic instability. These challenges pose significant obstacles to the attainment of SDG 1 (No Poverty) (Exploring Mechanisms for Sustainable Resource Management: An Empirical Study on Human, Social, Economic & Environmental Resources in Bangladesh, 2023). Effective implementation of sustainable resource management strategies is crucial for enhancing economic results and alleviating poverty in these areas. Deficient waste management in haor regions might result in health problems, akin to the difficulties encountered in Dhaka as a consequence of inadequate solid waste management, therefore affecting SDG 3 (Good Health and Well-being) (Aktar 2023).Insufficient implementation of environmentally sustainable waste management systems in healthcare facilities exacerbates challenges in preserving public health and environmental integrity (Chowdhury & Islam 2023).Despite the predominant emphasis on metropolitan areas, the distinct difficulties faced by haor regions need customized management approaches to guarantee sustainable development. Each of these approaches, including agricultural adaptation, risk management, waste management, and educational programs, contributes to a holistic framework for sustainable haor management. Development of short-duration boro rice cultivars is a crucial approach to reduce the adverse effects of sudden floods on agriculture in haor regions. The use of this method enables farmers to gather crops before the commencement of floods, therefore mitigating the potential for crop failure (Baishakhy et al. 2020). Implementing crop variety diversification and harvesting rice at 80% maturity are a very efficient adaptive approach. Implementing these techniques improves the ability to withstand environmental uncertainties and is essential for ensuring sustainable agricultural production in haor areas (Baishakhy et al. 2020). By including uncertainties inherent in natural hazard management, the use of a fuzzy multi-criteria decision-making technique facilitates the selection of sustainable risk management options. This approach offers a systematic framework for ranking options according to different criteria, therefore assuring resilient decision-making in the presence of uncertainty (Edjossan-Sossou et al. 2020). The implementation of efficient solid waste management strategies, including as recycling, composting, and waste-to-energy techniques, is crucial in mitigating environmental consequences in haor regions. The use of these protocols facilitates the management of pollution and the retrieval of resources, therefore enhancing the general sustainability of the environment (Samreen et al., 2024). Construction of facilities like as the Haor Eco-Interpretation

Center in Moulvibazar serves to advance environmental education and awareness. The centers include sustainable design concepts and function as exemplars for the interpretation and conservation of the haor environment (Kabir & Siddiqua 2023). Deliberate urbanization and unethical activities have resulted in unsustainable and inequitable urban settings in Bangladesh, which indirectly impact haor areas by exacerbating pollution and misuse of resources.The government's proposals for sustainable cities are often impractical and insufficient, underscoring the necessity of strategic redevelopment and restructuring of metropolitan areas to include natural zones such as haors (Mondal 2024).Water shortages and poor water quality in metropolitan areas such as Rajshahi City Corporation provide clear evidence of a substantial deficiency in sustainable water management methods. This statement highlights the wider scope of water governance concerns that also affect haor areas (Hossain et al. 2023). To preserve the ecological health of haor ecosystems, it is imperative to provide enhanced infrastructure, water treatment methods, and governance processes that guarantee access to clean water.The biodiversity of haor ecosystems, including the Mithamoin haor, is compromised by environmental changes and inadequate implementation of management initiatives. The conservation of fishing resources and the preservation of biodiversity need the implementation of an ecologically focused framework (Nahiduzzaman et al. 2023). Strategy that prioritise the interplay between physicochemical and biological characteristics may effectively stabilise and improve the ecological equilibrium in haor zones.Emphasizing the need of resolving these deficiencies, it is equally vital to consider the socio-economic aspects that impact haor management. For example, the incorporation of environmentally friendly supplies chain procedures in different industries, such as banking, may stimulate sustainable economic operations that indirectly contribute to the well-being of haor ecosystems. In addition, it is necessary to enhance legal frameworks and implement policies that may effectively deter exploitation and provide justice, therefore promoting the general sustainability of natural resources.

Methodology

This research uses a qualitative approach to investigate the difficulties associated with the sustainable management of haor in Hakaluki Haor. This approach enables a thorough investigation of the experiences and viewpoints of different stakeholders engaged in haor management, therefore

offering valuable understanding of present practices, obstacles, and possible approaches for attaining sustainable development objectives.

