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Evaluating the Influence of Sea Level Rise on Beel Kapalia's Livelihood and Local Adaptation Strategies: Perspectives from the Local Community

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Abstract

Bangladesh is vulnerable to climate change-induced sea level rise due to its location and socioeconomic position. The study examines the Beel Kapalia region in polder no. 24 of the Monirampur upazila of Jessore district, Khulna division. To assess local attitudes on sea level rise-related permanent flooding, Kapalia, Monoharpur, Nehalpur, Balidaha, and Panchakori were polled. This flooding has disrupted residents' lifestyles, making them vulnerable to increasing sea levels. Viability and adaptability were assessed using livelihood capitals. Participants' thoughts and knowledge about their resilience in several livelihood factors were gathered using participatory rural appraisal (PRA) instruments and a questionnaire survey in the area. Major discoveries include the impact of permanent floods on Beel Kapalia's livelihoods, vulnerability and resilience assessments in numerous villages, and community viewpoints on regional adaptation methods to mitigate these consequences. The study found that a sustained 30.5 cm inundation would reduce local human, natural, physical, financial, and social capital resilience to 69.6%, 30.7%, 69.1%, 68.9%, and 69.1%. A constant 61 cm inundation would lower resistance to 40.9%, 8.7%, 42.4%, 45.6%, and 43.8%. Residents believe they can weather a 30.5 cm inundation with local adaptation measures, but if the water level rises to 61 cm, they may be displaced.

Keywords

Adaptation, Beel Kapalia, Climate Change, Livelihood Capitals, Sea Level Rise

1. Introduction

The world is beginning to acknowledge climate change as the most critical environmental issue due to its close relationship to sea level rise (SLR). Notably, Bangladesh and other tropical nations are especially susceptible to the extensive effects of climate change [1]. A frightening projection of a sea level rise ranging from 9 to 88 cm from 1990 to 2100 was provided by the Intergovernmental Panel on Climate Change (IPCC) in their 2007 Third Assessment Report (TAR), highlighting the enormity of the impending task. The SAARC Meteorological Research Centre (SMRC) in Bangladesh has recently completed assessments of historical tide data that have revealed a worrying trend: the rate of sea level rise over the past 20 years has significantly surpassed the mean global rate seen over a century (SMRC, Year). It also creates a threat of slope failure in the nearby hills [2] [3]. It may even alter the design of nearby structures and in some cases result in earthquake induced liquefaction threat [4]-[11]. This alarming finding emphasizes how urgent it is to solve the serious problem of SLR in coastal areas that are vulnerable.

Bangladesh is among the nation's most vulnerable to SLR because of its heavily populated coastal areas and its smooth relief of wide and narrow ridges and depressions [12]. A 45 cm rise in sea level, according to World Bank projections made in 1998, might submerge 10% - 15% of Bangladesh's land by 2050 and force over 35 million people from coastal regions [13]. This is a severe situation. The World Bank published research in 2000 that indicated varied rates of sea level rise by 2020, 2050, and 2100, affecting different percentages of the nation's landmass. The projections ranged from 10 cm to 25 cm to an astounding 1 meter [14].

The 1998 estimates by Ahmed and Alam, which suggested that sea levels would rise by one meter by the middle of the twenty-first century, add even more weight to these projections. According to Ahmed and Alam's 1998 forecast, there will be a combined rise in sea level of 90 cm and an extra 10 cm due to local subsidence [14]. In addition, a 1993 pilot study carried out by the Department of Environment (DOE) predicted that Bangladesh would see a sea level rise of between 30 and 50 cm by 2050, confirming worries regarding the country's vulnerability to SLR. It is notable that along Bangladesh's coast, the rate of sea level rise shows an increasing gradient from west to east [15].

The size of the problem has been highlighted by Agrawala *et al.* (2003), who calculated that over 70 million people in Bangladesh may be impacted by climate change. Numerous factors contribute to this susceptibility, such as the nation's geographic location, low elevation, dense population, poor infrastructure, pervasive poverty, and strong reliance on natural resources [16]. It may be somehow similar to the process of predicting strength properties of soil [17]-[22]. The growing hazard of climate variability and changing places coastal regions, where a large majority of the population resides, are at disproportionate risk [23].

Bangladesh has warmed by about 0.5˚C over the previous century, indicating

a significant change in the climate, according to recent temperature data, which is concerning [24]. Even more concerning, studies suggest that more than 1.5 million residents of big cities like Dhaka, Chittagong, and Khulna may suffer greatly in the event that a one-meter SLR occurs by 2070 [25] [26]. Furthermore, study conducted in 2016 by Rahman and Alam revealed estimated SLR rates that, by 2100, will range from 0.53 to 0.97 meters in 37 locations along Bangladesh's southern coast [27]. This greatly exceeds the 0.09 to 0.88 meters predicted globally for SLR. Bangladesh's rapid pace of SLR raises serious questions about how vulnerable the country is to its negative effects.

