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ASSESSMENT OF LIVELIHOOD CHALLENGES DUE TO WETLAND ECOLOGICAL CHANGES: A CASE FROM CHALAN BEEL, THE LARGEST WETLAND OF BANGLADESH

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ABSTRACT

Chalan Beel is the largest wetland in Bangladesh and has historically provided numerous services to the local community. However, ecological changes have posed significant challenges to community livelihood. This study assessed the intricate relationship between ecological changes and community livelihood challenges. The study employed a qualitative approach to social research involving twelve focused group discussions with 96 participants from the *Chalan Beel* areas of Bangladesh along with seven key informant interviews and participant observations. The findings reveal many ecological issues, including the impermanent nature of water resources, unpredictable flooding, intensifying drought, increasing demand for fertilizer and mechanized irrigation, declining land production capacity, and increasing insect infestation, which affected the community's livelihood. The changes have led to a decreased fish population, reduced earnings, and a shift towards alternative occupations. The depletion of aquatic resources has increased livelihood expenditures, exacerbated by water impermanence and unpredictable floods during the rainy season. Farmers grapple with rising costs due to insufficient water for summer irrigation and heightened drought intensity in the *beel* area, necessitating increased reliance on fertilizers and machine irrigation, escalating cultivation expenses. The study identified seven driving forces behind these changes, including the construction of roads, the construction of the Farakka Dam, the closure of the Mirjapur Canal, population growth, indiscriminate use of fertilizers and insecticides, lack of wetland management plan, and climate change. As a result of the absence of adaptation management strategies, there is no visible improvement in community well-being. The study underscores the need for policy interventions and comprehensive planning to alleviate the community's hardships.

1. INTRODUCTION

Wetlands, constituting approximately 6.4% of the Earth's land, are vital ecosystems with far-reaching implications for environmental sustainability and human wellbeing (Md. N. Islam & Kitazawa, 2013).

Ecologically productive wetlands provide myriad ecosystem services that surpass those provided by terrestrial services (Gardner & Finlayson, 2018) and play a crucial role in sustaining the wellbeing of aquatic and terrestrial life forms (Mitsch & Gosselink, 2007). Wetlands control floods by decelerating water flow, diminishing water velocity, mitigating sedimentation (Keddy et al., 2009), and facilitating aquifer replenishment (Gosselink & Turner, 1978). Wetlands also hold significance for human society by offering diverse ecosystem services (Ramsar Convention Secretariat (RCS), 2007). They provide food, water, and livelihood to the people around them (Rebelo et al., 2010; Ricaurte et al., 2014; Schuyt, 2005). Wetlands support through regulating water and sediment quality and managing pollutants and nutrients (Chalov et al., 2017). Additionally, they contribute to mitigating climate change (Fennessy et al., 2018; Mitsch et al., 2013). Moreover, wetlands provide cultural and spiritual inspiration (Pedersen et al., 2019). The calculated annual global value of ecosystem services of wetlands is estimated to be USD 47.4 trillion (Davidson et al., 2019). Wetlands represent an exemplary socio-ecological system that maintains interactions between humans and the environment (Berkes, 2017; Langan et al., 2018). Wetlands play a pivotal role in achieving sustainable development goals such as zero hunger (SDG 2), quality education (SDG 4), clean water and sanitation (SDG 6), decent work and economic growth (SDG 8), sustainable cities and communities (SDG 11), responsible consumption and production (SDG 12), and climate action (SDG 13) at first hand (Adhya & Banerjee, 2022). They contribute to attaining universal priority targets such as 'sustainable management of resources,' 'improving water quality,' and efficient resource consumption (Jaramillo et al., 2019). Throughout the world and especially in developing countries, several studies reported high dependence of local communities on wetland ecosystems (Aryal et al., 2021; Camacho-Valdez et al., 2013; Owethu Pantshwa & Buschke, 2019; Wondie, 2018).

However, Wetlands continue to face persistent degradation in many countries despite the growing awareness of the value (Bhatta et al., 2016; Wei et al., 2015). As a result of urbanization and agricultural practices, pollution with pesticides (Davis & Froend, 1999), artificial drainage, overgrazing, and climate change (Li et al., 2021), expansion of settlements and human activities, construction of dams, disturbance of natural drainage and industrial wastes (Khan & Arshad, 2014), wetlands are encountering degradation. Furthermore, the lack of public and political awareness of wetland values and political will for wetland conservation and restoration (Finlayson & Rea, 1999) further exacerbates the degradation. In the twentieth century, the rates of wetland loss were nearly four times higher compared to earlier centuries, and this conversion trend persists into the twenty-first century. While some regions, such as Europe and North America, are experiencing low or decelerating loss rates, significant losses continue elsewhere, notably in Asia (Davidson et al., 2019).

In Bangladesh, where wetlands cover roughly 50% of the nation's land area, these ecosystems play a pivotal role in supporting human livelihoods by providing many ecosystem services (Al-Amin et al., 2021). Bangladesh's wetlands are essential reservoirs of biodiversity and ecosystem services, supporting subsistence, semi-commercial, and commercial requirements of adjacent communities (Al-Amin et al., 2021). Wetlands are particularly indispensable for rural communities, offering climate-sensitive services that vary with the seasons and serve as a lifeline for agriculture and fishing, upon which most households depend (Dhar et al., 2018; Huq et al., 2020). The wetlands of Bangladesh also have eco-tourism, cultural, and aesthetic values (Khan et al., 1994). The multifaceted benefits of wetlands, ranging from agribusiness potentials to supporting biodiversity, underscore their paramount importance for the socio-economic fabric of Bangladesh (Moniruzzaman et al., 2018).

Despite their significance, wetlands in Bangladesh are experiencing degradation due to increased population, agricultural growth, overfishing, siltation, pollution, ill-planned infrastructure, lack of institutional coordination, and lack of awareness (Byomkesh et al., 2009). The sustainability of these crucial ecosystems is under threat, resulting in impacts on livelihoods (Yousuf Haroon & Kibria, 2017). Rural livelihoods, intricately connected to wetland services, face challenges due to seasonal impacts (Huq et al., 2020).

Chalan Beel is the largest wetland in the northern and central parts (Md. N. Islam & Kitazawa, 2013), a low-lying land in Bangladesh (Ahmad, 1978; M. Islam, 1997). *Chalan Beel* has been historically instrumental in sustaining the livelihoods of approximately 5 million individuals (Hossain et al., 2009; Sayeed et al., 2015). Direct land ownership and engagement in crop cultivation by 90 percent of individuals in *Chalan Beel* highlight its pivotal role in providing sustenance and income to the local community (Ahmed et al., 2021). Fishing, both for personal consumption and as a source of income for nearly 100,000 fishermen in and around *Chalan Beel*, further emphasizes its economic significance (Ahmed et al., 2021; Kabir et al., 2021). The wetland also serves as a source of household materials, contributing to local housing construction (Kabir et al., 2021).

