Article

Climate Change, Ecological Modernization, and Disaster Management: The Coastal Embankment Project in Southwestern Bangladesh

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Abstract: Climate change, one of the severest environmental threats to humankind, disproportionately affects low-income developing countries in the global South. Having no feasible mitigation alternatives, these countries resort to adaptation efforts in addressing the climate perturbations. Climate change adaptation (or resilience) is primarily a localized course of action that depends on individuals, social networks, economies, ecologies, political structures, and the capabilities of all those to work collectively to absorb, learn from and transform in the face of new realities. With a view to controlling the floods that shattered the life and economy of the then East Pakistan, which is Bangladesh now, during the mid-twentieth century, the coastal embankment project (CEP) was instituted as an adaptation strategy to natural disasters in southwestern Bangladesh. Based on the qualitative analysis of primary and secondary data, this paper seeks to critically evaluate the efficacy of the CEP in terms of the space for feasible action and ecological modernization. The findings of this research indicate that the CEP has become an unrealistic venture that hinders the growing economic activity of shrimp aquaculture in the area. This paper is expected to contribute to generate further theoretical and empirical discourse on evaluating similar development projects around the globe.

Keywords: ecological modernization; climate crisis; space for feasible action; shrimp aquaculture; coastal embankment project

1. Introduction

Climate change is, and will remain, the biggest environmental threat in many parts of the world. Because of long residence time of CO2 and other greenhouse gases in the atmosphere and because of the thermal inertia of the oceans, the current trend of climate change will prevail in the coming centuries regardless of reductions in greenhouse gas emissions (Eriksen et al. 2011; Matthews and Caldeira 2008). For this, in addition to mitigation, climate change adaptation has become a pressing issue for the last couple of decades. Climate change adaptation (or resilience) is chiefly a localized course of action that depends on individuals, social networks, economies, ecologies, political structures, and the capabilities of all those to work collectively to absorb, learn from and transform in the face of new realities (Martin et al. 2015; Kais and Islam 2018, 2019, 2021). Accordingly, resilience in global aquaculture, as in elsewhere, is primarily an outcome of joint endeavors of various stakeholders. This paper explores, with case studies from Bangladesh, how the ecological modernization (EM) approach can be applied to achieving expected goals of adaptation strategies. We have taken the coastal embankment project (CEP)—originally developed as a mechanism for disaster management to control flood, cyclone and saltwater intrusion—for our investigation. Since coastal Bangladesh embraced a new agrarian transformation with industrial aquaculture, the second largest foreign exchange earner next to garments, the study of CEP is critically important.

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At the beginning, we can note a few crucial points. First, although few attempts have been made to test the EM theory at micro-levels of citizen opinion analysis (Spaargaren and Oosterveer 2010, Spaargaren and van Vilet 2000), this approach largely deals with macro-level issues of how governments, businesses, and organizations react to environmental problems (Adua, York and Schuelke-Leech 2016, Mol and Janicke 2010). Second, the concept of 'modernization' implies advancement in technosphere (Spaargaren and Mol 2010). Thus, EM literature so far suggests cleaning and greening of production and consumption in the capitalist world. In other words, EM studies have so far been conducted primarily in the context of the global North. Finally, related to the second point, the EM perspective largely addresses the mitigation aspects of global climate change. Since fossil-fuel based technological accomplishments and ever-increasing capitalist production and consumption patterns are blamed to be responsible for much of anthropogenic climate change (Baer 2012) and since EM focuses on eco-friendly technological overhauling as a means of addressing climate change (Spaargaren and Mol 2010), the EM approach ultimately becomes vastly concerned with mitigation interventions (Glover 2011) with very little focus on adaptive options at least up to now. Drawing on the understandings about the role of the EM approach, in this discussion on the applicability of EM perspective to the commercial shrimp sector in coastal Bangladesh, we concentrate on macro-level interventions to community resilience dealing with how governmental and non-governmental development/adaptation programs, including the CEP, could be ecologically modernized with an aim to foster resilience in the aquaculture communities. Previous literature, in assessing different embankment projects in Bangladesh, resorted mainly to understanding the technical, economic or environmental aspects of the projects (e.g. Boyce 1990, Choudhury, Paul, and Paul 2004, Hossain, Islam, and Sakai 2008; World Bank 2008, Rahman and Kabir 2013, Dewan, Mukherji, and Buisson 2015, Akter 2020). Those studies largely missed out the crucial matrix of social and political viability of the projects. The present study, however, by applying the framework of space for feasible action, endeavors to unearth the issues from a holistic perspective taking scientific, technological, environmental, economic, political, and social dimensions into consideration.

2. Conceptual Framework

2.1. Coastal management

With 84% of the countries of the world having a coastline with the open oceans, inland seas, or both, global coastline is a huge entity totaling 1,634,701 km (Martinez et al. 2007:255). Although the coastal zone plays crucial role in human habitation, agriculture, aquaculture, fisheries, industries, ecologies, and numerous other ecosystems services, the precise conceptualization of the coast is a difficult task. The coast has been variously defined as 'the land near a shore' (Merriam-Webster 2023), 'area where aquatic and terrestrial ecosystems interact' (Carter 1988), or 'that part of land most affected by its proximity to the sea, and that part of the ocean most affected by its proximity to the land' (Hinrichsen 1998). In order to cover most of the interactions between the contrasting aquatic and terrestrial ecosystems that co-occur at the coast, Martinez et al. (2007) defines coastal regions as "intertidal and subtidal areas on and above the continental shelf (to a depth of 200 m); areas routinely inundated by saltwater; and adjacent land, within 100 km from the shoreline" (p. 256). In Bangladesh, three indicators define the coastal region: tidal fluctuation, salinity intrusion, and risk of cyclones and storm surges (see below "Study area: coastal Bangladesh").

In terms of natural ecosystems within the 100 km inland boundary, forests comprise 44% of global natural coastal vegetation, shrubs 28%, savannas 21%, and grasslands 7% (Martinez et al. 2007:255). In the tropical coasts, such as in Bangladesh, mangroves make up a critical portion of coastal vegetation. Globally, mangrove forests cover an area of 14,650,000 ha of coastline (Alongi 2008:2) in 121 countries (Wilkie and Fortuna 2003) with an economic value of about 200,000 – 900,000 USD/km^2 (UNEP-WCMC 2006:5).

Economic values of the coastal zone lie in the fact that, globally, coastal ecosystems provide numerous goods and services including food for humans and animals, salt, minerals and oil resources, construction materials (sand, rock, lime and wood) and biodiversity, including the genetic

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stock that has potential application for biotechnology and medicine (Martinez et al. 2007). Additionally, as part of coastal terrestrial ecosystems, mangroves provide benefits under all the four categories of ecosystem services – regulating, provisioning, cultural, and supporting – as defined by the 2005 Millennium Ecosystem Assessment (UNEP-WCMC 2006). *Regulating* services include coastline protection from natural hazards, soil and beach erosion regulation, land stabilization, climate regulation e.g. carbon sequestration, and water quality maintenance; *provisioning* services are subsistence and commercial fisheries aquaculture, medicinal products, building materials, fuel wood, and ornaments e.g. jewelry, decoration; *cultural* services include tourism, recreation, spiritual i.e. sacred and heritage sites, and aesthetic appreciation; and *supporting* services include nutrient recycling, nursery habitats, and biodiversity (Crooks et al. 2011, UNEP-WCMC 2006).