Bangladesh has started large-scale infrastructure projects with assistance from the US Agency for International Development in response to these complex difficulties. According to Khadim and Kanak (2013), these projects entail building 282 sluice gates, 1566 kilometers of coastal embankments, and 37 polders [28] [29]. Even while the goals of these projects were to increase agricultural area and prevent saline water intrusion from the sea, they have also raised a new set of problems, such as waterlogging, salinized soil, and environmental damage, mostly because of poor design and management.

Climate change adaptation becomes critical in the face of these enormous obstacles. A variety of actions are included in adaptation, with the goal of lessening damage and seizing possibilities brought about by shifting climatic conditions [30]. These acts can be reactive, contemporaneous, or anticipatory, and their implementation is dependent on how well systems, regions, or communities are able to manage the effects of climate change [31]. Different types of capital—human, physical, ecological, financial, and social—are essential to the success of adaptation efforts because they support the resilience of ecosystems and societies.

This study aims to comprehend the significant effects of sea level rise (SLR) on communities living in beel areas bounded by polders, namely the Beel Kapalia region in polder no. 24. This area is tucked away in Bangladesh's Khulna division's Monirampur upazila of the Jessore district. **Figure 1** shows the map of Manirampur upazilla with marking Beel Kapalia.

Five villages in this region—Kapalia, Monoharpur, Nehalpur, Balidaha, and Panchakori—have been the focus of in-depth surveys to find out how locals feel about the ongoing flooding brought on by SLR. By means of this investigation, the research aims to examine how SLR affects the susceptibility of diverse livelihood metrics, providing insight into the decline in resilience and infrastructure. It also aims to obtain information from the community about the appropriateness and effectiveness of localized adaptation strategies for reducing the expected effects of SLR.

2. Methodology

2.1. Questionnaire Survey

An organized questionnaire was used as the main tool for gathering data.

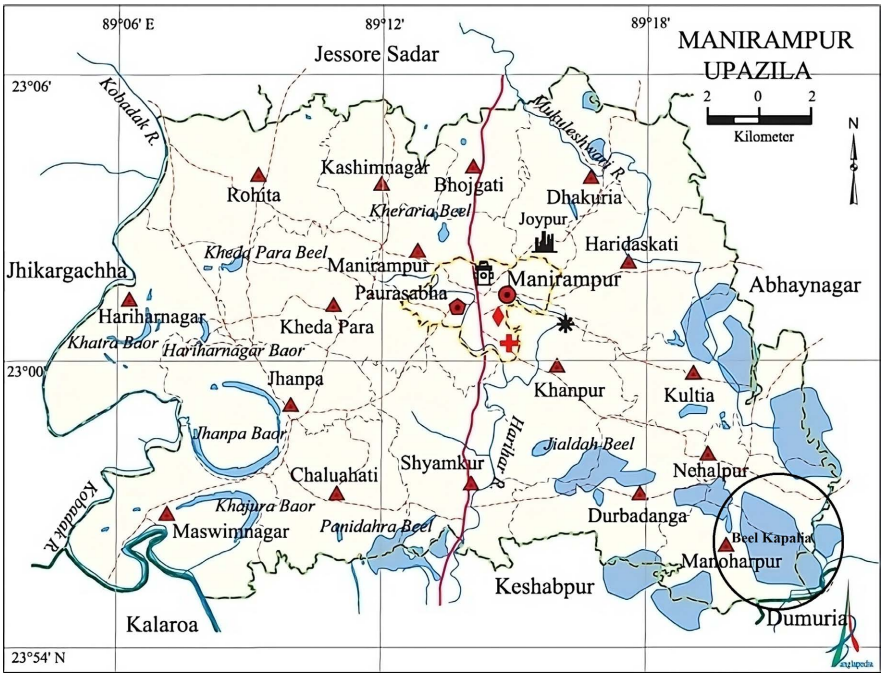

Figure 1. Map of Manirampur upazilla (Beel Kapalia in black circle) (Banglapedia, 2021).

Participatory Rural Appraisal (PRA) techniques were used to assess the viewpoints of residents on their resilience across a range of livelihood characteristics. PRA aims to incorporate rural people's perspectives and knowledge into the planning and administration of development projects [32] [33]. During the PRA process, the study considered five livelihood capitals: social, financial, natural, physical, and human capital.

The questionnaire used for the survey consisted of two main scenarios. The first scenario focused on the potential future impacts on residents' way of life in the event of a permanent inundation of 30.5 cm. The second scenario addressed the potential repercussions of a permanent inundation of 61 cm in the research region. Furthermore, the study sought to investigate the perspectives of community members in relation to potential approaches for mitigating the impacts of rising sea levels.

Aspects of livelihood capitals such as employment, housing, household security, public health, water sanitation, road networks, education, agricultural land, water bodies, sluice gate conditions, NGO activities, and adaptation strategies were all covered in the questionnaire.

Five villages named Kapalia, Monoharpur, Nehalpur, Balidaha, and Panchakori under Monoharpur and Nehalpur unions were surveyed to study the impacts of SLR induced inundation in Beel Kapalia. Percentages of families in survey at five villages in Beel kapalia are tabulated in **Table 1**.