While *Chalan Beel* has been historically indispensable for agriculture, housing, income, and fishing, its dependency is diminishing, and the wetland is experiencing environmental degradation, impacting the socio-economic conditions of the local inhabitants (Nurullah & Sarker, 2020; Parvez & Mohsin, 2022; Shahidullah et al., 2020). *Chalan Beel*'s historical role in providing groundwater for regions around it, preventing dryness during the dry season and flooding during the wet season, is now under threat (Hossain et al., 2009; Islam & Kitazawa, 2013). The wetland's area is shrinking daily, spanning only 10 Upazilas now, in contrast to its historical distribution over 18 sub districts (Hossain et al., 2009). The expansion of aquaculture activities has substantially reduced freshwater wetlands since 1990, impacting ecosystem services, including flood protection, fisheries, and biodiversity crucial for adjacent communities (Al-Amin et al., 2021; Khondoker, 2014). Embankments, dams, roads, and railway lines have disrupted water flows, coupled with the impacts of global climate change, resulting in a decrease in natural resources and adversely affecting the livelihoods of around 5 million people (Hossain et al., 2009; Kibria & Yousuf Haroon, 2017). Overusing chemical fertilizers, pesticides, and insecticides on croplands has further contributed to decreased fish and aquatic organisms, impacting local ecological resources and the livelihoods of around 100,000 fishermen (Islam & Hussain, 1970; Sayeed et al., 2015).

Several studies have focused on wetland degradation and its consequences for livelihoods. (Adhya & Banerjee, 2022) investigated the impact of encroachment on wetlands in the lower Gangetic Floodplain, revealing the significant effects on landless people dependent on wetland resources. Das & Bhattacharjee (2015) explored the challenges faced by fishing communities in Assam Sone *Beel*, India, due to climate change. (Bhatta et al., 2016) assessed the degradation of ecosystem services and livelihood challenges in the Maguri-Motapung Wetlands of Assam, highlighting the consequences of overexploitation and siltation.

In Bangladesh, numerous studies have investigated various aspects of wetlands, including dependency, changes due to climate change, economic valuation, and biodiversity dynamics. Notable among these are (Ahmed et al., 2021; Karim et al., 2020; Kibria & Yousuf Haroon, 2017; Shahidullah et al., 2020; Siddiquee et al., 2007; Tikadar et al., 2022). Moreover, Huq et al. (2020) explored the potential livelihood risks households' face in southern Bangladesh due to the volatile nature of climatic variability.

Researchers have conducted several studies in the specific context of *Chalan Beel* in Bangladesh. For example, Mou et al. (2023) focused on assessing species vulnerability, revealing birds as the most critically endangered community, while mammals were identified as the slightest concern. Hossain et al. (2009) contributed to understanding biodiversity degradation in *Chalan Beel*, investigating changes in its ecological balance. Ahmed et al. (2021) explored the impact of hydro meteorological hazards on crop cultivation, highlighting the adverse effects of various climatic events on agricultural production. Nurullah and Sarker (2018) studied the evolving nature of dependency within the *Chalan Beel* community, shedding light on changes in livelihood practices and strategies. Islam & Kitazawa (2013) proposed an Increased Public Awareness (IPA) policy model for short-term and long-term solutions to wetland degradation, taking *Chalan Beel* as a case.

Despite the rich body of literature on wetlands in Bangladesh, research needs to explicitly address the impact of ecological changes on the livelihoods of the *Chalan Beel* community. Existing studies in *Chalan Beel* have predominantly focused on biodiversity status, conservation efforts, and hydro meteorological hazards, leaving a crucial void in understanding how ecological shifts directly impact residents' daily lives and livelihoods. This research aims to fill the identified gap by addressing the research question: What are the impacts of ecological changes in *Chalan Beel* on the livelihoods of its community members? The specific objectives of the study were to investigate – (a) the perception of the local community on the past and present condition of ecosystem services of *Chalan Beel*, (b) the ecological changes they perceive in the wetland, (c) their perception of the challenges of livelihood and living due to the changes, and (d) their perception about the drivers behind the ecological changes of the wetland.

The Social-Ecological Environmental System Framework (SEES) is a widely employed conceptual model assessing the intricate interaction between evolving ecology and associated livelihood costs (Berkes et al., 2000; Folke et al., 2010; Ostrom, 2009). Integrating social, ecological, and environmental elements, it elucidates the interdependence of human society and the environment. Climate systems and various factors act as driving forces, impacting ecosystems and subsequently affecting human livelihoods. This study utilized SEES to explore the intricate dynamics of *Chalan Beel*'s ecological changes and their ramifications on community livelihoods. Additionally, the Millennium Ecosystem Assessment Framework was applied to elucidate changes in ecosystem services supporting SEES.

2. METHODOLOGY

2.1 Research design

The study employed the qualitative approach, which is dedicated to understanding the severity of the phenomenon (Minayo & Minayo-Gómez, 2003). As the research objective is to assess the intricate linkage between *Chalan Beel*'s ecological changes and the livelihood challenges of its community people, we used the qualitative method when this method favours studying the real-life situation, the perceptions, experiences, and beliefs (Yin, 2016).

2.2 Study Area

Chalan Beel is situated between 24.35° to 24.70°N and 89.10° to 89.35°E. The *Chalan Beel* discharges on the south through the Baral River into the Ganges and Brahmaputra Rivers (Hossain et al., 2009). Historically, it spanned across 18 sub-districts (upazilas) in six districts: Rajshahi (Paba, Bagmara, and Mohonpur); Pabna (Chatmohor, Vangura, and Faridpur); Sirajgonj (Tarash, Ullapara, Raigonj, and Shahjadpur); Natore (Sadar, Singra, Gurudaspur, and Baraigram); Naogaon (Manda, Raninagar, and Atrai); and Bogra (Nandigram). Currently, it extends over ten upazilas, including

Singra, Gurudaspur, Boraigram, Chatmohar, Bhangura, Faridpur, Shahjadpur, Ullapara, Tarash, and Raigonj, within the three districts of Natore, Pabna, and Sirajgonj. Once, the approximate *beel* area was 651,230 acres in 1967 (Hamid, 1967). Presently, the permanent flooded area of the *beel* has dwindled to approximately 18,120 acres, where most of the *beels* are experiencing drying conditions leaving only a small shallow and interconnected water body (Islam & Kitazawa, 2013). The permanent water bodies have been converted into agricultural lands, settlements, roads, and 255 highways (Islam & Kitazawa, 2013). The study collected data from nine villages in two unions of Tarash Upazila in the Sirajgonj district. These are Magura Binod Union and Soguna Union (Figure 1).