Similarly, the social importance of the coastal zone is enormous. The coast is like a magnet that attracts world human population by virtue of its beauty, accessibility, and services. People frequent to the coasts for living there or for tourism, recreation, leisure, livelihood, and commercial activities. As a result, although coastal area accounts for only 20% of all land area in the world, it provides housing for 41% of the world population (Martinez et al. 2007). This trend, in turn, puts pressure on coastal ecosystems through increasing demand for infrastructural development and economic activities required for the additional population. This pressure may rise in coming decades since an increasing trend of population movement toward the coastal zone is visible. Furthermore, in a warmer world in near future, it is projected that population pressure will further increase in the coasts, especially in the global South.

Since coastal areas are among the most inhabited and exploited regions globally due to their traditionally accepted attractiveness for human living, leisure, or tourism (Mumford 1961, Martinez et al. 2007, Miller and Hadley 2019) that lead to coastalization of people (Rempis et al. 2018), they are always a source of disputes among various stakeholders who engage in conflicting coastal land uses (user-user conflicts) and among human activities and the environment (user-environment conflicts) (Goudie 2006, Valeila 2006, Kiousopoulos 2008, Ehler and Douvere 2009). Coastal authorities throughout the world implement new interventions in coastal areas in order to address both types of conflicts, natural changes caused by new environmental and climate regime, and further social and economic development. Nonetheless, the execution of a development or protection project in the coastal zone is a multifaceted issue. Conflicting interests of the stakeholders and ever-changing nature of the coastal ecosystem often lead intervention schemes, such as the CEP in Bangladesh, to generate a series of reactions (Rempis et al. 2018). In Bangladesh context, competing and conflicting land use patterns in the coast that cause crucial concerns to the central and local administrations include agriculture, aquaculture (especially shrimping), fisheries, salt production, forestry, shipbreaking yards, ports, industry, tourism, human habitation, wetlands, and recreational activities (Islam 2006). Although embankments are viewed as a human intervention for addressing natural perturbations, embankments are a kind of land use that impact other types of land use in the region. Consequently, sometimes conflicts of interest surrounding the projects arise among different stakeholders.

2.2. Ecological modernization

In order to study the efficacy and sustainability of the resilience strategies adopted by the commercial shrimp industry in Bangladesh, this research employed ecological modernization (EM) theory. In explaining the ecological crises associated with the modern capitalist society, proponents of the EM theory believe that capitalism as a system is flexible enough to find solutions to the environmental issues and evolve toward 'sustainable capitalism' (Islam 2013, 2022). EM theory, originating as a concept in a debate in the Berlin municipal parliament on January 22, 1982 (Janicke 1993 [2010]:30) and through the writings of its founding father Joseph Hubert (Mol 1995, Murphy and Gouldson 2000), supports the basic economic and political foundations of the capitalist modernization project. This perspective differs significantly from neo-Marxian radical environmental theories like deep ecology or ecological Marxism theory. While the radical greens or deep ecologists argue that ecological crisis cannot be overcome unless society breaks away from industrial

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modernity, the EM theorists advocate for reformation of the capitalist economy through technical and procedural innovation (Hajer 2010) and restructuring of industries pertaining to ecological requirements (Huber 1991 [2010]).

In analyzing modern society, the EM theorists like Joseph Huber differentiate between three analytical categories or spheres: the industrial system (technosphere), the life world (sociosphere), and the nature (biosphere) (Spaargaren and Mol 2010:69). The domination of technosphere over the other two is the main cause of the emergence of the major problems in modern capitalism. These problems, which are interpreted by the EM theorists as structural design faults of the industrial system, can be overcome by an ecosocial restructuring of technosphere. Thus, the point of departure for the EM theory is the industrial character of modernity, not the capitalist and/or bureaucratic characters. In other words, the EM theorists question the technological structure of modern society, not the economic or political base. Up to now, we find two notable variants in the EM theory: techno-corporatist ecological modernization, and reflexive ecological modernization (Hajer 1995, Mol and Janicke 2010). The techno-corporatist school of EM views ecological reform as a purely techno-administrative affair, while the reflexive school points to practices of "social learning, cultural politics, and new institutional arrangements" (Mol and Janicke 2010:21). In short, according to the EM theorists, ecological problems associated with modernity are a techno-industrial issue that can be overcome through "modernizing modernity in a sustainable way" (Huber 1991 [2010]:45) by adopting technological restructuring or 'green technology' and by resorting to reflexive modernity like 'green consumerism' (Islam 2013).

One way of viewing the interconnections between modernity and aquaculture is that modern aquaculture itself is a development activity within contemporary neo-liberal globalization processes. In the late twentieth and early twenty-first century world, as part of the neoliberal globalization project, transnational corporations and international donor agencies invested in agriculture and aquaculture sectors in the developing countries with an aim of producing foods for global consumption. In the process, we found two revolutions that enhanced global food production but brought about troubled social and environmental legacies with them. These two revolutions are the Green Revolution in agriculture and the Blue Revolution in aquaculture. Influenced by the success of the Green Revolution in agriculture, neoliberal global governance initiated restructuring of global aquaculture sector. The commercial aquaculture farming, including industrial shrimp farming, started in 1970s in the Global South. With financing by international donor agencies, large coastal areas in developing countries were converted into aquaculture farms where new technologies had been used. As a result, a phenomenal increase of global aquaculture production occurred during the last decades, which is dubbed as the Blue Revolution (Islam 2014). As a modernization activity, aquaculture in general, and industrial shrimp farming in specific sense, has some negative implications on the environment. But those environmental ramifications can be solved, from the perspective of the EM theory, through technological overhauling and turning towards 'green aquaculture'. In order to ensure a healthy environment, we do not need to overthrow or put a halt on the whole aquaculture or the industrial shrimp cultivation, in the name of 'radical structural change', as suggested by neo-Marxist political ecology or treadmill of production theorists (Islam 2013:75).

That the very process of capitalist industrial development in the Global North is generating threats to the environment and climate of the entire world is another notable issue on the interactions between global aquaculture and neo-liberal modernity. The resulting climate change variability and extremes are affecting aquaculture, somewhat negatively in various regions of the world. Again, in this scenario, the solution lies in evolving towards a 'sustainable capitalism' and 'super-industrialization' process through "ecological switchover of the industrial system" (see Spaargaren and Mol 2010:69, Islam 2013:75). Developing a 'responsible capitalism' through 'cleaning' and 'greening' of technology, as suggested by EM theory, can mitigate the environmental and climate change evils in the current setting – a proposition that has yet to be seen fully in the global aquaculture.

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3. Materials and Methods

The aim of this study is to explore the applicability of ecological modernization framework in assessing the efficacy of govt.-run adaptation schemes in coastal aquaculture communities. In other words, we (the authors) try to appraise the CEP in Bangladesh, taking it as a case study, in light of the space for feasible action. In doing so, we have focused on collecting in-depth qualitative data from various stakeholders so that a critical understanding can be achieved. A triangulation of methods involving content analysis of secondary sources, ethnography, and in-depth interview was applied in order to acquire a comprehensive insight into the complex and diverse issues of climate threats, economic activities, and the feasibility of the CEP in the research area.