Data Collection

The data gathering process included doing semi-structured interviews with 10 important stakeholders from the KII and 20 from the IDI. These stakeholders included local community members, fishermen, farmers, merchants, government officials, and representatives from NGOs. Furthermore, a focus group discussion was carried out to get a thorough comprehension of the existing management methodology and obstacles in Hakaluki Haor. The results from the main data collection were supplemented and validated by reviewing secondary data from pertinent publications, research papers, and policy documents.

Interview No.	Interview Type	Stakeholder Type	Designation of Respondent	Years of Experience	Sector/Field	Interview Duration
1	IDI	Fisherman	Local Fisherman Leader	15	Fisheries	45 min
2	IDI	Farmer	Sustainable Farmer	10	Agriculture	40 min
3	IDI	Local Community Member	Village Representative	20	Community Leadership	50 min
4	IDI	Trader	Small Business Owner	12	Local Commerce	42 min
5	IDI	Government Official	Fisheries Officer	18	Public Administration	55 min
6	IDI	NGO Representative	Project Manager	14	Environmental Conservation	48 min
7	IDI	Local Community Member	Community Activist	8	Community Advocacy	39 min

8	IDI	Trader	Retail Business Owner	9	Local Commerce	37 min
9	IDI	Farmer	Organic Farming Advocate	11	Agriculture	46 min
10	IDI	NGO Representative	Field Officer	6	Rural Development	44 min
11	IDI	Fisherman	Senior Fisher	7	Fisheries	38 min
12	IDI	Local Community Member	Village Council Member	15	Community Leadership	43 min
13	IDI	Farmer	Sustainable Agriculture Practitioner	9	Agriculture	41 min
14	IDI	Local Business Owner	Small-scale Trader	10	Commerce	40 min
15	IDI	NGO Representative	Environmental Program Coordinator	17	NGO Sector	49 min
16	IDI	Government Official	Water Resource Specialist	16	Water Management	52 min
17	IDI	Resident	Local Community Advocate	8	Community Representation	39 min
18	IDI	Local Community Member	Youth Leader	5	Community Engagement	42 min
19	IDI	Trader	Agricultural Products Seller	10	Local Commerce	45 min

20	IDI	Government Official	Agricultural Extension Officer	13	Sustainable Agriculture	47 min
21	KII	Local Government	Senior Environmental Officer	20	Public Administration	60 min
22	KII	Media Representative	Environmental Journalist	14	Journalism	58 min
23	KII	Researcher	Senior Research Scientist	25	Environmental Research	65 min
24	KII	Local Government	Urban Development Officer	18	Urban Planning	66 min
25	KII	Policy Maker	Policy Advisor	28	Government Policy	62 min
26	KII	Academic	Professor of Environmental Science	22	Academia	60 min
27	KII	NGO Director	Director of Environmental Programs	23	NGO Sector	63 min
28	KII	Media Representative	Environmental News Editor	16	Journalism	59 min
29	KII	Researcher	Environmental Policy Analyst	21	Policy Development	64 min
30	KII	Government Official	Head of Environmental Policy	27	Public Sector Management	67 min

Data Analysis

A thematic approach was used in the data analysis of this research to find patterns and topics pertaining to the difficulties and possibilities of sustainable haor management in Hakaluki Haor. Upon thorough examination and coding of the interviews and focus group discussion transcripts, the material was systematically classified into prominent themes.

Findings and Analysis

Water Pollution

Consequently, pollution adversely affects the health of aquatic ecosystems, thereby disrupting the balance of plant and animal populations. This phenomenon has led to the depletion of clean water supply for the local population and the degradation of fisheries, which are vital for their livelihood.

It is well-established that the decreased fish populations resulting from contaminated waterways pose significant challenges in maintaining their livelihood and traditional lifestyle. Our primary issue is the polluted water that is negatively impacting agriculture irrigation, resulting in reduced crop yields and soil deterioration. The detrimental effects of agricultural runoff, industrial waste, and chemical contaminants on aquatic life have resulted in a decline in the quality of water accessible for their everyday need (Interview NO 01 & 03).