2.2. Data Analysis

Data analysis involved the interpretation of both qualitative and quantitative data

Table 1. Percentage of family participation.

Name of the Village	Union	Household	No. of families surveyed	% of families surveyed
Kapalia	Monoharpur	746	26	3.5
Monoharpur	Monoharpur	1474	25	1.7
Nehalpur	Nehalpur	1462	26	1.8
Balidaha	Nehalpur	935	23	2.5
Panchakori	Nehalpur	1137	25	2.2
Total		5754	125	2.2

gathered through field notes and questionnaire surveys. The data was initially input into Microsoft Excel to create necessary data sheets required for vulnerability analysis. Afterwards, graphs, tables, and maps were generated using these data sheets.

2.3. Assessment of Vulnerability

The assessment of vulnerability was conducted by considering the viewpoint of the local population, employing a combination of qualitative and quantitative approaches to enhance the comprehension of vulnerability. This study highlights the importance of employing qualitative approaches, such as Participatory Rural Appraisal (PRA), to investigate intricate topics such as vulnerability. The determination of vulnerability in various livelihood characteristics was conducted using a methodology proposed by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and documented. An assessment was conducted on each criterion, wherein a rating was issued to represent the degree of susceptibility. The determination of resilience was additionally derived from vulnerability evaluations, wherein reductions in facilities were observed and visually depicted. The data facilitated the identification of villages that saw the greatest and least impact, as well as the assessment of which livelihood capitals were most susceptible to permanent inundation resulting from the rise in sea levels. The graph illustrates the decline in resilience and amenities at two specific levels of permanent flooding, namely 30.5 cm (1 ft) and 61 cm (2 ft).

Vulnerability = Probability × Risk × Preparedness.

3. Analysis of Results

3.1. Vulnerability of the Livelihood Parameters

The vulnerability of the different livelihood parameters is determined by using the vulnerability analysis method suggested by The Joint Commission on Accreditation of Healthcare Organizations (JCAHO). Each of the parameters was analyzed and thus obtains a rating that signifies the level of vulnerability. The survey showed the following ratings for different parameters.

Table 2 shows the vulnerability ratings for different livelihood sub-parameters of which water bodies and agricultural land seem to be most vulnerable with respect to other sub-parameters. Out of a maximum rating value of 45, water bodies obtained 30.5 and 40.3 ratings for one ft and two ft permanent inundations, respectively. Whereas agricultural land obtained 31.9 and 42 ratings for one ft and two ft permanent inundations respectively. Considering the total score of all the parameters, from Table 2 it can be concluded that Kapalia, Nehalpur and Balidaha are very similar in case of vulnerability. On the other hand, Panchakori was the most vulnerable and Monoharpur was the least. Figure 2 illustrate the rating conditions for different sub-parameters graphically.

Different villages have different topography and water level. The height of the roadway system and the livelihood of the local people are also different for every village, and that's why the vulnerability of the different villages is different for any single sub-parameter. Table 3 shows the degree of vulnerability for different sub-parameters due to permanent inundation of one ft and two ft this table

Table 2. Vulnerability of different livelihood sub-parameters for villages surveyed (C1: one ft and C2: two ft permanent inundation cases).

Vulnerability Ratings for parameters (out of 45, 15 > low, 15 - 30 = moderate, 30 < high)							
Village		Kapalia	Monoharpur	Nehalpur	Balidaha	Panchakori	Avg. Ratings
Education	C1	13.5	12.6	12.7	13	14.7	13.3
	C2	27	26.3	26.5	28.3	28	27.3
Health	C1	14.4	13.6	14.2	14.3	14.6	14.2
	C2	24.9	24	25.8	26.7	28.8	26
Water Bodies	C1	30.7	30.5	30.5	30	31	30.5
	C2	40.5	40	40.1	40.1	40.9	40.3
Agricultural Land	C1	31.9	31.9	31.9	32	31.7	31.9
	C2	42.3	41.8	42.8	41.3	41.6	42
Road Network	C1	13.2	11.7	11.8	12.3	12.3	12.3
	C2	23	19.9	23	23	22.9	22.3
Housing	C1	13.5	13.6	13.7	13.2	14.3	13.7
	C2	26.8	25.2	28	25.5	29.4	27
Safe water	C1	16.5	15.1	16.2	16.1	15.8	15.9
	C2	28.2	27.9	28.6	28.5	29.4	28.5
Income	C1	13.4	12.8	14.5	14.6	15	14
	C2	23.7	23.4	23.9	25.4	26.6	24.6
Social Security	C1	14.6	12.8	14.1	14.1	14.1	13.9
	C2	25.5	23.3	25.3	25.7	26.7	25.3

