

Article

Resilience to Climate Change in Industrial Shrimping in Bangladesh: Assessing the Comparative Role of the Stakeholders

Shaikh Mohammad Kais ¹ and Md Saidul Islam ^{2,*}

¹ Department of Sociology, University of Rajshahi, Rajshahi 6205, Bangladesh; skais11@yahoo.com or smkais@ru.ac.bd

² Division of Sociology, Nanyang Technological University Singapore, 48 Nanyang Avenue, Singapore 639818, Singapore

* Correspondence: msaidul@ntu.edu.sg

Abstract: Over the last few decades, the global shrimp aquaculture industry has grown considerably and experienced important transformations in coastal regions in the Global South. However, despite being a major contributor to GDP and export earnings of the country, the shrimp industry in Bangladesh is not yet fully developed. This important sector is often plagued by numerous environmental challenges including frequent climate disasters. To address local climate perturbations, the shrimping industry undertakes a wide range of individual, communal, and institutional level resilience activities. Drawing on primary data collected through ethnography and qualitative interviews in three shrimping communities, this paper examines the nature, effects, and efficacy of resilience strategies adopted by various stakeholders in the shrimp industry in coastal Bangladesh. This research demonstrates that there is a clearly visible resilience gradient in the shrimp aquaculture industry in Bangladesh: individual shrimp farmers and households play a pivotal role in resilience enhancement, while other stakeholders including community, state, and civil society organizations have moderate-to-little involvement in aiding resilience in the sector. The study offers a series of recommendations for resilience to climate change.

Keywords: climate crisis; community capital; NGO interventions; resilience gradient; shrimp policy; Bangladesh



Citation: Kais, S.M.; Islam, M.S. Resilience to Climate Change in Industrial Shrimping in Bangladesh: Assessing the Comparative Role of the Stakeholders. *Sustainability* **2021**, *13*, 307. <https://doi.org/10.3390/su13010307>

Received: 30 November 2020

Accepted: 28 December 2020

Published: 31 December 2020

Publisher's Note: MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.



Copyright: © 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

1. Introduction

Industrial aquaculture in the tropical regions is particularly vulnerable to anthropogenic global warming. In recent decades, scientists have increasingly focused on the intersections between climate change impact, adaptation, and aquaculture. Climate change-related threats to aquaculture arise largely from (i) stress due to increased temperature and oxygen demand and decreased pH, (ii) uncertain future water supply, (iii) extreme weather events, (iv) increased frequency of diseases and toxic events, (v) sea level rise and conflict of interest with coastal defenses, and (vi) an uncertain future supply of fishmeal and oils from capture fisheries [1]. Predicted climate changes will cause physiological (growth, reproduction, disease etc.), ecological (organic and inorganic cycles, predation, ecosystem services etc.), and operational (species and site selection etc.) changes in global aquaculture [2]. All these changes have direct impacts on aquaculture production and aquaculture dependent livelihoods and indirect influences on aquaculture through fishmeal and fish oil availability [2–6]. Only after a thorough analysis of contextual factors affecting exposure, sensitivity, and adaptive capacity of aquaculture communities and stakeholders, realistic adaptation and resilience plans and actions can be devised for specific groups and communities. In addition to aquaculture species' biophysical and environmental influences, several socio-economic, networking and governance factors act as determinants of resilience for aquaculture-dependent human communities.

Resilience, commonplace as a frontier concept in physical, ecological, health, psychological, and social sciences [7], is conceptualized as an inherent or antecedent condition or ‘outcome’ of a system [8–11] as well as the system’s adaptive quality during and after a crisis. Community resilience, comprising of environmental, social, economic, infrastructural, and institutional dimensions [12,13], is a multi-scalar phenomenon and changes to one scale may lead to changes in other scales [14]. While outcome-oriented resilience at a community level tends to espouse ‘command and control styles’ which aim to retain the social status quo, process-oriented disaster resilience schemes focus on series of actions that enhances a community’s coping capacity over time [13,15,16]. In the context of shrimp-farming communities in Bangladesh, the ‘resilience strategy’ has been conceptualized as any action taken by the farmers and other stakeholders that helps them survive and sustain when facing adverse climate impacts.