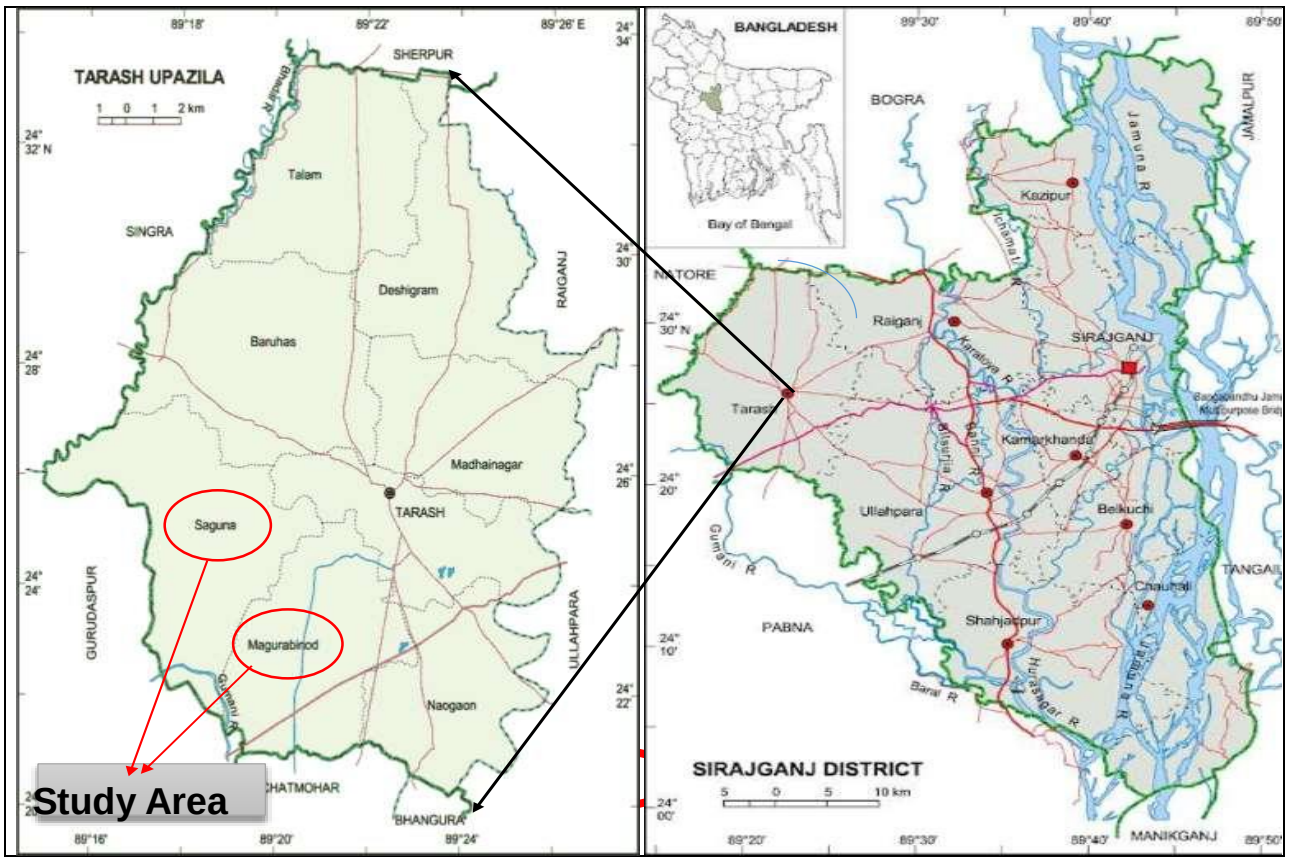

Figure 1: Map of the Study Areas

(Source: https://bdmaps.blogspot.com/2011/09/sirajganj-district.html https://sirajganjdistrictinformation.blogspot.com/2016/03/tarash-sirajganj-district.html)

The selected areas include Nado Syadpur, South Sampur, Ambaria, Hamkuria, Dobila, Ghor Gram of Magura Binod Union, and Kamarson, Makorson, and Kondoil villages of Soguna Union. The author has chosen these for two main reasons: 1) their proximity to *Chalan Beel* and 2) ease of accessibility.

2.3 Participants

Since this research aims to discuss the different challenges faced by the community people of the wetland area, the research development took place in nine villages in two unions of Tarash Upazila in the Sirajgonj district. As we see in Table 1, 96 research participants aged between 18 and 75 years (M=48.2) were in the 12 focus group discussions. The majority of the respondents were male (N=64)

Table 1: General Profile of Focus Group Participants

Unions of Tarash Upozila	*Villages*	*Women*	*Percentage*	*Men*	*Percentage*	*Total*
Magura Binod	Nado Syadpur	8	8.24	9	8.33	17
	South Sampur			8	8.24	8
	Ambaria	7	7.21	9	9.27	16
	Hamkuria			8	8.24	8
	Dobila			7	7.21	7
	Ghor Gram	9	8.33			9
Soguna Union	Kamarson			8	8.24	8
	Makorson	7	7.21	8	8.24	15
	Kondoil			9	9.27	9
	Total	31	31.95	66	68.04%	97

2.4 Data collection

The focus group, as described by Minayo et al. (2010), is a collective interview where individuals convene to discuss a common theme or focus under the guidance of a moderator. Flick (2009) contends that group interviews address the limitations of individual responses, offering advantages such as the generation of rich data, stimulation for content elaboration, and enhanced recall of events. Throughout the survey, we conducted two focus group discussions in Nado Syadpur, one in South Sampur, two in Ambaria, one in Hamkuria, one in Dobila, one in Ghor Gram of Magura Binod Union, one in Kamarson, two in Makorson, and one in Kondoil villages of Soguna (Table 1). Each session had an average duration of one hour. The Topic Guide used for conducting the focus groups encompassed various themes, including rural population lifestyles, perceptions of fish and aquatic resource availability in *Chalan Beel*, water accessibility, frequency of floods and droughts, the need for pesticides and fertilizers in cultivation, agricultural land production capacity, and production costs in the area. Participant selection criteria included residence in one of the nine villages selected for further research, age 18 or older, expression of consent after reading the Free and Informed Consent Term, and availability to participate for the entire group session, the approximate duration of which was informed in advance.

We generated supplemental insights into the livelihood challenges faced by the community through key informant interviews. We conducted key informants, including the chairman, members, and female union parishad members, to gather valuable perspectives. We conducted a total of 7 Key Informant interviews at the selected study site.