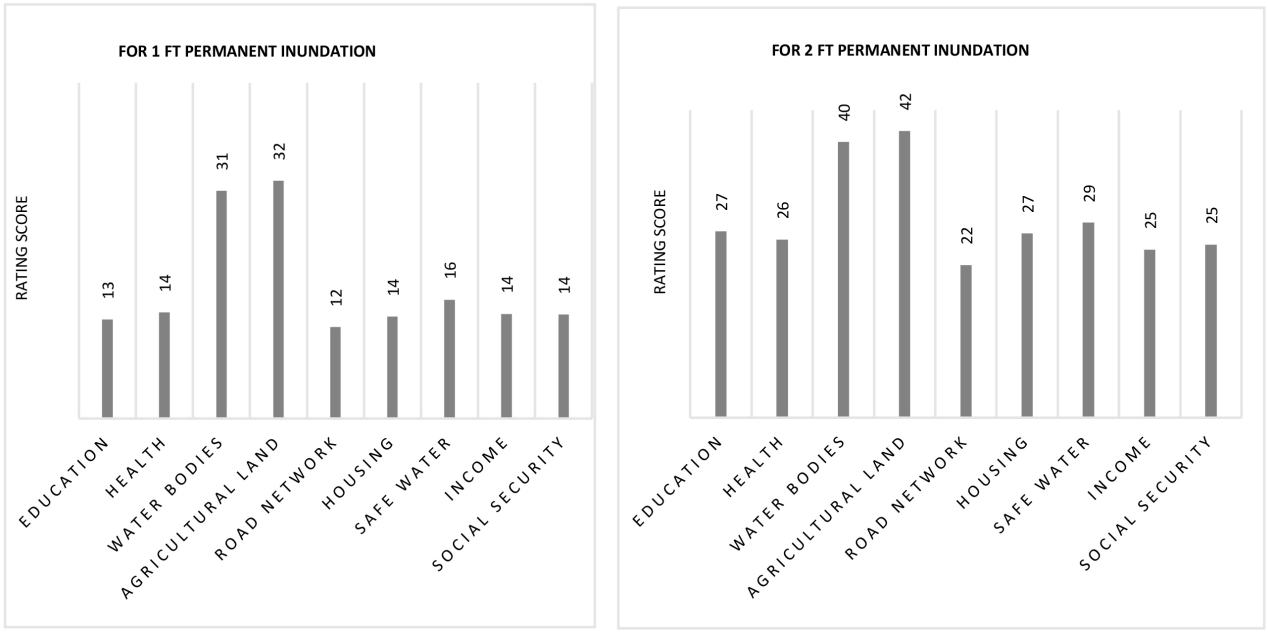

Figure 2. Vulnerability ratings of the different sub-parameters if one (Left) or two (Right) ft permanent inundation occurs.

Table 3. Sub-parameters classification according to low, moderate and high vulnerability.

Conditions	Low Vulnerable	Moderately Vulnerable	Highly Vulnerable
Classification for one ft Permanent Inundation	Education and Road Network	Health, Housing, Safe Water, Income, Social Security	Water Bodies and Agricultural Land
Classification for 2 ft Permanent Inundation	Nil	Education, Health, Road Network,	Water Bodies, Agricultural Land, Housing, Safe Water, Income and Social Security

indicates that the water bodies and the agricultural lands are the most vulnerable sub-parameter in the Beel Kapalia region. All the parameters are found to be moderate to highly vulnerable for two ft SLR induced permanent inundation situations.

The vulnerability of livelihood capitals is given in Table 4. It is observed that the natural capital is relatively more vulnerable than other capitals.

3.2. Impact of Sea Level Rise on the Livelihood of People of Five Villages

Impacts on different livelihood parameters due to possible SLR induced permanant innundation have been studied on five villages. The impact on Kapalia Beel is calculated as average stress of these five villages. The result is presented in next sub-sections for the most and least affected villages as well as the overall impact on Kapalia Beel.

3.2.1. The Most Effected Village: Panchakori under Nehalpur Union

Panchakori is the most vulnerable village in the Beel Kapalia region. Most

Table 4. Ratings for the livelihood parameters.

Livelihood Parameters	Cases	Ratings for the livelihood parameters
Human Capital	30.5 cm inundation	13.7
	60.1 cm inundation	26.6
Natural Capital	30.5 cm inundation	31.2
	60.1 cm inundation	41.1
Physical Capital	30.5 cm inundation	13.9
	60.1 cm inundation	25.9
Financial Capital	30.5 cm inundation	14.0
	60.1 cm inundation	24.5
Social Capital	30.5 cm inundation	13.9
	60.1 cm inundation	25.3

livelihood capitals are largely affected under an inundation depth of 30.5 to 61 cm during the monsoon period. Figure 3 shows that if 30.5 cm permanent inundation occurs, the local people's resilience in human capital, natural capital, physical capital, financial capital and social capital are likely to be reduced to 67.6%, 30.4%, 68.7%, 66.7% and 68.7% respectively. The present resilience of the people is considered here as 100%. If 61 cm permanent inundation occurs then the local people's resilience in human capital, natural capital, physical capital, financial capital, and social capital will be reduced to 36.9%, 8.4%, 39.6%, 41.1%and 40.7% respectively.