Developing adaptability and resilience to counteract the negative impacts of climate disruptions is the main challenge for the shrimping community now. Meeting this challenge needs investment in the building and safeguarding of protective infrastructures, development of climate proof production technologies, and strengthening coping capacity of households and institutions. Previous studies have suggested several strategies for the techno-structural overhauling of the sector such as mixed prawn-shrimp culture [17,18], Integrated Multi-Trophic Aquaculture (IMTA) [19], silvo-aquaculture or integrated mangrove-shrimp cultivation [20,21], social forestry [18], and Reducing Emissions from Deforestation and Forest Degradation [22]. The process of resilience to climate change, however, is not just a perfunctory adjustment to natural perturbation, but a more intense socio-cultural encounter with core causes of vulnerability. Resilience strategies should incorporate local actions taken by the affected people and communities themselves in response to shifting environmental and climate regimes supported by larger-scale, and planned interventions by government or other institutions, which offer supports that are beyond the capacity of the local communities.

After this brief introduction, the methods of data collection for this study have been explained in Section 2. How households and communities adapt to changing ecologies are adumbrated in Sections 3 and 4, respectively. Governmental and NGO interventions are elucidated in Sections 5 and 6. Section 7 summarizes the comparative role of different stakeholders in building resilience in shrimping communities. Finally, this article concludes with a series of recommendations in Section 8.

2. Materials and Methods

We (the authors) used a cross-sectional research design in conducting this qualitative study. In total, two specific methods, namely ethnography and in-depth interview, were employed in collecting primary data from three research sites in coastal Bangladesh—Mongla in Bagerhat, Koyra in Khulna, and Shyamnagar in Satkhira. We selected these sites purposively because of two pressing reasons. First, about 80% of shrimp in Bangladesh is cultivated in these three districts [15,23,24]. Second, the coastal districts, compared to their inland counterparts, are more vulnerable to anthropogenic climate crisis [25,26].

As a primary method, we chose ethnography because it is both a process and a product that requires active participation in particular social/cultural groups in order to gain an “in-depth” and “insider perspective” [27]. As a primary method of, and hence an integral to, social sciences and humanities, ethnography offers not only a holistic picture of a community under study with its connecting tissues, but also an access to more informed subjects for further in-depth interviews. In order to have a clear understanding of the local dynamics in the shrimping communities, we conducted two ethnographic visits in each of the sites. Although the ethnography allowed us to generate a bulk of data, we interviewed 45 informed subjects from different stakeholders representing shrimp farmers, fry catchers, traders, government officials, and NGO officials. We employed semi-structured interview schedules to gather in-depth qualitative data from the respondents.

In addition, we used secondary sources to corroborate the primary data. After collecting and processing, data were analyzed qualitatively by finding out themes and patterns.

Taken as a whole, our cross-sectional research methods provided us with an in-depth understanding of the local dynamics of, and narratives over, industrial shrimp farming, diverse roles of the stakeholders, impacts of climate change, and a comprehensive account of local and national response to climate-induced risk and vulnerabilities.

3. Adaptation to Climate Crisis

3.1. Farming Level

The shrimp farming communities apply specific strategies to tackle immediate effects on shrimps and ghers (shrimp ponds). At the shrimp fry collection level, since the peak time for PL collection in the Sundarbans is the pre-monsoon months of April–June and since this is one of the two peak periods for cyclones hitting the Bangladesh coast, fry collectors often encounter, and have become accustomed (or, resilient) to this problem. As an adaptive response, they move out from the big rivers where they catch fry and take refuge in canals in the jungle during cyclones.