3.1. Study area: coastal Bangladesh

The Bangladesh landmass is connected to the Bay of Bengal in the south through a 710 km long coastline (Ahmed and de Wilde 2011:2). The coast is not a fixed, static line between land and sea; rather, it is intersected by a vast network of river systems, an ever-dynamic estuary, and a drainage basin through which a huge amount of freshwater is discharged into the sea from Bangladesh, and parts of India, Nepal, Bhutan, and China. The Coastal Development Strategy of 2006 takes three physical criteria in defining the coastal area in Bangladesh: the limits of tidal fluctuation (difference of 0.3 meter between the high and low tide in a day), salinity intrusion (4 dS/m, 5 dS/m and 2 dS/m as threshold salinity level for soil, surface water and ground water respectively), and risk of cyclones and storm surges (among high risk, risk, wind risk, and no risk zones mapped by the Disaster Management Bureau, the first two are the coastal areas) (Ahmed and de Wilde 2011, Karim and Mimura 2008).

An *upazila* (sub-district) is considered to be 'coastal' (Figure 1) if at least one of the defining parameters of coastal area is at the threshold level in the *upazila*. A district is termed as 'coastal' if it includes at least one coastal *upazila*. In Bangladesh, 133 *upazilas* under 19 districts[1] are defined as coastal. In 48 *upazilas* in 11 districts all three indicators are above threshold level making them 'exposed coastal zone' (Ahmed and Wilde 2011), the remaining area is referred to as 'interior coast' (Rashid 2014). The exposed coastal districts are defined as 'southern region of Bangladesh' in a Master Plan of the Bangladesh Government (MoA and FAO 2013). In total, the coastal zone covers an area of 47,201 km^2, 32% of the total landmass of Bangladesh (Rashid 2014:59), and is home to 46 million people (Sarwar 2013:218).

For this study, we selected three upazilas (sub-districts) Mongla from Bagerhat district, Koyra from Khulna, and Shyamnagar from Satkhira. For close investigation, we again picked three villages from these three sub-districts namely Haldibunia (Mongla), Gazi Para (Koyra), and Ghar Kumarpur (Shyamnagar) (Figure 2). All these upazilas are situated in exposed coastal region. Vast majority of the inhabitants of the selected villages are engaged in shrimp farming and shrimp related activities. According to the Bangladesh Bureau of Statistics (BBS), 79.43% of employed males in Haldibunia of Mongla are engaged in agriculture (BBS defined shrimp cultivation as an agricultural activity) (BBS 2012a:C-11:31), 95.65% in Gazi Para of Koyra (BBS 2012b:C-11:39), and 80.67% in Ghar Kumarpur of Shyamnagar (BBS 2012c:C-11:53). The study areas are vulnerable to anthropogenic climate extremes including SLR, salinity ingress, cyclones, and storm surges. There is a total of 227 km paka (carpeting) road in the three *upazilas*, and 275 km of brick-soling road out of more than 1737 km of road. The total length BWDB embankment in Koyra and Shyamnagar is 339 km with 46 sluice gates (information collected from Upazila Nirbahi offices). Although there is no embankment in Haldibunia, Mongla, we took this site for our research in order to understand people's experience of exposure to climatic events in an unprotected area. This enabled us to appraise the efficacy of the CEP in a holistic manner.

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[1] The districts are Bagerhat, Barguna, Barisal, Bhola, Chandpur, Chittagong, Cox's Bazar, Feni, Gopalganj, Jessore, Jhalkathi,Khulna, Lakshmipur, Narail, Noakhali, Patuakhali, Pirojpur, Satkhira and Shariatpur (MoWR 2005:2).

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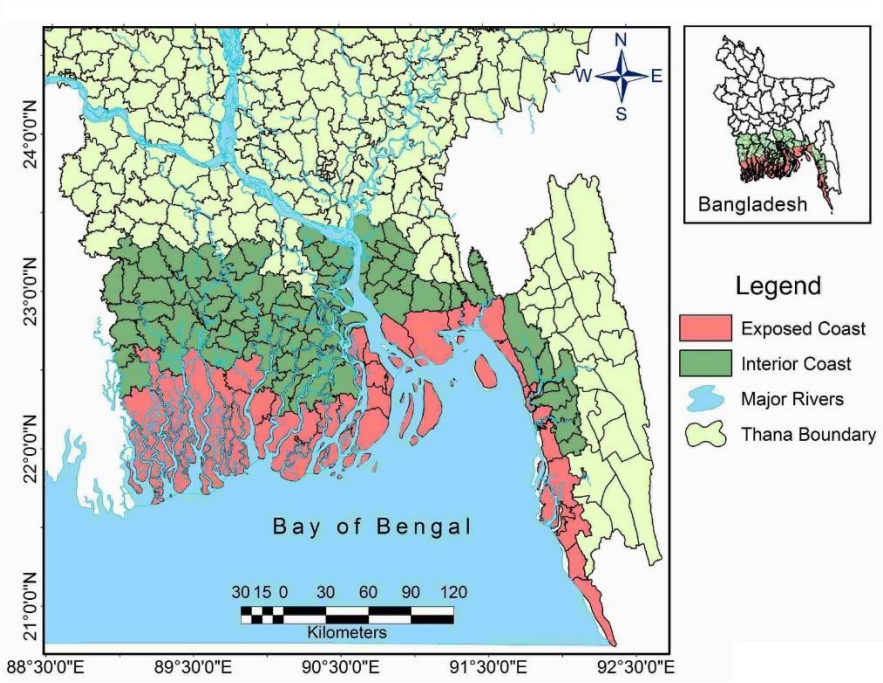

Figure 1. Map of the coastal region of Bangladesh.