Figure 4 shows that education, health, road network, housing, income, social security is low vulnerable due to 30.5 cm inundation and moderately vulnerable due to 61 cm inundation of water. Safe water is moderately vulnerable for both 30.5 and 61 cm inundation of water. Figure 4 shows that water bodies and agricultural land are highly vulnerable for both 30.5 and 61 cm inundation of water. From Figure 3 it is observed that the natural capital (agricultural lands) is at greater risk than the other parameters for 30.5 cm permanent inundation. For 61 cm inundation, almost all the parameters are highly stressed which causes the reduction of people's resilience for different livelihood parameters.

3.2.2. The Least Effected Village: Monoharpur under Monoharpur Union

Monoharpur is the least vulnerable than other villages in the Beel Kapalia region. The livelihood of the people is affected due to inundation depths of 30.5 to 61 cm during the monsoon period. Figure 5 shows that if 30.5 cm permanent inundation occurs, the local people's resilience in human capital, natural capital, physical capital, financial capital, and social capital are likely to be reduced to 71.1%, 30.7%, 70.2%, 71.8% and 71.8% respectively. The present resilience of the people is considered here as 100%. If 61 cm permanent inundation occurs then

the local people's resilience in human capital, natural capital, physical capital, financial capital, and social capital will be reduced to 44.2%, 9.3%, 46%, 48.2% and 48.2% respectively.

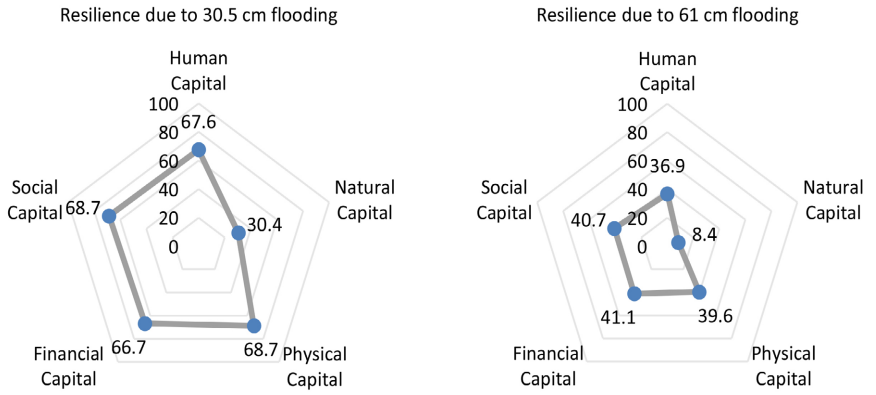

Figure 3. Reduction of peoples resilience if (Left) 30.5 cm and (Right) 61 cm permanent inundation occurs (Panchakori, Nehalpur Union).

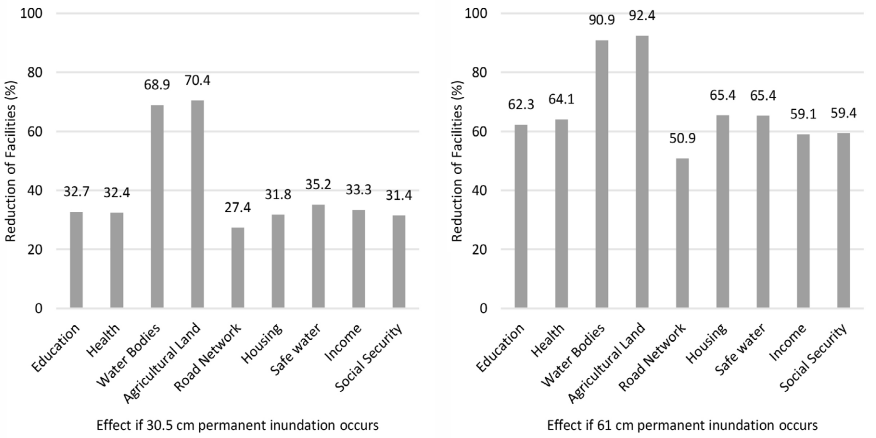

Figure 4. Stress on different sub-parameters if 30.5 cm and 61 cm permanent inundation occurs (Panchakori, Nehalpur Union).

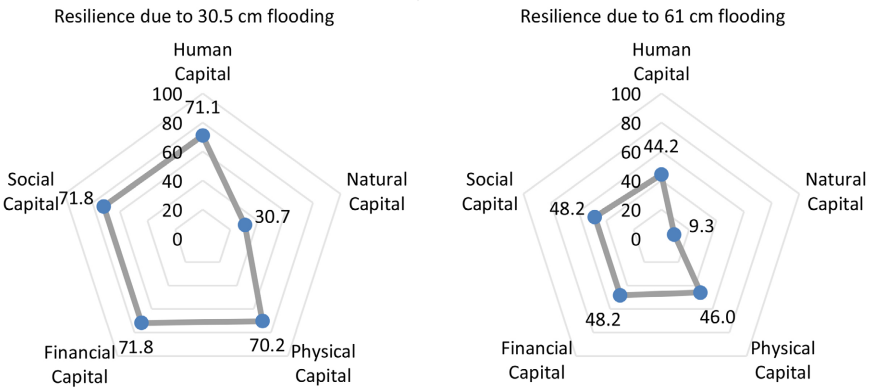

Figure 5. Reduction of peoples resilience if (Left) 30.5 cm and (Right) 61 cm permanent inundation occurs (Monoharpur, Monoharpur Union).