Shrimpers perceive that there is an increasing trend in the number of hot summer days with intense heat in the region [28]. At the shrimp farming level, one of the reasons behind the death of shrimps in summer months is the shallowness of shrimp farms. Although the optimum level of water depth in gher for bagda (brackish water shrimp) is 1.5 m [29], water depth in most of the ghers in coastal Bangladesh is as low as 0.75 m [15]. As a result, shrimps die frequently because of heat stress. A few farmers now increase the depth of their farms by making trenches at least at some corners of the gher so that shrimps can take shelter at that corner to avert heat stress during hot days. In addition, since shrimps may die because of oxygen shortage in gher water, which is caused by increased shrimp density within a lower amount of water due to climate change-induced extreme heat, some farmers have now become conscious enough to keep the stocking density of shrimp at a moderate level in order to avoid the above problem. This is an adaptive measure to the climate change perturbations in the shrimp economy. During storm surge floods and excessively heavy rainfall, dykes of ghers submerge and shrimps escape. Farmers address this problem by raising the height of the gher dykes. As a protective measure, a few farmers also put nets around their ghers to prevent shrimp escape. In addition, selling out pre-mature shrimp before any devastating disaster like cyclones and storm surges is viewed as an option by a section of farmers. This is because, according to them, it is better to cash partially than to lose everything. They base this on the fact that cyclones Sidr (in 2007) and Aila (in 2009) completely washed away thousands of shrimp farms in the coastal areas, causing almost 100% loss to the shrimp farmers [15].

3.2. Household Level

Ownership, control, and distribution of resources are an important facet of vulnerability and resilience. Since poverty generally leads to lack of access to tangible and intangible community capitals that are crucial in the face of risks from environmental hazards and the resultant stress on livelihoods, poverty is a significant indicator of individual vulnerability [30]. Nguyen and Wodon [31] in their study in the Sundarbans found local people adopting mainly three broad coping strategies when responding to cyclone hazards: consumption smoothing, income smoothing, and reducing investments in human capital. Poor and marginal households in shrimp farming communities who suffer from climate disturbances in the areas of the present study also take various adaptive mechanisms (Table 1 below).

Table 1. Adaptive strategies at household level.

Coping Strategies	Mechanisms and Methods	Supporting Sources
1. Consumption Smoothing	<ul style="list-style-type: none"> • accumulating reserves in good times for using in crisis periods: the farmers who make profit earlier can spend from their savings during disasters. • curtailing family consumption expenses, for example, through reducing food intake and spending less on clothing. • restarting shrimp stocking in ghers through borrowing money from neighbors, friends or relatives if enough savings are not available. • taking loans from moneylenders, banks and NGOs, and repaying them after harvesting. • selling poultry, reserved food grains, livestock or other assets such as land, which may have long-term negative effects on the households' income. 	[28,31,32]
2. Income Smoothing	<ul style="list-style-type: none"> • diversifying a household's sources of income and making those sources less exposed to climate chaos. • diversifying aquaculture practice: If bagda production, for example, drastically falls due to viral attack or other shocks, they depend on other aquatic species (grass carps, mono-sex tilapia etc.) that survive despite the shocks. • cultivating aman rice in the lean season of shrimp although due to water and soil salinity, rice production is not satisfactory. • growing vegetables in highlands and courtyards although it often comes with little success. • seeking off-farm employment in and outside of the locality as a response to economic shock due to adverse climate and environmental conditions, sometimes causing circular migration among the lower strata. 	[33–39]
3. Reducing Investments in Human Capital	<ul style="list-style-type: none"> • not seeking medical advice (especially by fry catchers and petty farmers) from specialized doctors because of higher expenses, and instead depending on village level quasi-medical persons for treating any physical ailment. • stopping children's education after a certain stage (especially after Higher Secondary Certificate exam, HSC) when education cost rises. • marrying their girls off after HSC and engaging their boys in farm activities or letting them search for jobs outside. 	[15,28]