2.5 Data analysis

The data underwent analysis using Bardin's (2011) Thematic Content Analysis facilitated by the qualitative analysis software Atlas Ti 8.4. It serves as a tool for organizing data analysis but does not employ automatic commands. We recorded the focus group sessions and key informant interviews, and the audio was transcribed and translated. After importing the translated statements into the software, we become familiar with the data. Then, we initiated an inductive coding process to capture the nuanced meaning. We identified patterns and grouped related codes into overarching themes. We divided the transcripts into broader themes like 'ecosystem services.' We subdivided this theme into provisioning, regulating, cultural, and supporting. Under the sub-theme of 'provisioning,' the author noted all the statements people described the present and past conditions in the focus group discussion and interview. Under the sub-theme 'regulating,' 'cultural,' and 'supporting,' the author documented all

the statements describing the comparison of wetlands' role in the past and present. Other themes were 'the changes in wetland ecology' and 'the driving forces.' 'Under the theme 'the changes in wetland ecology,' we documented all statements where the respondents described the visible changes and their livelihood hardships due to these changes. Under the theme 'the driving forces of the changes', the author noted all the statements explaining the causes of the ecological changes they perceive in *Chalan Beel* (Table 2). We also noted other relevant information. We extensively used the comments of the respondents in the result section. We used the number of FGD, the number of participant, and the number of KII to identify the statements.

Table 2: Themes, subthemes, and the studies where they focus these themes

Themes	*Sub-themes*	*Linkage with livelihood challenge*	*Sources*
Status of ecosystem services	- Provisioning -regulating - cultural -supporting	Availability or absence of these services impacts livelihoods	(Adhya & Banerjee, 2022; Bhatta et al., 2016)
the changes in wetland ecology	-nature of water - nature of flooding - nature of drought -land production capacity -demand for fertilizers and insecticides	Impact livelihood	(Bograd et al., 2019)
Driving forces of ecological change	-Construction of Roads -Construction of Farakka Dam -The closure of Mirjapur Canal -Population Growth -Indiscriminate Use of Fertilizers and Insecticides -Lack of Wetland Management Plan -Climate change	These forces have an impact on the ecology of *Chalan Beel*, resulting in challenges to the livelihoods of the community.	(Adhya & Banerjee, 2022; Bhatta et al., 2016)

3. RESULT

3.1 Status of Ecosystem Services of *Chalan Beel* and Its Livelihood Costs

We identified twenty-four essential ecosystem services from responses in focused group discussions and key informant interviews (Table 3). Based on the framework of the Millennium Ecosystem Assessment (2005), we have classified these services into thirteen provisional, seven regulating, two cultural, and two support services. Respondents perceived changes in the quantity and quality of the services, resulting in livelihood challenges for the wetland inhabitants surrounding the village.

Provisional Services

Respondents identified thirteen services from the wetland, including fish, fuel wood, edible and non-edible plants, snails, leafy vegetables, and medicinal trees (Table 3). They also get fodder and water for irrigation from the *beel* and hunt birds from the *beel*. Respondents said that these resources have decreased compared to the past.

Fish production in the *beel* has experienced a staggering decline, with most of the respondents engaged in fishing and those not involved unanimously expressing their concerns about the significant reduction in fish population. Previously, those relying on fish catching reported a daily income ranging from 400-500 Bangladeshi Taka; however, the current scenario reflects a drastic decrease in income to 250-350 Bangladeshi Taka, despite an increase in the price of fish.

Crop cultivation dominates the *Chalan Beel* landscape, starkly contrasting its previous state. The *Chalan Beel* of the past, abundant with wetlands, has transformed into cultivable lands. The once robust productivity of fish has witnessed a significant decline. A 46-year-old respondent actively involved in fishing from Shampur village in Binod Union, Tarash Upazila, Shirajgonj, explained the changes: "*Now, besides crop cultivation, you do not see any other things. The previous Chalan Beel and the present are not the same. Here, we had many wetlands, but now those are cultivable lands. The productivity power of fish has decreased compared to the past. Right now, there is no water. People are cultivating crops and using fertilizer in croplands. Beels have been dried in the Chalan Beel. For this, some fishes have vanished. Now, we see the fish production here is not the same as in the past, and it has decreased.*" (FGD 1, Participant 3).

As the abundance of fish in the area has significantly declined, the number of fishermen has decreased. According to another 54-year-old respondent who catches fish in Shampur village, Binod union, Tarash Upazila, Shirajgonj participant, "*The number of fishermen has decreased as fish have decreased. We saw in our childhood a lot of big Beels. Those Beels are hampered now. Now, these are cultivation lands…"* (FGD 2, Participant 4).

The phenomenon of declining fish populations due to habitat loss and environmental changes has been documented in various studies (Dudgeon et al., 2006; Olden et al., 2007). Such transformations often result in the loss of biodiversity and disrupt ecosystem services. Ahmed et al. (2021) emphasize the staggering decline in fish populations within Chalen *Beel*. As respondents in this study highlighted, the reduction has significant implications for the livelihoods of the predominantly fishing-dependent community.

Table 3: Distribution of Chalan Beel Ecosystem Services.

Service category	*Services*
Provisioning services (13)	Fish, fuelwood, livestock grazing, edible and non-edible plants, water for irrigation, fodder, hunting birds, snails, reed, catkin grass, jute stick, leafy vegetables, medicinal trees
Regulating Services (7)	Air Quality Maintenance, Climate Regulation, Water Regulation, erosion control, purification, pollination, storm protection
Cultural Services (2)	Recreational visit, bird watching
Supporting (2)	Nutrient retention, water cycling

The aquatic resources in the *Chalan Beel* area have experienced a significant decline. Previously, inhabitants could quickly obtain building materials for houses, such as Vetibar Grass (Chrysopogon zizanioides), Catkin grass (also known as ament), reed (Phragmites australis), and mud easily from *Beel*. However, now, all elements for construction must be purchased from the market, especially for those without land for cultivation. A 46-year-old respondent involved in fishing expressed, "*Nothing we take from the Beel now without fish. Moreover, fish is also now scarce. We cannot rely on it. In a line, the Beel helped us construct a house, but now it does not give us. She has no it now, so what will give us?*" (FGD 3, Participant 5). In focus group discussions, community members expressed the loss of traditional building materials like Binna grass and Dhap grass (*Cynodon dactylon)* that were once abundant on the *Beel*'s shores. The disappearance of these resources is attributed to the absence of uncultivated lands in the *Beel* area. A 70-year-old respondent reminisced, "*I have found in my childhood, even fifteen or twenty years ago, the Beel was our only income source. The fish, grass, fodder, fuel, birds, and turtles were huge. The most popular sentence was 'Biler mach Biler Sakh, Sukhe Aci Baro Mash' (The fish and grass of Beel bring happiness for the whole year)*." (FGD 8, Participant 2) Another 58-year-old respondent of Dobila village, Magura Binod UP, under Tarash Upazila, Shirajgonj, lamented the current situation, saying, "*In our childhood, we saw people fishing here. It was not a problem if they fished in other areas. Nevertheless, now it is not possible. No one can catch fish in other areas. No one will leave an inch of land. Everyone wants to capture more and more. Moreover, for this reason, people cannot get natural things from here anymore. Moreover, now nothing can be found except fish in this area.*"(FGD11, Participant 4). In a focus group discussion, one respondent said that: *"I saw in my childhood that my father used to hunt herons (Buck Pakhi) almost from Chalan Beel. Mother used to cook them. Now, eating these birds' meat has become a luxury. Herons (Buck Pakhi) are not seen like before in Chalan Beel".* (FGD 5, Participant 8)