Water contamination is recognized as a contributing element to the decline in fish output within the Hakaluki Haor wetland habitat located in northeast Bangladesh. The escalating release of industrial and agricultural pollutants has exerted significant strain on the area water resources ecosystem, thereby compromising the overall sustainability of these resources. However, the lockout in 2020 effectively improved the water quality in extensive regions of Lake Vembanad, highlighting the need of tackling human activities to ensure the sustainable management of coastal ecosystems and water resources (Aziz et al., 2023; Sun et al., 2016; Kulk et al., 2021; Schellenberg et al., 2020).Enforcement of more stringent rules on the disposal of industrial waste and agricultural runoff, advocacy for environmentally sustainable farming methods, and improvement of water quality monitoring systems. Active involvement of local people in awareness initiatives and the implementation of sustainable water management techniques.

Biodiversity Loss

Excessive fishing, deforestation, unregulated agricultural expansion, and pollution are the primary causes responsible for the decline of indigenous species and the degradation of natural habitats. The activities erode the delicate ecological balance of the haor, therefore reducing its capacity to support a diverse array of plant and animal groups.

The decline in biodiversity in Hakaluki Haor has had a profound impact on their means of subsistence and the stability of the local environment. The declining fish populations resulting from overfishing and pollution have posed considerable challenges in maintaining their economic viability. An uncontrolled growth of agriculture and the use of toxic pesticides have deteriorated natural ecosystems, resulting in a decrease in beneficial species and disturbing the ecological equilibrium (Interview NO 02, 05).

Research findings suggest that the primary cause of the decrease in biodiversity in Tanguar Haor, Bangladesh is the absence of collaboration between community leaders and government officials. Several environmental determinants, such as climate and human activities, contribute to the decrease of biodiversity in China. The global rise in population and economic growth has resulted in ever more severe impacts on bird diversity and carbon sequestration. Cow ranching has emerged as a major driver of the reduction in biodiversity (Ara et al., 2019; Lu et al., 2020; Marques et al., 2019; Green et al., 2019). The implementation of more stringent rules on fishing and pesticide usage, in conjunction with the promotion of sustainable farming methods, is imperative. By enhancing community understanding and engagement in conservation initiatives, it is possible to restore natural equilibrium and save livelihoods.

Environmental Degradation

Principally, it is driven by unregulated agricultural expansion, overfishing, pollution from chemical runoff, and uncontrolled construction activities. Through the compromise of water quality and disruption of the natural habitat of many plant and animal species, these activities worsen the deterioration of the wetland ecosystem.

Aquatic contamination caused by chemical runoff and uncontrolled waste disposal has significantly diminished fish populations, therefore directly affecting their means of subsistence. The uncontrolled growth of agriculture and excessive use of pesticides have deteriorated the

quality of soil and water resources, therefore intensifying the challenges in maintaining their crops (Interview NO 04 & 06).

These results suggest that the degradation of the environment in Bangladesh negatively impacts the sustainable management of Haor through its threats to agriculture, decrease in fish production, worsening of natural disasters, and emergence of social issues such as income, education, and health deficiencies (Islam et al., 2022; Hossain & M 2019; Imran et al., 2023; Smith et al., 2021). The implementation of more stringent laws on waste disposal and chemical consumption, in conjunction with the promotion of sustainable agriculture methods, is critical. Incorporating education and engagement of local populations in conservation initiatives may effectively safeguard the haor ecosystem and guarantee the long-term viability of fishermen and farmers.

Effects on Livestock

The degradation of wetlands and the depletion of natural vegetation have significantly decreased the supply of natural feed and grazing grounds for animals. Thus, the deterioration in cattle health and production has adversely affected the means of subsistence of rural farmers reliant on animal husbandry.

Diminished availability of uncontaminated water and organic feed has undermined the well-being of cattle, resulting in illnesses and a decrease in agriculture output. This problem has imposed additional financial burden on their means of living, since both fishing and agricultural groups depend on robust cattle for additional revenue and nourishment, therefore establishing a circular pattern of difficulty in efficiently managing their resources (Interview NO 08, 10).

Influence of farmers' understanding and awareness of climate change on livestock production in the Northeastern Haor region of Bangladesh. The presence of water pollution in the haors directly endangers cattle, often resulting in illnesses and increased death rates, therefore worsening the economic difficulties among the local inhabitants (Fahim et al., 2021; Islam et al., 2023; Hoq et al., 2021; Ali et al., 2020). Implementation of sustainable water management strategies and improvement of natural fodder availability. The establishment of community-led initiatives for habitat restoration and the provision of training to local farmers in sustainable livestock management are essential measures to mitigate the adverse effects and improve resilience in the haor ecosystem.