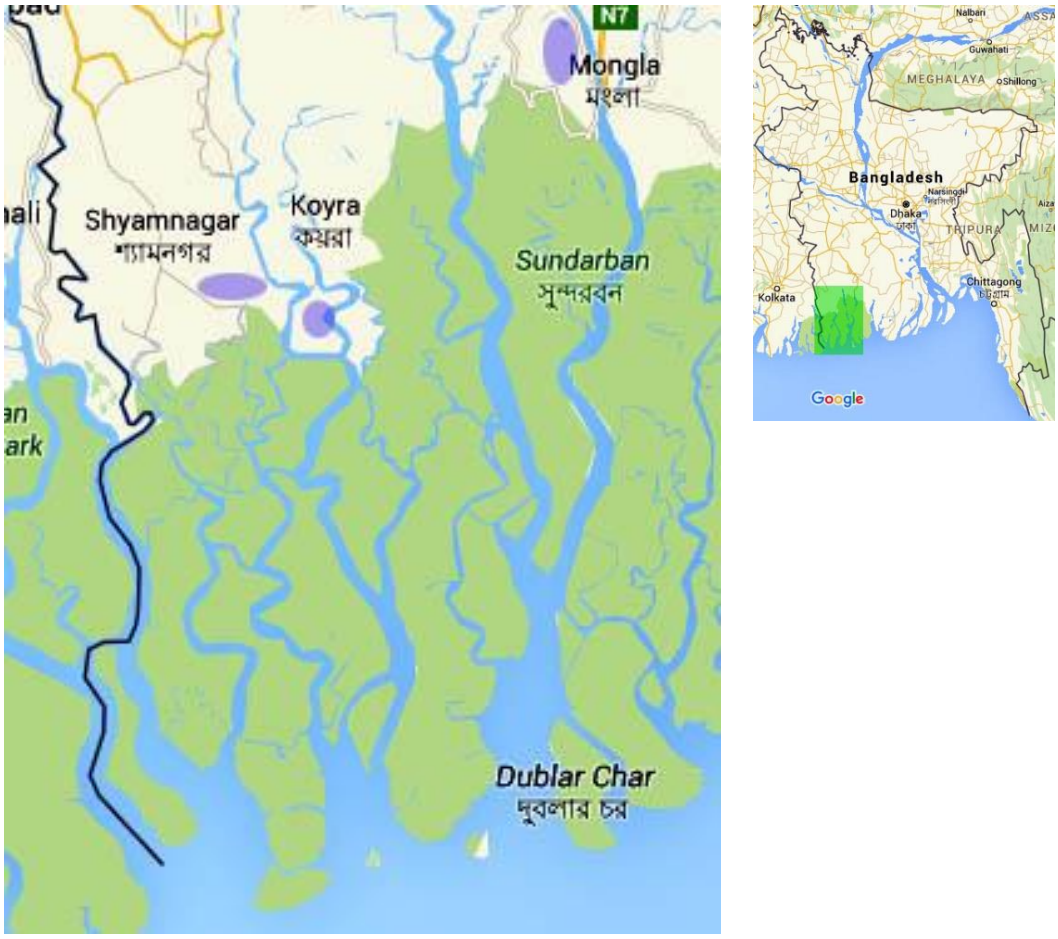

Figure 2. Map of the research areas (Interviews were conducted in villages in the purple-marked areas.). Source: Google Maps.

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3.2. Content analysis

At first, to gain a thorough understanding of the CEP and the applicability of the EM theory to it, we (the authors) resorted to the content analysis of existing secondary documents in Bangladesh. After mapping out the entire project – we searched libraries of various institutions and organizations in Dhaka, Khulna, Satkhira and Bagerhat including District Fisheries Offices, Bangladesh Water Development Board (BWDB) offices, Bangladesh Centre for Advanced Studies (BCAS), Bangladesh Unnayan Parishad (BUP), Bangladesh Disaster Preparedness Centre (BPDC), Centre for Environment and Geographic Information Services (CEGIS), Climate Change Cell of Department of Environment (DoE), Department of Fisheries (DoF) under the Ministry of Fisheries and Livestock, Coastal Development Partnership (CDP), Bangladesh Institute of Development Studies (BIDS), Bangladesh Frozen Foods Exporters Association (BFFEA), the World Bank Country Office, Bangladesh Bureau of Statistics (BBS), Institute of Disaster Management and Vulnerability Studies (IDMVS) at the University of Dhaka, Shrimp Research Station of Bangladesh Fisheries Research Institute (BFRI) etc. This phase of content analysis helped us to become familiarize with the whole set up of climate change vulnerabilities, adaptation policies and programmes, and embankment projects that are currently on going or planned for future realization in Bangladesh.

3.3. Ethnography

In the next phase, we had three ethnographic visits to three coastal districts in which, along with other coastal districts, the CEP was instituted – Bagerhat, Khulna, and Satkhira. As a data collection method, ethnography involves the researcher "participating, overtly or covertly, in people's daily lives for an extended period of time, watching what happens, listening to what is said, and/or asking questions through informal and formal interviews," (Hammersley and Atkinson 2007:3). Ethnographic inquiry involves a 'prolonged, systematic, first-hand and direct encounter' (Payne and Payne 2004) with the people concerned in their own cultural 'settings' (Warren and Karner 2015) through their lived experiences (Bernard 2013). The main aim of the ethnographer is the 'thick description' (Fetterman 2009, Tracy 2013, Babbie 2021) as well as 'interpretation' (Payne and Payne 2004) of the observed pattern of human activities (Van Maanen 1979). The ethnographic visits to the research areas helped the researchers understand the on-the-ground scenario of pros and cons of the CEP.

3.4. In-depth interview

At the final stage, after getting a clear insight into the local dynamics through ethnography, we interviewed selected people from different stakeholder groups. They include three upazila agricultural officers, three upazila fisheries officers, three BWDB officials, three other key informants (experts), and fifteen shrimp cultivators (Table 1). In selecting the respondents, we resorted to purposive sampling technique which allowed us to find the most useful or representative samples. We used unstructured interview schedule in order to collect in-depth qualitative data from them. Taken as a whole, we took exhaustive efforts to understand the local dynamics in relation to this research.

Table 1. Selection of respondents for in-depth interview.

Participants	Area			Total
	Bagerhat	Khulna	Satkhira	
Upazila Agricultural Officer	1	1	1	3
Upazila Fisheries Officer	1	1	1	3
BWDB official	1	1	1	3
Key informant	1	1	1	3
Shrimp farmer	5	5	5	15
Total	9	9	9	27

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4. Results and Discussion

4.1. Ecological modernization approach in addressing adaptation and resilience

Ecological modernization, as a broad environmental paradigm has different versions – from a set of attractive policy ideas that are not real (Hajer 1995) to an identifiable phenomenon of institutional reflexivity (Mol 1995), from mild corrective activities to radical movements that re-cast the role of the state (Christoff 1996, Glover 2011). As Hajer (1995), Weale (1992) and others described, ecological modernization succeeded in reducing pollution, cutting down wasteful resource use and addressing other environmental issues throughout the global North. EM can play a role in channelizing resilience and adaptive actions in the global South in a way that prevents or minimizes perverse consequences, restricts the rise of 'maladaptation' (see Schipper 2020, Barnett and O'Neil 2010, Juhola et al. 2016 for discussion on maladaptation) and promotes 'sustainable adaptation' (Beckman 2011, Brown 2011, Eakin, Lemon and Nelson 2014, Eriksen and Brown 2011, Eriksen et al. 2011, Gachathi and Eriksen 2011, Owuor, Mauta and Eriksen 2011).

Up to the recent past, adaptation was thought to be benign for development; thus, negative social and environmental consequences of coping mechanisms were overlooked for long. However, balancing trade-offs and avoiding potential negative outcomes have now, especially after a double session on sustainable adaptation at the Human Security in an Era of Global Change Conference in June 2009 (Eriksen and Brown 2011), become a growing concern for adaptation and resilience schemes throughout the climate challenged societies. A few researchers have already explored the negative implications of planned and autonomous adaptations in developing countries (Below et al. 2010, McGray, Hammil and Bradley 2007, Mearns and Norton 2010). Spatial and temporal negative consequences of an adaptation action may turn it to become a maladaptation. Maladaptation can be defined as "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors or social groups" (Barnett and O'Neill 2010:211), or "a result of an intentional adaptation policy or measure directly increasing vulnerability for the targeted and/or external actor(s), and/or eroding preconditions for sustainable development by indirectly increasing society's vulnerability" (Juhola et al. 2016:139). Thus, adaptation can become maladaptation if it creates increased exposure and sensitivity for the actors or targeted actors or others and if it decreases adaptive capacity of the actors or targeted actors or others (Juhola et al. 2016). We can cite few examples (examples cited in Juhola et al. 2016) of maladaptation around the globe (a) increased exposure: trees planted in Scandinavian countries to provide shade, which damage buildings during a storm (Glaas et al. 2015), (b) increased sensitivity: development of floodplains that leads to reduced buffering capacity of river water (Klein et al. 2007), and (c) decreased adaptive capacity: investments in power grids in Australia leads to increased prices on power, decreasing adaptive capacity in vulnerable groups (Quezada et al. 2014).