Moreover, natural capital (agricultural lands) is at greater risk than the other parameters for 30.5 cm permanent inundation. For 61 cm inundation, almost all the parameters are highly stressed which causes the reduction of people's resilience for different livelihood parameters.

Figure 6 shows that education, health, road network, housing, income, social security is low vulnerable due to 30.5 cm inundation and moderately vulnerable due to 61 cm inundation of water. Safe water is moderately vulnerable for both 30.5 and 61 cm inundation of water. It also shows that water bodies and agricultural land are highly vulnerable for both 30.5 and 61 cm inundation of water.

3.2.3. Overall Impact on Livelihood of Beel Kapalia

Each of the five villages in the Beel Kapalia region is affected under an inundation depth of 30.5 to 61 cm during the monsoon period. Water bodies and agricultural lands are mostly affected by the permanent inundation.

Figure 7 shows that if 30.5 cm permanent inundation occurs, the local people's resilience in human capital, natural capital, physical capital, financial capital, and social capital are likely to be reduced to 69.6%, 30.7%, 69.1%, 68.9% and 69.1% respectively. The present resilience of the people is considered here as 100%. If 61 cm permanent inundation occurs then the local people's resilience in human capital, natural capital, physical capital, financial capital, and social capital will be reduced to 40.9%, 8.7%, 42.4%, 45.6% and 43.8% respectively. Moreover, it is observed that the natural capital (agricultural lands) is at greater risk than the other parameters for 30.5 cm permanent inundation. For 61 cm inundation, almost all the parameters are highly stressed which causes the reduction of people's resilience for different livelihood parameters.

Figure 8 shows that education, health, road network, housing, income, social security is low vulnerable due to 30.5 cm inundation and moderately vulnerable due to 61 cm inundation of water. Safe water is moderately vulnerable for both 30.5 and 61 cm inundation of water. In addition, water bodies and agricultural land are highly vulnerable for both 30.5 and 61 cm inundation of water.

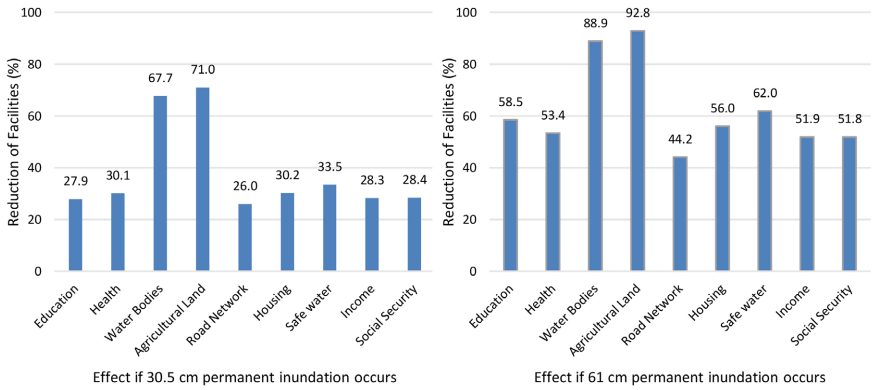

Figure 6. Stress on different sub-parameters if 30.5 cm and 61 cm permanent inundation occurs (Monoharpur, Monoharpur Union).

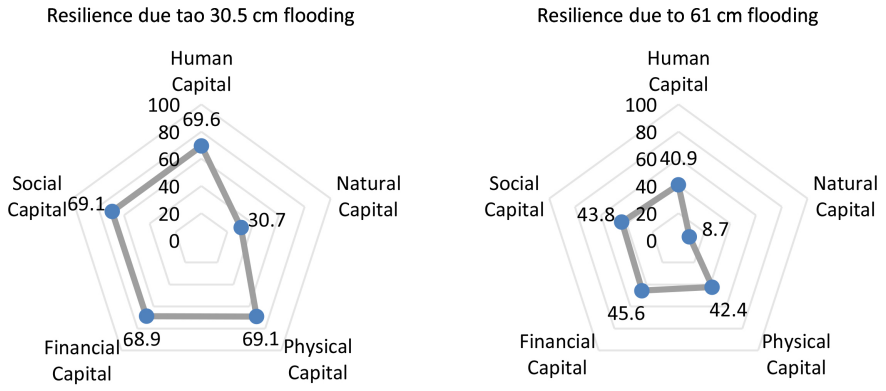

Figure 7. Estimated Reduction of peoples resilience if (Left) 30.5 cm and (Right) 61 cm permanent inundation occurs in Beel Kapalia.