4. Resilience at Community Level

Long-lasting general resilience, which is a manifestation of communities' latent adaptive capacities [40,41], can be built on strong community capitals. Community capitals are resources of a community that are invested for the collective wellbeing of the entire community. Social scientists frequently mention human capital (i.e., an individual's innate and acquired personal attributes such as work skill, education, knowledge, and health which contribute to ability to earn a living and strengthening the community), cultural capital (i.e., community's worldview, values and norms), financial or economic capital (i.e., material property, wealth and other financial sources available to be invested for business development, civic and social enterprises), physical or built capital (i.e., physical infrastructure of a community including machinery, homes, factories, water, roads, transport, shelter and energy), political capital (i.e., community members' access to resources, power and power brokers), environmental or natural capital (i.e., availability and sustainable use of natural resources for human consumption), and social capital (i.e., the extent of social networks) [13,42–50].

As delineated in previous literature, a human community's overall resilience is positively correlated with how rich it is in terms of various community capitals and how efficiently its members utilize those capitals [13,43]. Figure 1 schematically presents this conceptual model.

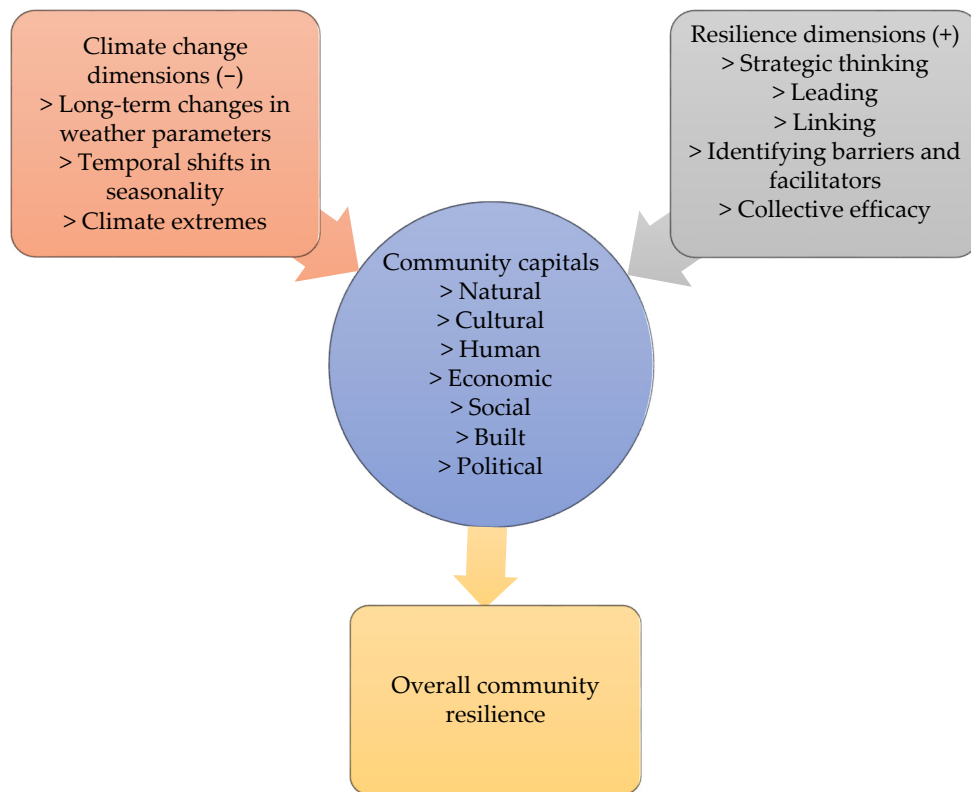


Figure 1. Interrelationships between climate change, community resilience and community capitals. Source: adapted from Kais and Islam ([13], p. 12).