In order to avoid such maladaptive policies or strategies that bring positive outcomes to people of a particular time and space but may have negative effects on some other groups in other areas or time, it is crucial to identify the synergies between adaptation and sustainable development and devise schemes of 'sustainable adaptation', i.e. "adaptation that contributes to socially and environmentally sustainable development pathways" (Eriksen et al. 2011:8). A synergy can be established between sustainable adaptation and ecological modernization, in which basic features of EM can foster sustainability of adaptation (resilience) policies and actions. Glover identified few aspects of EM that can serve as foundations for adaptive strategies in responding to climate change: (1) 'actions will reduce the costs of climate change impacts for current and future generations', (2) 'adaptation will protect, secure, and promote future economic growth', (3) 'adaptation actions will serve as a source of innovation' and (4) adaptation actions should focus simultaneously on scientific information and advice as well as institutional frameworks and processes (2011:1-12).

In order to serve the above functions in respect to resilience initiatives, EM places social learning at its heart and focuses on societal need for detecting and understanding new climate issues, for framing such issues in ways with which different powerful actors comply, for responding to such issues in ways that are technologically, economically and politically viable (Gouldson and Sullivan

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2012). In this way, EM promotes to build a 'space for feasible action' (Baily, Gouldson and Newell 2011, Gouldson and Sullivan 2012) in society, through which climate challenges and other environmental problems can be addressed within existing social context. Space for feasible action on climate change lies in the intersection of policies and programmes that are 'scientifically justified, technologically possible, economically viable, socially supported and politically accepted' (Gouldson and Sullivan 2012:117).

We can add 'environmentally harmless' as the sixth component with the above five. If one or more of these pre-conditions are not fulfilled, the space for feasible action can be restricted and hence progress of the actions addressing climate change may be hampered. Thus, for any adaptive or resilience action to be fully sustainable in the long run should meet all the criteria of a feasible action. If any program fulfils one or more criteria but not all, it can be feasible in some degree or for the time being. Ecological modernization thus, by creating space for feasible resilience actions, promotes sustainable adaptation, which reduces vulnerability and increases adaptive capacity of the actors or targeted actors or others. Figure 3 shows the ecological modernization pathways to sustainable adaptation.

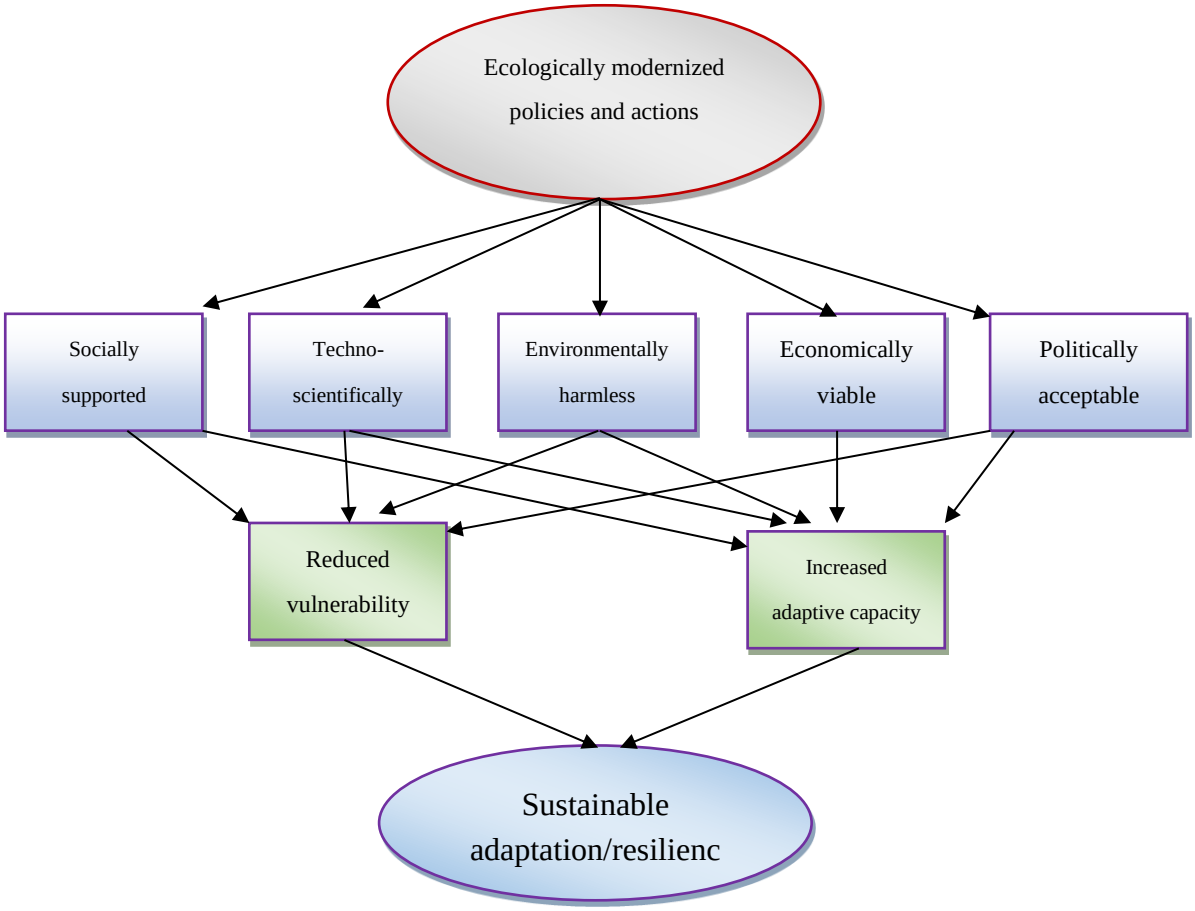

Figure 3. Ecological modernization pathways to sustainable adaptation.

4.2. The Coastal Embankment Project in Bangladesh: A Case Study

We can apply this framework to judging resilience policies and programmes designed for the aquaculture industry in the global South. Here we will have a case study from coastal Bangladesh, which will explain how an adaptation effort (in this case the coastal embankment project) can turn to be maladaptive if it is not designed as an ecologically modernized action by meeting the criteria of spaces for feasible action.

Though vernacular embankments have always been a part of cultural landscape in the coastal region of Bangladesh (Mukerjee 1938, Rahman and Kabir 2013), systematic development of large-scale embankments for flood control started in the 1960s (Banglapedia 2015, Haq and Burns 1967,

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Schmidt 1969, World Bank 2000, World Bank Group 2010). After Bangladesh (the then East Pakistan) experienced severe floods for three successive years in 1954, 1955 and 1956, the UN, following a request from the Pakistani Government, sent a technical assistance mission in 1957 under the leadership of J. A. Krug (Schmidt 1969, World Bank 2000). The Krug Mission made a number of recommendations that eventually laid the foundation of flood control policies in Bangladesh. The coastal embankment project (CEP) in East Pakistan was initiated as per one of those recommendations and as part of a master plan for water and power development (Bowles 1965). The newly formed East Pakistan Water and Power Development Authority (EP-WAPDA, established in 1959) undertook this gigantic project as a hard structural response to existing environmental problems in the region (Thomas 1974).

With an intended 350,000,000 cu yd of earth moving (Haq and Burns 1967), the project was believed to be one of the biggest earth moving jobs in the world at that time. The CEP, which covers all the exposed coastal districts of Bangladesh, comprises a complex network of dikes and drainage sluices (see Figure 4) and was the first extensive plan for providing protection against flood and salinity ingress in the coastal region. The project, completed between 1961 and 1978, created 139 polders (embanked areas) (MoA and FAO 2013, Gain, Mondal, and Rahman 2017), 5017 km of embankment (World Bank Group 2010) and 1039 drainage sluices (Banglapedia 2015), and protected around 1.5 million hectare of land (World Bank Group 2010).