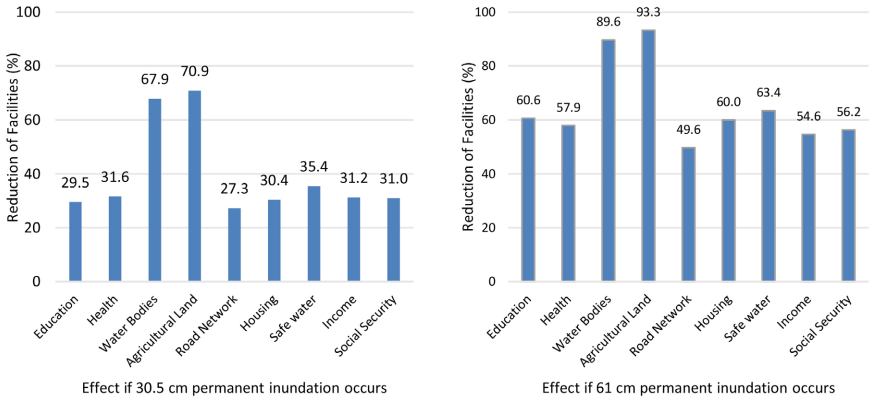

Figure 8. Estimated Stress on different livlihood sub-parameters for 30.5 cm & 61 cm permanent inundation in Beel Kapalia.

4. Local Adaption Techniques

4.1. Housing

Many households sought safety with relatives or on roads, highways, and embankments during moments of extreme waterlogging. To lessen the consequences of waterlogging, locals started raising their houses, restrooms, tube wells, and roadways. The majority of Beel Kapalia's homes are made of mud, making them brittle enough to crumble when water levels rise to 61 cm. There are fewer, stronger semi-Pacca homes in existence. While mud house residents plan to take refuge in surrounding areas or on roadways until the waters subside, Pacca and semi-Pacca house residents think that elevating the plinth levels of their dwellings can reduce threats. Elevating infrastructure is one of the short-term options; nevertheless, siltation and polder system maintenance problems provide a hurdle to long-term solutions like Tidal River Management. It also indirectly suggests that as communities that region face the threat of displacement due to sea level rise, the changes in living conditions and practices may have secondary implications for air quality and hospital disposal [34] [35] emphasizing the interconnectedness of environmental challenges [36] [37] [38].

4.2. Access to Safe Water

Pure drinking water is scarce in Beel Kapalia. Most Beel Kapalia residents are too impoverished to install tube-wells. Not everything has enough clean drinking water. People currently must fetch water from deep tube wells in distant portions of the village. Beel Kapalia residents fight for drinking water. In addition, flooding causes significant freshwater shortages. Beel Kapalia residents fear a flood may deplete their fresh water supply and force them to drink tainted water. This depletion includes the rise in *E. Coli* and immediate household water treatment is necessary [39] [40] [41]. They also believe that tube-well bases should be raised to get contamination-free water during flooding. While the research primarily focuses on the socio-economic aspects of SLR vulnerability, it indirectly underscores the importance of effective water supply, hygiene practices, and wastewater treatment in regions prone to environmental changes [42] [43] [44]. This further emphasizes the significance of enacting efficient solid waste management tactics in susceptible coastal areas such as Beel Kapalia, where the rise in sea levels can intensify environmental issues, including waste disposal and pollution regulation [45]-[51]. Additionally, it highlights the potential significance of rainwater harvesting as a localized adaptation strategy [52].

4.3. Road Networks

Beel Kapalia's road network consists of pavements, brick soling roads, and Kaccha roads. Kaccha roads, which are mostly internal roads, are frequently drowned during monsoons and high seas. Raising these roadways would improve year-round accessibility, according to locals. Despite being vulnerable to floods in some locations during monsoons, government attempts have been made to raise brick-soling roadways. Moreover, pavements can be used as shelter during storms and floods. The government should take action to raise road levels to strengthen all types of roads against ongoing floods and to mitigate its negative impacts. Various road materials, such as Styrene Butadiene Styrene (SBS) [53], Ground Granulated Blast-furnace Slag (GGBS) [54], Asphaltic materials [55], fly ash [56], and several other compounds, have the potential to contaminate groundwater. Overall, it has its own impact on the entire transportation networks and public safety [57] [58] [59] [60].

4.4. Natural Water Bodies

The Beel Kapalia water bodies, which are vital to the local fisheries, are vulnerable because of protracted dry spells that prevent surface water storage and groundwater recharge. The influence of mean water level deviations on fishing is substantial. Fish farming requires rain during the monsoon season, especially in irrigated communities whose traditional water sources are dependent only on monsoon rain. Disruptions to farming and fishing due to changed rainfall patterns and a delayed start of the monsoon create socioeconomic difficulties for

households [61] [62]. Furthermore, salty river water inundates the low-lying areas during high tide, damaging trees, and crops. To reduce these water body risks, adequate drainage, bank elevation, and sluice gate maintenance are crucial [63].