This study focused primarily on the role of four major community capitals—natural, physical, economic, and social—in building and activating resilience attributes in community members as well as in the community as a whole. In the shrimp-farming communities in Bangladesh, there are somewhat developed physical infrastructures by means of roads and buildings, etc. compared to those a few decades before; but the economic condition of the average people is not so much strong. Similarly, though these communities have rich natural capital by means of forest and water resources, they lack strong social capital to fight collectively against any disaster. They have strong bonding capital (i.e., close ‘inward looking’ horizontal ties of social network that build cohesion within a community), but weak bridging capital (i.e., loose horizontal ties of ‘outward looking’ social networks across various social and ethnic groups) and very weak linking capital (i.e., vertical relationships across power or authority gradients). This fact leads to cooperation among close relatives and neighbors during a calamity but fails to erect a strong broader community based on cooperation and leading to self-reliance of the entire community. Moreover, there are only limited external institutional supports through governmental and non-governmental organizations. The following paragraphs explain this.

4.1. Natural Capital

Shrimping communities rely significantly on coastal resources for their livelihood. The shrimp communities reiterated the significance of natural capitals in building climate proofed livelihoods in the region. Natural capitals, including the Sundarbans, rivers, water resources etc., have direct use value, indirect use value, and non-use value on

them [51]. They recognize the Sundarbans, the largest contiguous mangrove forest in the world, as their main natural capital. About 0.6 million people from surrounding areas depend directly on this mighty forest for earning their livelihoods. Everyday thousands of people from the research areas enter the jungles to extract assets of various categories. Moreover, mangrove ecosystems have high potential for sequestration of carbon—ranging 40–450 mt/km²/yr, and CO₂—184–987 mt/km²/yr [52]. Considering the total area covered by the Sundarbans, it can be said that this forest sequesters enormous amounts of carbon and carbon dioxide every year. Thus, the Sundarbans acts as a shield against climate chaos for the poverty-stricken people in coastal Bangladesh. One shrimp farmer from Shyamnagar commented on the protective role of the Sundarbans, “Despite our torture, the Sundarbans always protect us from disasters from the sea. The jungle is like our mother—it nourishes us, protects us, brings up us.”

The brackish-water ecosystems in the Sundarbans are the breeding field for bagda, golda, horina, and other species of shrimp. All wild shrimp fry, whether inside the jungles or from the rivers, come from the Sundarbans. A substantial number of fry catchers from the research areas regularly collect shrimp PL from rivers in the jungles. In addition to the Sundarbans, the local people view surrounding rivers as important natural capitals that provide livelihood support to them. At least ten big or small rivers including Kobadak, Pasur, Koyra, Kholpetua, Jamuna, Chuna, Malancha, and Shakbaria, run through the three upazilas (sub-districts). Shrimp cultivation is directly related to these rivers. Aquaculturists use water from the rivers in their ghers for stocking shrimp. They regularly exchange gher water from the rivers. Moreover, as mentioned above, wild fry is caught from the rivers. Farmers generally prefer wild fry to hatchery fry because of their higher survival rate.

Although overall natural capital declined in the past two decades, it continues to be very vital for building resilience to climate change for the local communities. Local people’s perception, which matches with scientific findings [28], is that the Sundarbans is a natural protector for them against cyclone and other disasters. This mangrove forest works as buffer against tidal surge reducing the strength of cyclones significantly. Moreover, the forest and the rivers are the last resort for many during disasters in the shrimping communities. After Cyclone Aila, for example, people had no employment in the locality since all ghers were washed away and could not be cultivated again for up to two seasons. Many small-scale shrimp farmers have no other choice but to go to the jungle and river and try for earning their livelihoods there. One of the interviewees in Koyra, after losing his ghers in Aila, started collecting honey from the jungle. He worked in a group of four. Every day, from dawn to dusk, they would collect about 40 kg of honey that they would split among themselves. In this way, he earned a livelihood for his family and managed to bear the education costs of three young brothers. So, in addition to protection and regulating services, the forest offers provisioning services to the shrimp-farming community in times of crises, allowing them to be resilient to shocks.