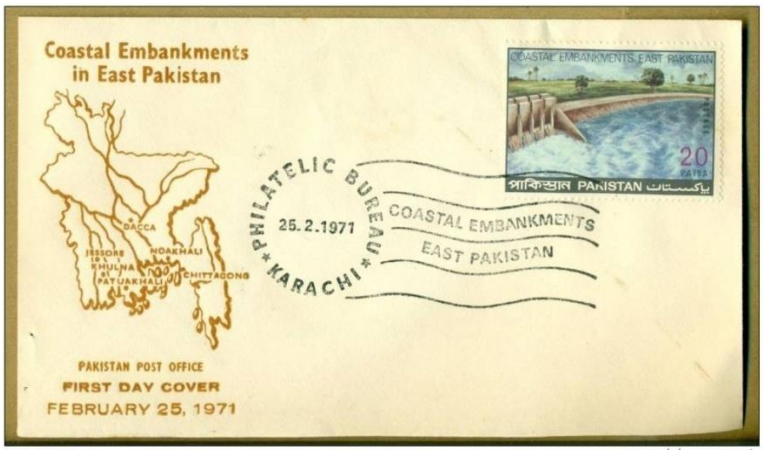

Figure 4. First day cover of a postage stamp of Pakistan on the Coastal Embankments in East Pakistan, 1971.

The CEP was designed with a view to ensure food security of the people of the country by increasing the yield of agricultural crops in the coastal reclaimed land through protecting the area from tidal and storm surge flooding and saltwater intrusion. It was estimated that the CEP would result in an increased rice production of 480,000 tonnes per year (Haq and Burns 1967). Initially, this project was successful in achieving its target through increased rice production in the area for few years (MoA and FAO 2013).

But as time passed, some serious ecological and social problems, termed as 'second generation problems' (MoA and FAO 2013), emerged in the project area as a result of impoldering. First, this huge anthropogenic activity – along with other anthropogenic interventions like reclamation of forestland, deforestation, agriculture, and construction of upstream dams – caused changes in natural processes of land formation and altered topographic and hydrologic landscape of the area (Martin et al. 2015). The floodplain delta is still under active formation through natural processes including regular shifts in the courses of rivers, and emergence and submergence of coastal islands. Sediment accumulation from rivers meets with the coastal forces of tides, cyclones, and storm surges to form the fluid landmass through a constant process of erosion and accretion (Martin et al. 2015, Rahman 2000). The artificial change of natural landscape, while the delta was still in a state of immaturity, brought by the embankments created a division among the land users in the coastal areas – polders

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and unprotected areas (Peerbolte and Zubair 2011). The polder areas were no longer subject to regular flushing of tidal water and hence land formation through natural siltation was severely hampered.

Second, the CEP resulted in livelihoods shifting for a portion of people who were previously depending on fishing in the beels – i.e. small depressed areas. Historically, the Sundarbans area was a land of fishers. Early settlers were completely dependent on water resources for their livelihoods. Human settlement in the Sundarbans area dates back to almost two thousand years from now. The ruins of a city, which was located near present-day Baghmara Forest Block in West Bengal, indicate that it was presumably built by Chand Sadagar, an elite Indian merchant, around AD 200-300 (Martin et al. 2015). Historical records and artefact also suggest that there had been a flourishing agrarian settlement in the region for centuries before the Mughal invasion of Bengal in 1128. Later Indo-Turkish Muslims continually settled in the Sundarbans area from 1204 to 1574 (Martin et al. 2015). This was the period when the indigenous inhabitants had to adopt new livelihood options. The early Hindu settlers were fishers for centuries, but the Muslims introduced a cultural penchant for crop agriculture. Figure 5 portrays a village in a reclaimed area of the Sundarbans.

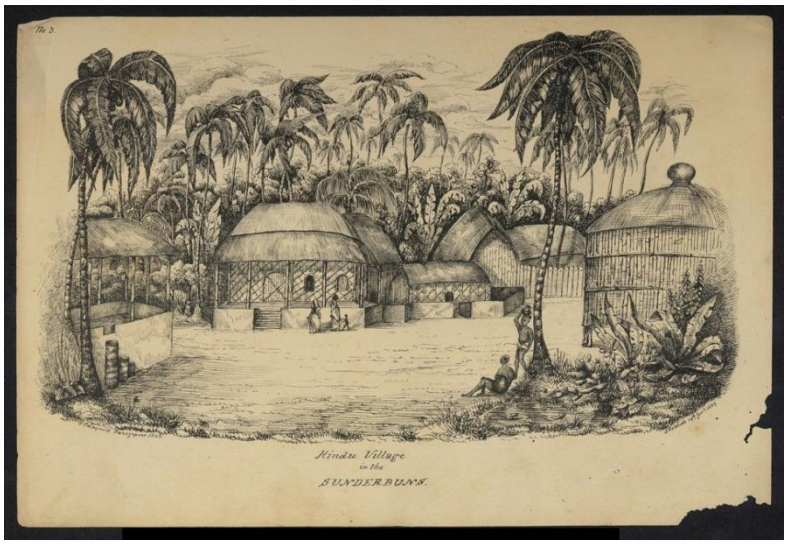

Figure 5. A village in a reclaimed area of the Sundarbans. Drawing by Frederic Peter Layard following an original sketch of 1839. Source: British Library (2016).

During the Middle Ages, the whole area of the Sundarbans was depopulated significantly; several reasons have been forwarded behind this including earthquakes and natural calamities that led to a sudden subsidence of the land (Chakrabarti 2009, O'Malley 1908), attacks by Portuguese and Arakanese pirates (Sarkar 2012), and a hostile environment (Beveridge 1876, Ghosh et al. 2015, Hunter 1876). Thus, before the 19th century, the Sundarbans were very sparsely settled. Human settlements in the region again soared under the British agrarian and land tenure policies (Ghosh et al. 2015, Martin et al. 2015, Sarkar 2009) that focused on generation of revenue by using and managing forests and its resources in new ways. The effects of these measures still affect the area's present-day ecology, landscape, land use, social organization and livelihoods. In the pre-colonial period, there were instances of reclamation of the Sundarbans land, but those efforts were mainly individual, isolated, and erratic in nature, and did not leave any long-lasting marker on the physical and geographical landscapes of the region. Only the British policy pushed the jungle back significantly through clearance and occupation. British passion for economic gains through the commercialization of agriculture ramped up the amount of forest converted to rice cultivation markedly. British Collector General Claude Russell in 1771 (Ghosh et al. 2015), and later in 1783 the then Magistrate of Jessore, Tilmann Henckell (Sarkar 2012), set off an arrangement to divide the Sundarbans into plots and to lease them out to local zaminders (landlords) for timber extraction, land reclamation and the collection of revenues. These zaminders engaged poor people from different parts of Bengal in

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clearing and developing land for crop agriculture. Thus, it was agriculture, not aquaculture or shrimp cultivation, which destroyed the mangrove forest of the upper regions.