4.5. Agricultural Land

The primary industry in Bangladesh, agriculture makes a substantial contribution to GDP and employment. However, it faces increasing difficulties due to growing food demands, the depletion of land and water resources, and the additional concerns posed by climate change and sea level rise. The study reveals that of the analyzed factors, agricultural land is the most susceptible. Nearly 90% of agricultural land would be under water in the event of a persistent 61 cm flood, which would be extremely dangerous for productivity. To control surplus water, local communities support the use of well-maintained sluice gates. High crop yields are traditionally achieved in these regions by floating agriculture, which is akin to hydroponics. Despite the additional challenges of ongoing climate change, this local knowledge-based strategy shows promise for sustainable livelihoods in vulnerable locations.

4.6. Income Level

In Beel Kapalia, farming and fishing are the main sources of income. But maintaining these occupations becomes difficult as agricultural fields and aquatic sources become more vulnerable. Locals anticipate that they will need to switch jobs and possibly move to neighboring towns in pursuit of new employment prospects to secure the required money for daily costs. Households in coastal Bangladesh used a variety of coping mechanisms, such as food-related measures, asset sales, and borrowing money, to secure their family's survival, drawing on their experiences after Cyclone Sidr in November 2007. Aquaculture ponds were essential in supplying food and revenue after the disaster, but access to aquaculture assets had little effect on coping mechanisms. Recognizing the value of aquaculture in post-disaster recovery, 78% of households indicated a readiness to reinvest in the industry despite the dangers.

4.7. Education System

The lack of education in Beel Kapalia prevents the people from knowing enough about social security, health, sanitation, and the effects of climate change. There are not enough educational facilities, and people are unwilling to send their kids to school since they are illiterate. The current educational system may survive if prolonged flooding takes place and nearby road networks do not sink. The locals believe that elevating the school's grounds and plinth level is necessary to address the issue of ongoing flooding. They beg the government to construct more disaster-resistant facilities so that they may be used as both schools and shelters during emergencies.

4.8. Intervention of Non-Governmental Organizations

In Beel Kapalia, there are a lot of non-governmental organizations (NGOs) operating there. Few of these organizations—BRAC, ASA, Progati, Mohona, Janata, Somokal, Jagoron, etc.—are focused on climate change-related issues. Most of them work in "micro-credit" finance systems, and following the flood, they give the locals some money to get back to their regular lives. The locals are not given any instruction on how to reduce flooding losses, where to find safe havens, how to obtain clean drinking water, or how to enhance their health and sanitation infrastructure. NGOs had no appreciable impact on the management of water in the polder 24/G area.

4.9. Recommended Adaptation Measures for Beel Kapalia

Forecasts of climate change and international efforts to reduce its negative effects are rife with uncertainty. It is essential to reevaluate climatic data and its possible impacts. Analysis of sustainable adaptation strategies is required for several areas. An integrated drainage assessment is required for Beel Kapalia in the southwest since most livelihood indicators are moderately to highly vulnerable to sea level rise. It is recommended to implement crop diversification—particularly regarding salt-tolerant cultivars—floating agriculture, integrated farming, and sustainable aquaculture techniques. Expanding rescue facilities and considering elevated housing due to past flooding are necessary. It's critical to strike a balance between urban migration, meeting necessities, and incorporate local expertise. Water management requires the upkeep of sluice gates, controlled siltation, and river loop cuts. Addressing the effects of climate change requires empowering and raising community understanding.

5. Conclusions

Due to its location, Bangladesh is extremely vulnerable to climate change, with increasing dangers to its coastal population from events like floods, cyclones, and erosion of riverbanks. Sea-level rise (SLR) and its effects on the Beel Kapalia region—which includes the five villages of Kapalia, Monoharpur, Nehalpur, Balidaha, and Panchakori—are the main subjects of this study. The study emphasizes how SLR negatively impacts the livelihood characteristics in the area, with agricultural areas and water bodies being the most vulnerable elements.

The results show that all criteria in Beel Kapalia are moderately to highly vulnerable in the event of a permanent flood caused by 61 cm SLR, with Panchakori village in Nehalpur union being the most vulnerable. SLR significantly reduces livelihood capitals' resilience, resulting in a wide range of problems such waterlogging, a lack of clean drinking water, hunger, poverty, health problems, crop losses, and effects on the area's biodiversity.

Local communities struggle with meager mitigation initiatives that fall short of the scope of their requirements. Due to unemployment brought on by this, many farmers are turning to fishing. To mitigate the negative impacts of climate

change, those impacted must investigate alternate sources of income. To successfully address the implications of SLR, it is therefore essential to establish and implement adaptation strategies and programs for mitigating measures. Coastal towns are trying to increase their resilience through the adoption of alternative economic opportunities. In conclusion, this study emphasizes how critical it is to take immediate action to protect vulnerable coastal populations' livelihoods from the effects of climate change.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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