The reduction in the fish population has had alarming repercussions on income levels, forcing individuals to seek alternative occupations. This depletion has disrupted the once smooth existence of low-income households, which previously sustained themselves by managing rice and fish from the *beel*. With the inability to collect from the *beel*, those people feel compelled to purchase these resources, resulting in increased daily expenditures for the household. The livelihood challenges extend beyond the landless individuals, impacting farmers in the community as well. Previously, farmers could supplement their livestock's diet with snails and crabs from the environment. However, the changing ecological dynamics now require them to purchase food for ducks, cows, and goats, adding to household expenditures and intensifying the economic hardships experienced by these individuals.

Regulating Services

From the oral testimonies, the author identified seven regulating services. These services encompass air quality maintenance, climate regulation, water regulation, erosion control, purification, pollination, and storm protection. The respondents explained that the quality of these services has decreased. As a respondent stated, "Previously, *the wetland was deeper, which protected us from erosion. Now the depth of the rivers in the wetland has decreased, causing erosion*" (FGD 3, respondent 4).

Cultural Services

The participants expressed that the *beel* allowed them to enjoy meaningful moments with their family and friends, utilizing it as a preferred picnic spot. A 42-year-old respondent mentioned, "*Nowadays, there are numerous designated picnic areas around the beel where we can relax and spend time with*

our loved ones. Unfortunately, some individuals contribute to pollution by discarding bottles and polythene bags in the beel." Respondents also highlighted using the *beel* for bird-watching purposes.

Supporting

The author identified two supporting services from the respondent's testaments. The services are nutrient retention and water cycling.

3.2 Changing Pattern of *Chalan Beel* Ecology and Livelihood Costs

Respondents perceived the wetland's ecology changes in the last twenty years. The responses professed that these changes have affected the livelihoods significantly.

Impermanent nature of water resources

The water levels in the *Chalan Beel* area are transiently marked by irregular fluctuations, presenting challenges to agricultural practices, particularly the cultivation of Aman rice during August and September. This unpredictability in water flow has become a significant impediment to agricultural production, as highlighted in feedback from a participant, "*In the past, water in this area was a constant presence, allowing for predictable patterns. We used to gauge the water levels, and if there were 8 or 10 feet of water, we confidently sowed paddy. However, the situation has evolved. Now, instead of cultivating rice, we opt for jute. After harvesting jute, we intend to cultivate paddy, but unexpected water surges lead to land inundation…. While we used to cultivate Aman rice in these lands, the inconsistency in water access has hindered our ability to do so now. As a result, we face challenges in Aman cultivation and sustaining fishery activities."* (FGD 7, Participant 3). The unpredictability of water resources imposes mental strain on farmers in the region. Crop losses resulting from insufficient water availability place farmers in precarious situations, especially those dependent solely on agriculture. These findings align with the study Sayeed et al., (2015) who delved into the difficulties of the people of *Chalan Beel* due to water scarcity in fisheries and agricultural activities. Irregular water availability and dam-induced disruptions resonate with broader discussions on the impacts of water infrastructure on local hydrology and ecosystems (Nilsson et al., 2005; Poff et al., 2007).

Unpredictable Flooding During the Rainy Season

Unpredictable floods during the rainy season are a prevalent challenge, causing substantial damage to crops, particularly Aman paddy. The crops are often inundated during cropping, making collecting yields from the fields difficult. The unpredictability of instant floods leaves farmers needing help to take sufficient measures to safeguard their crops. Respondents expressed their concerns in a focus group discussion: "*We face considerable uncertainty during the rainy season. If water arrives within the first 15 days, harvesting jute becomes impossible. Fortunately, it came after 15 days, allowing us to proceed. However, if the water level surpasses that of our planted paddy, our crops are at risk of being flooded"* (FGD 9, Participant 7). People cannot harvest jute conveniently from the *beel* due to the unforeseeable flooding in the area. A respondent expressed his agony: "*The lack of flood predictability is a significant challenge. We plan to harvest jute and plant paddy, assuming that rain will not come suddenly, but water unexpectedly inundates our fields, causing crop destruction. Regular and continuous rainfall would benefit us, but we experience unpredictable patterns.*

Furthermore, when we harvest paddy, rain often begins, submerging the harvested crops underwater for 20 to 25 days. This prolonged submersion affects the quality of our crops, so we struggle to obtain fair prices for our harvest" (FGD 10, Participant 6). The crop losses pose challenges for farmers in fulfilling their families' basic needs. In some instances, they resort to obtaining loans from local NGOs and local money lenders, often burdened by high interest rates. Nepal & Shrestha, (2015)

discuss challenges induced by climate change, focusing on unpredictable flooding. Their research corresponds with these findings, emphasizing farmers' struggles facing uncertainties in crop harvests due to erratic rainfall patterns and unexpected floods.

Insufficient irrigation water during the Dry Season

A notable shortage of irrigation water has emerged during the non-rainy season. The water table has significantly deepened, requiring extensive digging, often reaching depths of 80-100 meters and beyond, to access water for irrigation. This deepening water layer has imposed substantial financial burdens on farmers, mainly when cultivating boro paddy fields that necessitate continuous irrigation for three months. In a focus group discussion, one respondent said*: "We have to manage to supply water with machines to paddy in the summer season. We rent machines and have to buy machine oil. It is challenging for us to manage"* (FGD 12, Participant 6).

Intensifying Drought Conditions

The consensus among almost all respondents is a shared concern regarding the escalating intensity of drought in the area; a sentiment echoed unanimously. According to their collective observations, drought severity has been progressively rising, presenting an alarming trend. In particular, respondents emphasized that the past year witnessed an exceptionally high intensity of drought, amplifying the challenges faced by the local community. The increased severity significantly threatens the *Beel* area's agricultural landscape, water resources, and overall livelihoods. The heightened intensity of drought raises immediate concerns about water scarcity and has broader implications for crop cultivation, affecting the region's agrarian economy. In a focus group discussion, one respondent said that: *"The kind of drought we are seeing now, we have not seen in our childhood. As time goes by, farming in this area is becoming unusable and difficult due to water scarcity and loss of productivity."* (FGD 2, Participant 4). Farmers already grappling with poverty, particularly those heavily dependent on agriculture, bear the brunt of the adverse effects of drought in the area. Ahmed et al. (2021) address the escalating intensity of drought in *Chalan Beel*, stressing the urgent need for sustainable water management strategies. The concerns raised by respondents in the present research align with the imperative for mitigating the adverse impacts of drought on the local community and ecosystem.