Even after the above-mentioned land reclamation initiatives, the economy of the region was primarily based on fishing because of the abundance of natural water resources in the area. Crop agriculture was the secondary profession for only a few months in a year (Rahman and Kabir 2013), when freshwater was available. Unlike in many areas of the country, farmers in the coastal zone can produce only one agricultural crop in a year, and not three. Thus, the CEP was an initiative that aimed at forceful conversion of a saline water ecosystem into a freshwater zone. Moreover, after this conversion, as reported by the locals, the fishing community locally known as Bagdi was affected badly since the availability of brackish-water fish species declined in the beels in the polders. The Bagdi community (Figure 6), according to members of this community, was forced to depend only on the rivers and many of them to change their livelihoods. Though there were other reasons behind this shift – such as reduction of fish availability in the rivers – the CEP had an effect.

Figure 6. A Bagdi settlement on the riverside of an embankment in Koyra. Source: Field data.

Third, the CEP resulted in alteration of natural watercourses in the region. As mentioned earlier, earthen embankments are an age-old practice in the coastal region (Harrison 1875), with the earliest record of coastal embankments in Bangladesh dates back to the seventeenth century (Banglapedia 2015) when the local zaminders patronized the construction of small-sized embankments and by 1900, Bengal had 1298 miles of embankment (Khan 2009). However, those embankments were dwarf in size, were separate from one another each enclosing relatively small piece of land, and many of them were constructed seasonally for cultivation. Thus, those small-scale embankments did not impede the natural water circulations in the region. Regular flushing of tidal water served in many ways: it helped the formation of land through siltation, it brought nutrient with the silt that increased fertility of soil, and it provided the local people with a livelihood based on abundant wild fish and other aquatic resources. With the large-scale construction of coastal embankments, the natural flow of water was restricted to outside of polders and thus the impoldered land was devoid of the above-mentioned benefits. This has turned to be an ecological crisis in the region because of the serious alteration to the natural brackish water-based ecosystems.

Fourth, related to the third one, the land levels in impoldered areas gradually dropped with respect to sea level because of subsidence, settlement of upper layers, climate induced SLR and the absence of new sedimentation within the polders. Natural delta systems respond to these phenomena by increasing rate of sedimentation and accretion, but impoldered areas are isolated from such accretion activities (Peerbolte and Zubair 2011). This has resulted into a number of spill-over effects. (a) Because of siltation of outfall channels, canals and other channels within impoldered areas lost their drainage capability resulting in water logging. This water logging problem is exacerbated because a significant number of sluice gates (nearly half in Koyra and Shyamnagar) are currently out of order. Moreover, persistent rainfall during the monsoon also causes water logging because of shortage of drainage channels. (b) With a height ranging from eight to twenty feet, the embankments

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are not designed to give protection against cyclonic storm surges. Moreover, the relative height of the embankments has already reduced because of the elevation of ground level in rivers through siltation, as mentioned above, and because of anthropogenic SLR. Thus, the embankments have now become more vulnerable to the overtopping of storm surges. Moreover, if saline water from the sea enters in large amount in the polders, water and soil salinity increases rapidly, sometimes crosses threshold limits even for the old trees. This is evident throughout the Aila-affected areas in the region. After Aila in 2009, since many of the areas were inundated by salt water for up to two years because of drainage congestion, production of vegetables and domestic trees is quite difficult up to now because of permanent salinity increase. (c) The above-mentioned issues have led to severe scarcity of potable water in the Aila-affected areas. In some villages, people need to travel long and spend considerable sum of money and time to fetch drinkable water for the households. If the water scarcity runs for long, according to Rahman and Kabir, this may influence even to disintegrate the coastal settlements in time (2003).

Fifth, though the embankments are not primarily designed to give protection from cyclonic surges, people living inside might have a 'false sense of security' (Rahman and Kabir 2013) and they may build their houses without taking sufficient safety measures, which can make them even more vulnerable to climate disruptions.

Sixth, the CEP also prevented the natural expansion of the mangrove areas. Since the expansion of mangrove forests is a natural phenomenon that occurs through spreading of mangrove seeds through water in nearby areas and throughout the saline water areas, coastal embankments retarded this process, at least in some extent, by restricting saline water outside the polders (Rahman and Kabir 2013).

Seventh, the CEP reduced the natural habitation of the shrimp fry in the area, which may eventually affect the shrimp industry (Rahman and Kabir 2013). Eighth, The CEP also instigated conflicts between different land-users including shrimp and rice cultivators. Shrimp farmers bring saline water inside the polders in various ways, which may affect standing crops in surrounding plots. There are records of confrontations in the past, affecting social fabric in the area. Multi-functional land use was not in consideration during the construction of polders and the BWDB has no effective strategy to date to address the land use conflicts (MoA and FAO 2013). Finally, many of the embankments are now under the threat of collapse because of overtopping, toe erosion, slope erosion and inadequate operation and maintenance (O & M) budget (World Bank Group 2010).

4.3. Efficacy of the coastal embankment project

From the above case study on the coastal embankment project, we can draw a few conclusions with respect to space for feasible adaptive action on and ecological modernization to coastal Bangladesh and the shrimp farming community. The CEP was an adaptive action taken by the central government in response to weather shocks and climate hazards, namely coastal floods and salinity intrusion, with a view to enhancing resilience of the coastal communities. Though initially the project was a success in terms of protecting the coastal communities from natural disasters and increasing crop yields, eventually it turned to be maladaptive in the end.

First, the CEP was politically acceptable since there is no known case of protest from any quarter of people, including the shrimp culture community, during the initial period of implementation. In this sense, it is a feasible adaptive action. Second, initially the project was technologically and scientifically justified. The EP-WAPDA appointed Leedshill-De Leuw Engineers as consultants (Haq and Burns 1967) for the project who completed it successfully within a span of 17-year time. All the components of the project – including height, width, and slopes of the embankments; drainage sluices with flap gates; and the materials and methods of construction – were techno-scientifically justified and feasible as per design. However, in the end, the techno-scientific justification did not remain valid. The embankments have become weak because of regular tidal wave action and occasional cyclone-related water surge that exerts tremendous hydrological load on the embankments, resulting in toe erosion and causing damage to the structure (World Bank Group 2010). Already, in some

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instances, the embankment was damaged severely in several areas during cyclonic storm surges in the last decade (Figure 7).

Figure 7. Part of an embankment in Shyamnagar damaged during cyclone *Amphan* in 2020. Source: Field data.

Similarly, slope erosion from natural causes such as rainfall, piping action, poor design (e.g. insufficient setback), substandard construction, and insufficient compaction led to the weakening of the embankments (World Bank Group 2010). Thus, though the project seemed to be techno-scientifically justified at the beginning, it eventually turned into an ineffective action, from a technological point of view.

Third, as noted above, this project produced significant environmental and ecological concerns in the coastal areas affecting both physical setting and agro-aquaculture. The CEP, in no way, can be treated as an environmentally benign action. Fourth, again the project was at first economically viable if we consider it from the funding point of view. The total estimated cost of the project was USD 238 million (Haq and Burns 1967), funded by USAID and the Pakistan (and later Bangladesh) Government. The economic return from rice cultivation was, as noted above, satisfactory in the first few years, up to the 1980s. Initially the EP-WAPDA estimated an increase in rice production of over 480,000 tonnes per year, with a 2.56:1 benefit-cost ratio for agricultural yield (Haq and Burns 1967). Nevertheless, within a decade of its completion, the CEP started losing its positive impact on agricultural yield in the polders. As discussed above, the rice production hampered due to the decreasing fertility of soil because of stoppage of regular tidal flushing on it. Again, starting in the mid-1980s, the embankments were overtopped by saline storm surges several times causing long-term water logging and salinity ingress in water and land because of drainage congestion, which also decreased overall rice production. Shrimp farmers in Koyra and Shyamnagar reported that in most of the areas shrimp culture started during 1980s when the region was flooded by saline water associated with cyclonic storms. Now, after Aila, rice production in the polder areas has become completely unfeasible. At present, no serious farmer wants to cultivate rice in his land, since the cultivation of rice in the area is not beneficial economically from a cost-benefit perspective. Moreover, even salinity-resistant rice varieties cannot tolerate the current salinity level in water and soil in the research areas. Thus, the single most important goal of the CEP – i.e. increase in freshwater crop yield through preventing salinity intrusion – has completely failed.