Unplanned Development and Encroachment

The expansion of agroforestry, modernization of infrastructure, and intrusion by local communities and businesses have led to the deterioration of natural habitats and disruption of the haor ecosystem. The actions described above reduce the wetlands' capacity to sequester water, exacerbate soil erosion, and alter the natural water flow patterns, therefore causing negative effects on both biodiversity and local livelihoods.

Unauthorized structures, agricultural expansions, and inappropriate land use are altering the ecological equilibrium, resulting in inundation and a reduction in biodiversity. The absence of vigorous implementation of current rules and inadequate governance has worsened the issue, therefore complicating the sustainable management of the haor (Interview NO 07 & 09).

Sustainable haor management in Bangladesh is threatened by unplanned development and encroachment onto agricultural land. It perturbs the inherent hydrological patterns and biological equilibrium of the haor area, resulting in heightened inundation, depletion of habitats, and a reduction in biodiversity. The activities impede the sustainable management of haor by intensifying environmental deterioration and restricting the efficacy of conservation procedures (Islam et al., 2022; Newaz et al., 2019; Islam et al., 2023; Hossain et al., 2019). The report recommends the implementation of stringent land-use rules and the strengthening of enforcement measures to deter unlawful building. Promotion of sustainable development techniques by means of community education and cooperation among stakeholders may effectively conserve the natural environment and facilitate sustainable management of haor.

Poor Governance and Corruption

Insufficient regulatory frameworks and a conspicuous lack of transparency lead to the ineffective enforcement of environmental laws, therefore facilitating the prevalence of illegal activities such as overfishing, deforestation, and uncontrolled development. Furthermore, corruption at various administrative levels exacerbates these issues by undermining conservation efforts and diverting funds initially designated for sustainable management.

The absence of rigorous regulatory supervision and a dearth of openness result in unregulated use of haor resources. Moreover, corruption within municipal governments often leads to the improper distribution of financial resources and insufficient implementation of environmental regulations.

This disregard not only weakens conservation efforts but also permits perpetuation of harmful behaviors (Interview NO 11, 14).

Inadequate governance and corruption greatly impede the success of sustainable haor management in Bangladesh by allowing unregulated exploitation of resources, improper distribution of cash, and ineffective enforcement of environmental regulations. This phenomenon results in the deterioration of the environment and weakens the attempts to conserve the haor ecosystem (Newaz et al., 2019; Rahman & M. 2018; Rana et al., 2020). It is of utmost importance to fortify institutional structures, boost openness and accountability, and promote community participation in decision-making. The implementation of rigorous rules and the establishment of autonomous monitoring agencies may effectively enhance resource management and mitigate the adverse effects of corruption on the environment.

Lack of Awareness

A significant portion of the population lacks awareness of the environmental repercussions of their activities, including overfishing, inadequate waste management, and the adoption of detrimental farming methods. Insufficient comprehension of this phenomenon results in actions that compromise the haor ecosystem, therefore reducing its biodiversity and the long-term viability of its resources.

A considerable number of inhabitants lack a comprehensive understanding of the significance of conserving the haor ecosystem or the adverse consequences of unsustainable activities, such as overfishing and inadequate waste management. The lack of understanding in this respect hinders the active involvement of communities in conservation initiatives, therefore posing difficulties in the successful implementation of policies targeted at sustainable management (Interview No 12 & 15).

These studies suggest that a lack of knowledge significantly hinders the sustainable management of Haor in Bangladesh by obstructing the implementation of climate-resilient agricultural practices, compliance with fishing rules, and effective community governance (Tima et al., 2021; Newaz et al., 2019; Rahman et al., 2018; Rana et al., 2020). Therefore, it is crucial to execute focused educational programs and community engagement activities. Their main objective should be to enhance local knowledge of haor ecosystems and emphasize the need of sustainable

behaviors. Through the implementation of seminars, awareness campaigns, and engagement with local leaders, it is possible to enable citizens to actively participate in conservation efforts and endorse sustainable management techniques.