Escalating Demand for Fertilizer and Mechanized Irrigation

In the cultivation of land in this region, there is a growing need for fertilizer. Farmers feel compelled to drill wells to depths exceeding 80 feet for irrigation, resulting in heightened diesel consumption during cultivation. During a Key Informant Interview (KII) with a 55-year-old member of Saguna Union Parishad, he underscored, "*Cultivating in this area has become reliant on diesel and fertilizer. The costs of both diesel and fertilizer have surged compared to earlier times. The poorly developed roads force us to pay higher wages for transporting goods to my residence. Presently, the utilization of diesel and fertilizer has increased. The fertility of the fields has diminished compared to the past"* (KII, 3). The rising demand for fertilizers is resulting in higher production costs, and the excessive utilization of these fertilizers is triggering an environmental crisis in the wetland, leading to degradation.

Decline in Land Production Capacity

The prevailing sentiment among almost all respondents is a unanimous acknowledgment of the decreasing production capacity of their land in the *Beel* area. According to their shared perspective, cultivating a single crop in the *Beel* area has become unfeasible without an increased reliance on fertilizers. This perspective marks a notable departure from the conditions 15 years ago when it was

possible to cultivate paddy in *Beel* land without the necessity of fertilizers. Those highlighting a decline in production capacity emphasize the critical role of fertilizers in the contemporary agricultural landscape of the *Beel* area. The inability to sustain crop cultivation without increased fertilizer usage reflects the changing dynamics of soil fertility and nutrient levels in the region, prompting a shift in traditional agricultural practices. In a focus group discussion, one respondent who is a farmer argued that: *"Last year, I put in much effort, but unfortunately, my rice yield was not satisfactory. Despite working hard and taking a loan for cultivation, most paddy was crushed, a common occurrence when the land loses its soil fertility"* (FGD 7, participant 8).

Conversely, a subset of respondents presents a contrasting viewpoint, contending that land production capacity in the *Beel* area has increased. Their argument centres on the positive impact of fertilizer application, which, according to their observations, has led to higher crop yields than prevailing conditions. This perspective suggests that, for some farmers, strategic fertilizer use has become a crucial factor in optimizing agricultural productivity.

Rising Production Costs in Cultivation

Cultivation expenses in the region have seen a significant increase, with farmers grappling with elevated costs related to irrigation, fertilizer, pesticides, and additional expenditures on day laborers, putting a strain on their financial resources. Despite these investments, they could not attain the returns from sales, leading to a sense of disillusionment among farmers. In a focus group discussion with farmers in the study area, they expressed their grievances: "*The set selling prices for dried maize are 800 takas per Mon (40kg), and for wet maize, it is 500 takas per Mon. Nevertheless, it takes a cultivation cost of 600 TK. There are instances where additional payments are necessary for day laborers. The rising expenses for fertilizers and irrigation add to the financial strain."* (FGD 5, Participant 6). Another respondent added in the discussion: *"...the transportation costs for harvesting crops have surged, with a new standard payment of 2500 taka per bigha to labourers. It is disheartening that despite investing 700 takas per Mon in cultivating the crops, the selling price remains 600 takas per Mon. This harsh reality underscores the formidable challenges faced by the people in this region..."* (FGD 5, Participant 6).

The disparity between cultivation costs and market returns highlights systemic challenges within the crop marketing system. Limited market access and pricing challenges contribute to the economic hardships faced by farmers. The financial difficulties faced by farmers resonate with discussions on the sustainability of modern agricultural practices and the need for equitable economic frameworks (Giller et al., 2009; Pretty, 2008). (Rahman, 2017) discuss the economic challenges of agriculture in Bangladesh, emphasizing rising production costs.

Escalating Insect Infestation

The proliferation of insects in agricultural lands has witnessed a concerning surge. During a key informant interview, a respondent *said, "We are encountering new and diverse types of insects in our paddy, mustard, and maize fields. Some of these pests are proving resistant to conventional pesticides. Consequently, we find ourselves compelled to intensify pesticide application in our lands, yet every year brings new varieties of insects"* (KII, 5). The growing infestation is pushing them to employ higher amounts of pesticides, leading to a rise in production expenses. Furthermore, excessive pesticide usage is disrupting the ecological equilibrium in the *beel*.

3.3 Driving forces of change

Respondents pinpointed seven key factors contributing to the shifting ecology of *Chalan Beel*. According to the majority, the construction of roads over the past 20-30 years coincided with the

onset of changes in the wetland ecology. A senior citizen participating in a focused group discussion highlighted, "*Those beels are hampered now. They have turned into cultivated lands because the river streams in this beel were closed due to road construction. Consequently, fish production has been significantly affected*." (FGD 2, Participant 4). Table 4 shows that the Farakka Dam in the Murshidabad district of India emerged as another factor affecting water flow and resource depletion in *Chalan Beel*. A respondent stated, "*The water flow is sluggish, and the impact of the Farakka Dam has disrupted the regular water supply to this area*." (FGD 7, Participant 3). During an interview with a member of Magura Binod Union Parishad, the respondent mentioned, "*Dams in the Char Ghat area constrain water accessibility.*" (KII 3). The closure of the Mirzapur Canal was identified by respondents as another factor negatively impacting the wetland. During a focused group discussion, a participant explained, "*Fish used to come from Mirzapur through canals before, but now these fishes cannot come because the canal has been closed.*" (FGD 2, Participant 4).

Respondents highlighted population growth in the last 20-30 years as a cause of landscape changes in the wetland (Table 4). A senior citizen shared, "*I have five sons, and they are building houses in the agricultural lands in the beel. Many people are constructing houses, and the flow of water becomes disrupted. The increasing number of people is causing the wetland to dry up."* (FGD 4, Respondent 1). Overexploitation of wetlands resulted from population activities like agricultural practices, fishing, and using the *beel* as a picnic spot. Respondents identified the indiscriminate use of fertilizers and insecticides as a factor disrupting the ecological balance. A respondent explained, "*Some days ago, there was lots of water in the area, and we found many fish here. However, nowadays, people excessively use fertilizers and insecticides, hampering fishes and other insects in the beel*." (KII, 2). Respondents cited the lack of a management plan as another reason for changing wetland ecology. A respondent expressed, "*The area of this Chalan Beel is now divided into various parts for powerful persons. Twenty years ago, no one was interrupting in this area. Nevertheless, now, everyone wants to capture land. For this reason, most people have lost their land and the chance to earn*." (KII, 3). Respondents also identified climate change as a factor influencing the changing ecology of the wetland. A participant reminisced, "*In our childhood, we saw lots of rainfall, and we got lots of fish. Nevertheless, we cannot cultivate in the area* due to the lack of rainfall." (FGD 3, Participant 1).