There has been no serious study to date on the economic impact of the CEP on shrimp aquaculture. When the CEP started in early 1960s, shrimp cultivation for the market did not spread so much, the industry was in its nascent stage. Shrimp culture had been increasing slowly in the 1970s and made a leap forward in the 1980s and 1990s. Since there is a lack of documentation of the role of coastal embankments, this research tried to gauge it through information from senior inhabitants of the research areas. Local people reported, as mentioned above, that shrimp farming in Koyra and Shyamnagar was sporadic and was concentrated mainly in the 'unprotected areas' outside polders, especially before mid-1980s. Similarly, in Mongla, though there is no BWDB embankment in the

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upazila, shrimp farming was a very small-scale business before 1980s. The growth of the shrimp industry in Bangladesh is connected to the global food regimes. The neoliberal global food governance project, through restructuring of the global aquaculture under Blue Revolution, "open[ed] up the natural resource pool of the global South to satisfy the appetites of wealthy consumers in the global North" (Islam 2014:49). Initially, local landowners were not aware about the huge economic return from shrimp farming in the area, some entrepreneurs from outside started to take land as lease from the owners and introduced large-scale shrimp culture in the areas. At the beginning, as discussed above, there were incidents of confrontation between outsider entrepreneurs and local landowners. Thus, when local people became aware about the profitability of shrimp culture, they started cultivating shrimp in their lands. Coastal embankment played both positive and negative roles in the shrimp aquaculture. It restricted the expansion of shrimp culture, since salt-water intrusion in the polders was prohibited initially. On the other hand, after introduction of shrimp farming in the polders, the embankments provided protective support from natural disasters, at least to some extent.

The economic viability of an embankment also depends on its regular maintenance. The infrastructure is subject to wear and tear by natural and environmental factors such as erosion, cyclone, storm surge and flood, and by human interventions and activities by animals. Thus, preventive, periodic and emergency maintenance as well as rehabilitation (if necessary) is crucial for the sustainability of the embankment. However, in Bangladesh, sufficient amount of funding is not allocated for O & M of the BWDB projects. Since 1959, BWDB implemented at least 710 projects with an estimated total value of investment of BDT 200 billion. Since annual O & M costs amount to 3% of the total investment costs as a rule of thumb, yearly requirement for O & M of BWDB infrastructure is BDT 6 billion (Peerbolte and Zubair 2011). However, the O & M budget of the BWDB never exceeds half of the required amount. Lack of resources has restricted even routine O & M of the embankments, making them weak and fragile (World Bank Group 2010). Thus, the economic viability of the CEP, considering from a space for feasible adaptation perspective, is largely questionable.

Finally, the social acceptance of the embankments – as the embankments are at present – is not at reasonable level. As mentioned above, after the initiation of large-scale shrimp farming in polders by the end of the 1980s, land use conflicts between aquaculture and agriculture led to several confrontations in the impoldered areas. Initially the shrimp cultivators also breached the dams to exchange gher water. There were some initiatives to restrict shrimp cultivation in the polders during and after 1990s also, but those initiatives brought no results. Since crop agriculture is not feasible at all in the areas, people are compelled to resort to salt-water shrimp farming. Respondents from Koyra reported an event. In 1999, the then MP requested all farmers to restrain from shrimp cultivation in Koyra. Following the appeal of the MP, almost none of the local people cultivated shrimp in the area for two consecutive years. Nevertheless, most of them eventually incurred loss by cultivating rice. Then, the community people arranged a meeting to solve the issue. In that meeting the landowners and the shrimp farmers agreed to restart shrimp farming in the area by bringing salt-water into the polders. This example illustrates the low level of social acceptance of the CEP in the shrimp-farming community.

5. Conclusion

After considering all the above components of spaces for feasible adaptation actions, we can conclude that the CEP, at least in its current state, cannot be referred to as a fully 'sustainable adaptation' strategy in addressing salinity, storm surge, flood, and cyclonic phenomena in the coastal shrimp communities in south-western Bangladesh. Its role in reducing vulnerability and increasing adaptive capacity and resilience of the coastal aquaculture and agriculture communities are very much a questionable phenomenon. Realizing the severe ecological, environmental, economic, and social drawbacks of this project, the District Fisheries Officer of Khulna termed it as 'a development massacre', the president of the Bangladesh Shrimp and Fish Foundation (BSFF) called it as 'an assault on nature', and a shrimp farmer from Mongla dubbed it as 'a premature action'.

To make the project a space for feasible action, a few ecological modernization schemes need to be incorporated into it. The height of embankments should be increased at a level to protect impoldered area from cyclonic storm surges. Sufficient number of two-way sluice gates should be installed so that these gates can be used for intrusion of regular tidal water from rivers, flushing of which can contribute to land formation as well as to the increase in soil fertility through natural siltation within the polders. In addition, these gates could be used for draining extra amount of water during monsoon and passing river water into shrimp farms when needed. An effective system of drainage channels should be erected to avoid waterlogging in the polders. Regular dredging of rivers along embankments is required for avoiding siltation outside the polders. Periodic, preventive, emergency and rehabilitative maintenance should be ensured to get optimum benefit from the project. To meet this end, sufficient fund needs to be allocated. Finally, taking the above-mentioned ecologically modernized initiatives, the polders should be redesigned for multi-functional land use, eradicating any confrontation among the land users. From the above brief case study of the CEP in coastal Bangladesh, we can conclude that resilience and adaptation schemes in aquaculture can be ecologically modernized to prevent any maladaptive consequences and to establish a sustainable aquaculture practice in the new climate regime.

The potential contribution of this research to climate change and coastal studies literature lies in the fact that, as mentioned earlier, this study is a novel attempt to appraise a govt.-run intervention project in the global South in light of the ecological modernization approach. This study applies the EM perspective in evaluating an adaptation program, in contrary to existing trend of using this perspective in climate change mitigation schemes in the global North. It is also novel in terms of scrutinizing an embankment project through the lens of space for feasible action. Going beyond the popular techno-economic perspective of project evaluation, this study equally highlights all major dimensions such as techno-scientific, environmental, economic, political, and social feasibilities of the CEP. Thus, it is hoped that this holistic approach of mega-projects evaluation can be replicated in similar projects around the globe.

Using robust methodologies, the study is a sociological investigation of CEP focusing on the applicability of ecological modernization approach in the Global South. However, as the issue is very complex, multi-disciplinary investigations are helpful to get comprehensive dynamics. A further study, for example, applying remote sensing image data and GIS technique to illustrate the changes in the development and utilization of the area inside and outside the CEP dam is necessary, and presenting the results in more graphic form is easier for many to understand better.

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