Inadequate stakeholder collaboration

Inadequate collaboration among government entities, local communities, non-governmental organizations (NGOs), and private sector participants has resulted in disjointed endeavors in the management of haor resources. The lack of coherence in this approach leads to contradictory interests and overlapping duties, therefore impeding the progress and execution of whole management plans.

Insufficient coordination at times leads to the duplication of efforts and ineffective use of resources, hence worsening environmental deterioration. Lack of a cohesive strategy leads to the emergence of opposing interests, therefore impeding the successful use of management technologies. The need of establishing robust collaborations to synchronize goals, enhance the allocation of resources, and guarantee the sustainability and effectiveness of conservation initiatives was underscored (Interview NO 13, 16, 17 & 19).

Insufficient community organization and leadership at the local level hinder the sustained implementation of wetland management in Tanguar Haor. Furthermore, insufficient cooperation among stakeholders in watershed programs throughout Bangladesh often results in initiatives that give higher importance on social and economic sustainability while neglecting environmental sustainability. Conversely, the effectiveness of co-management in Hail Haor is augmented by greater contact with official entities and strong organizational capabilities. Moreover, inadequate collaboration that disregards factors such as gender, poverty, social capital, and farmers' attitudes towards technology and training adversely affects the effectiveness of disaster risk management among farmers at the community level (Debnath & R. 2016; Mazumder et al., 2016; Tima et al., 2021; Rana et al., 2020; Newaz et al., 2019). The enhancement of local community organization and leadership should be given priority to promote sustainable haor management. To optimize the efficiency and long-term viability of projects, it is essential to promote the involvement of stakeholders and maintain good communication with authorities. Furthermore, the incorporation of more diverse social factors into management strategies has the potential to augment the degree of community resilience and the efficacy of programs.

Need for Policy Intervention

Current regulations often lack thoroughness and do not effectively tackle the complex issues encountered by haor ecosystems. The absence of strong and flexible policy frameworks impedes the successful management and conservation of these wetlands.

It is our contention that the current policies pertaining to haor management lack comprehensiveness and effectively implement. The successful management of environmental deterioration and resource depletion is a tough task in the absence of strong governmental interventions. The need for modernized and rigorously implemented regulations to improve the long-term viability and adaptability of haor ecosystems (Interview NO 18 & 20).

The evaluations indicate that policy intervention is crucial in Bangladesh to ensure the effective implementation of laws, enhance enforcement, foster suitable business and agricultural conditions, strengthen community involvement, tackle sedimentation problems, improve climate change adaptation, and overcome technical and institutional obstacles for sustainable Haor management (Uddin et al., 2019; Hossain et al., 2023; Hoq et al., 2021; Smith et al., 2021; Tima et al., 2019). The implementation of effective policy interventions is essential for the sustainable control of haor. By implementing comprehensive and enforced rules that include clear guidelines and sufficient monitoring, it is possible to effectively tackle environmental degradation and resource depletion, therefore guaranteeing the long-term health and resilience of the ecosystem.

Practical Implications

The paper underscores the importance of improving policy development to tackle water pollution, biodiversity decline, and environmental deterioration in haor management. This emphasizes the need of enhancing community involvement by means of educational and awareness campaigns to promote more responsible management and backing for sustainability effort. Integrated management techniques are essential, necessitating collaboration among government agencies, non-governmental organizations (NGOs), and local communities to tackle issues comprehensively. It is essential to invest in infrastructure to alleviate the consequences of uncontrolled expansion and invasion. Ensuring the effectiveness of conservation initiatives and preventing their undermining by unlawful activity requires the imperative tasks of combating corruption and enhancing governance. The dissemination of knowledge and the encouragement of sustainable

practices may effectively influence the behavioral modifications of stakeholders. In conclusion, the use of adaptive management techniques will provide the ability to effectively address developing issues, therefore guaranteeing enduring ecological and socio-economic advantages.

Conclusions

The study's results suggest that the sustainable implementation of Hakaluki Haor in Bangladesh faces significant challenges, including water contamination, depletion of biodiversity, and environmental degradation. Successful solutions need the adoption of stronger policy frameworks, more collaboration among stakeholders, and heightened involvement of local communities. Ensuring proper governance and combating corruption are crucial for attaining successful implementation. Considering adaptive management and education as important concerns can improve the conservation of haor resources and contribute to the achievement of sustainable development goals.

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