Table 4: Responses on the drivers of change in the wetland and their consequences in Focus Group Discussion and Key Informant Interviews.

Drivers of Change	*Consequences*
Construction of Roads	- *Beel*s turn into cultivable lands - River stream has been closed - Fish production has been affected
Construction of Farakka Dam	- Sluggishness of water flow - Disrupted regular water supply - Affected fish production - Affected agricultural activities
The closure of Mirjapur Canal	- Impacted fish availability negatively - Impacted aquatic resources negatively
Population Growth	- Unplanned construction of housing - Disrupted water body and water flow - Wetlands are experiencing dryness
Indiscriminate Use of Fertilisers	- Hamper fish production

and Insecticides	- Impacted flora and fauna negatively
Lack of Wetland Management Plan	- Unplanned use of *beel*s - *Beel*s become divided into different parts - Unplanned housing - Unplanned road construction - Unplanned dam construction.
Climate change	- Increasing drought - Increasing flood

4. DISCUSSION

This study revealed that people residing beside the *Chalan Beel* perceive that the wetland contributes significantly to the quality of life and a source of livelihood. However, various factors such as the construction of roads, the presence of Farakka Dam, the closure of Mirjapur Canal, the growth of population, excessive use of fertilizers and insecticide, lack of a wetland management plan, and the impact of climate change are collectively diminishing the wetland ecology. Consequently, the *Chalan Beel* community people are grappling with challenges to their livelihoods, causing an increasing vulnerability to disaster in the area (Figure 2). Similarly, Dudgeon et al. (2006) and Olden et al. (2010) identified road development, construction of railways and housing, dams in rivers, and the removal of natural water bodies and fish migration routes as factors behind the ecological changes in wetlands primarily affected the livelihood status of community people.

The author recorded twenty-four ecosystem services of the *Chalan Beel*, including thirteen provisional services such as fish, fuel wood, livestock grazing, edible and non-edible plants, water for irrigation, fodder, hunting birds, snails, reed, catkin grass, jute stick, leafy vegetables, and medicinal trees. According to the testimonies, previously, these services subsidized the living costs of the respondents in many ways. They could collect abundant fish, edible plants, fuel wood, fiber, and materials for house building from the wetland. Once, the *Chalan Beel* was abundant in fish and aquatic resources (Islam & Kitazawa, 2013), and then fishing was one of the income sources of the people living in and around *Chalan Beel* (Sayeed et al., 2015). Most *beel* families depended directly or indirectly on fishing, marketing, and other activities (Rahman & Haque, 2008). Due to ecological degradations, the abundance of fish and the productivity of the land in the area has significantly declined (Islam & Kitazawa, 2013; Hossain et al., 2009). The residents also could obtain cattle fodder, snails for ducks, and some trees for medicinal purposes without monetary expenses. Wildlife, including birds, fish, fish habits, faunal and floral resources, and other water resources, were the elements of wetlands (Hossain et al., 2009), and these were available in the past (Nepal & Shrestha, 2015). According to the respondents' testimonies, these services have decreased compared to the past.

Once, people of the wetlands collected household materials such as traditional building materials notably 'Binna' grass and 'Dhap' trees from *Chalan Beel* for building their housing (Nepal & Shrestha, 2015). These were once abundant on the *Beel*'s shores. However, this dependency is now reduced to building housing (Nurullah & Sarker, 2020). The wetland also provided regulatory services such as air quality maintenance, climate regulation, water regulation, erosion control, purification, pollination, and storm protection (Figure 2). The *Beel* also played a role in providing cultural Services such as recreational visits and bird watching. Additionally, the wetland contributed supporting services such as nutrient retention and water cycling. Respondents perceived that the nature of these services has changed compared to the past.

The oral testament corroborated that there have been significant changes in the ecology of the *Chalan Beel* over the last 20-25 years. These changes impacted the livelihood of the community.

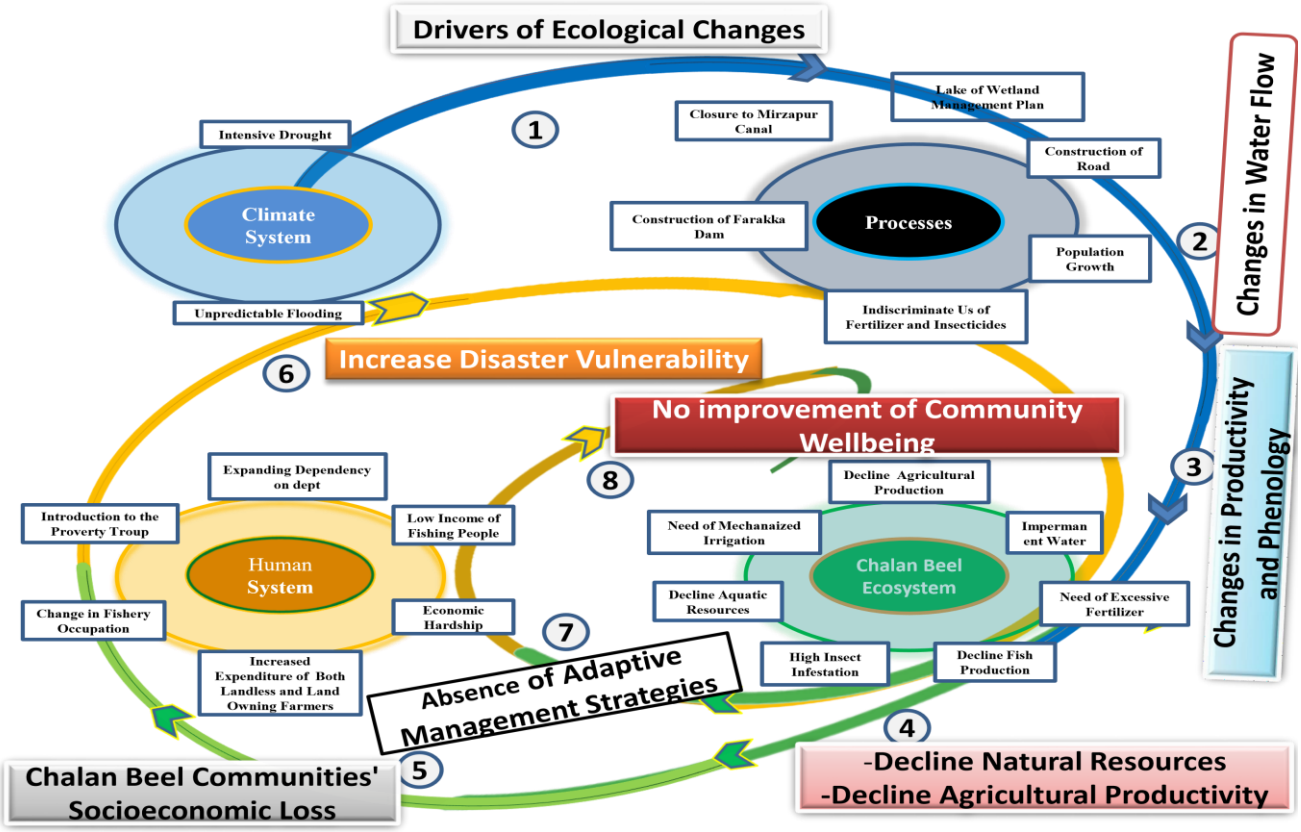

Figure 2: The Nexus between Chalan Beel Ecological Change and Livelihood Challenges

(Developed by author)

The impermanent nature of water resources and sudden floods in the area disrupt agricultural production, resulting in financial losses that impede meeting the basic needs of family members. Inadequate irrigation water during the dry season and intensifying drought conditions threaten agriculture and impose additional economic burdens on farmers. Similar studies like Morton (2007) and Lobell et al. (2011) explored how extreme weather events, such as floods and droughts, and unpredictable water availability can disrupt agricultural productivity, resulting in economic loss. The deepening water table during the dry seasons has compelled the farmers to rely on mechanized irrigation, increasing production expenditure and imposing a financial burden on them. Mechanized irrigation is a known response to water scarcity in agricultural settings(Shah et al., 2000).

The testimonies also suggested that the productive capacity of the agricultural land has decreased. Consequently, farmers find themselves compelled to use more fertilizers. The decreased productive capacity and increased fertilizer use align with global concerns about soil degradation and declining fertility (Lal, 2015; Montgomery, 2007). Additionally, the farmers reported an upsurge in the amount of insects in the area, necessitating the purchase of more insecticides. The increased demand for insecticides and fertilizers has led to an overall surge in production costs. Unfortunately, this increased expenditure has not converted into profits for cultivation. As a result, farmers have to carry the economic burden, which affects their ability to meet the needs of family members. Sometimes, they take loans with high-interest rates from NGOs and local money lenders. The use of additional insecticides due to increased insect production resonates with the discussion on the relationship

between climate change and pest dynamics in agriculture (Bebber et al., 2013). The testimonies of increased production costs and decreasing profits align with the literature on farmers' economic vulnerability due to environmental degradation (Deressa et al., 2009). The difficulties in livelihood are rendering the community vulnerable to disasters. Testimonies indicate that, in the face of these challenges, there is a lack of apparent adaptive management strategies from government and non-governmental organizations. As a result, positive changes in their livelihoods are not being realized.

5. CONCLUSION

The findings of this study illuminate the intricate relationship between ecological changes in *Chalan Beel* and the livelihood challenges the local community faces. The ecological degradation, driven by factors such as extreme fertilizer and insecticide use, road constructions, the presence of Farakka dam, population growth, lack of management plan, and climate changes, has resulted in a myriad of ecological changes affecting the livelihoods of the people reliant on the wetlands. The decline in provisional services such as fish, leafy vegetables, fuel wood, fodder, house construction grasses, scarcity of water during dry seasons, intensifying drought conditions, unpredictable flooding, increasing insect infestation, and decreasing land production capacity and escalating production costs are among the significant ecological changes outlined in this research. The ecological changes affect the life and livelihood of landless households and the landowner farmers. Household expenditures have increased for both landless peoples and landowners as they do not get as many essential resources as they once had. The increasing production costs derived from mechanized irrigation, fertilizers, and insecticides challenge farmers to meet basic needs. The loss of cultivation due to drought and flood makes them bound to take loans from NGOs and local money lenders with high interest rates, kicking them into the vicious cycle of poverty and making them vulnerable to disaster. The adverse impacts of the ecological changes highlight the need for comprehensive and sustainable wetland management strategies to restore ecological balance and support the livelihoods of the affected population. Thus, a holistic and collaborative approach is required to address the complex interplay between ecological changes and livelihood challenges in *Chalan Beel*.

6. POLICY IMPLICATIONS OF THE STUDY

The research underscores vital policy implications for sustainable wetland management and the well-being of the *Chalan Beel* community. These include:

-It is necessary to develop and implement a comprehensive wetland management plan addressing identified ecological change causes (e.g., road construction, dam, population growth, climate change) to balance ecological conservation and socio-economic needs.

-It needs to ensure environmental impact assessments and protective measures for infrastructure projects (e.g., road construction, dam operation) considering the ecological sensitivity of wetlands.

- Involvement of the local community in decision-making is crucial for wetland management and introduce livelihood diversification options.

- The study identify the necessity of establishing regulations for fertilizer and insecticide use to conserve and restore the ecological balance of the wetland.

- It requires a monitoring and research framework for continuous assessment of *Chalan Beel*'s health, informing policymakers about emerging challenges.

- Overall, it is necessary to develop resilience programs for the *Chalan Beel* community, providing access to insurance, improving early warning systems, and offering training to mitigate disasters like droughts and floods.

7. LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

While the study provides valuable insights into the complex interplay between *Chalan Beel*'s ecological changes and the livelihood challenges faced by its community, this study has several limitations. Firstly, this is a qualitative study that analyses the perception of 96 respondents in nine villages. While qualitative study is suitable for exploring experiences and perceptions, it may lack generalizability to a larger population. Moreover, as the study seeks the correlations between ecological changes and livelihood challenges, the qualitative approach fails to establish causality. Secondly, the study's participant sample is limited to nine villages in two unions of Tarash Upazila. This sampling approach might not fully capture the diversity of experiences and perspectives across the entire *Chalan Beel* community, potentially leading to a biased representation of the broader population. Thirdly, the study heavily relies on the oral testimonies of community members, which are subjective and might be influenced by individual perceptions and interpretations. The accuracy of the reported information is contingent on the participant's ability to recall and express their experiences accurately.As the study did not intensively focus on the impact of climate change on community livelihood, future research may emphasize on impact of climate change on the *Chalan Beel* community. The future study may focus on adaptive strategies employed by the *beel* community in response to environmental changes. The future study may also evaluate the effectiveness of existing policies and management interventions in addressing the challenges faced by *Chalan Beel*. Identify gaps in policy implementation and propose recommendations for more robust and adaptive policy frameworks. Additionally, an assessment of the impact of environmental changes on the health and well-being of the *Chalan Beel* community may be conducted to explore the connections between ecosystem services, access to clean water, and public health outcomes in the region.

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