4.2. Built Capital

In terms of the development of physical or built capital, the aquaculture communities are in a moderate to lower position. Most of the dwelling houses in these areas are *kacha* houses built with a tin roof, earthen floor, and wooden walls. During Aila, most of the thatched or mud houses were completely damaged. After that, almost all households improved their housing conditions but still *paka* (full brick-built) house is rare in the vicinity. The vast majority (above 95%) of the dwelling houses are semi-*paka* (only floors are brick-built) or *kacha* which are not cyclone resilient. In most of the villages, there is no electricity connection from the Rural Electrification Board (REB). However, they purchase solar panels for lighting their homes by taking loans from NGOs. In addition to privately owned dwelling houses, there are government and non-government establishments such as buildings of various offices and organizations, educational and religious institutions, and cyclone shelters, which are part of the areas’ physical infrastructure. Table 2 shows

some of the selected categories of institution/establishment buildings, which are accessible to common people especially during disasters.

Table 2. Number of selected types of establishment in the research areas.

Institute or Establishment	Mongla	Koyra	Shyamnagar	Total
College	4	3	6	13
High/Junior high school	26	48	41	115
Government primary school	32	54	81	167
Registered non-govt primary school	29	58	73	160
Community primary school	3	14	22	39
Madrasah	16	28	38	82
Mosque	110	157	499	766
Temple	29	136	94	259
Church	11	1	0	12
Cyclone shelter	16	47	16	79
Total	276	546	870	1692

Source: ethnographic data collected from the respective Upazila Nirbahi Offices (executive director of sub-districts).

Other than the above-mentioned infrastructures, 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 of the BWDB (Bangladesh Water Development Board) embankment in Koyra and Shyamnagar is 339 km with 46 sluice gates. The main transports used for the harvesting, carrying, or marketing of shrimp or shrimp PL are truck, lorry, trawler, korimon-nosimon, pick-ups, motorcycle, rickshaw-van, bicycle etc. In general, the condition of roads is not good in the aquaculture communities. Instead of being an asset for resilient livelihoods, roads and transport infrastructure can become a constraint. If the roads are not in good condition, shrimp farmers and traders are deprived of an expected amount of profit due to the damage of shrimp and extra carriage cost. A shrimp trader at Bongshipur Mokam sarcastically commented on the condition of a local road, “If you go to Nowabnki from Shyamnagar Proper by motorcycle, your kidneys will fail, let alone your shrimps!”

Built capital can provide essential services in the wake of disruptive climate events. It is used in various capabilities to enhance adaptability of the community. During Sidr, 15% of the affected people took refuge in cyclone shelters. Currently there are 2591 cyclone shelters in which 2.8 million people (7.3% of coastal population) can take refuge during disasters [39]. Generally, people also take shelter in neighbors’ houses if those are strong enough. Schools and college buildings are also used as temporary cyclone shelters for a few days. Though mosques and temples are not usually used as cyclone shelters, disaster warnings are circulated through announcements from mosques. While newly constructed cyclone shelters have provisions for keeping cattle at the open space of ground floors, during cyclones and storm surges, cyclone shelters could not be used for any shrimp related purpose. Only the affected people can take shelter there. If, for example, a cyclone hits the community at a time when a farmer had already harvested shrimp from his gher, he cannot use the shelters for preserving harvested shrimps. He can have only two options either to leave it at home unattended or to sell it to farias within the quickest possible time, generally for a cheap price. Some people during the disasters take advantage of others’ vulnerability and exploit the situation.

4.3. Economic Capital

Economic or financial capital is vital because it can be readily converted into other types of capital in times of necessity and can be used for achieving desired livelihood outcomes [51]. In general, the state of finance capital and its role in building resilience is poor in the shrimp communities. According to the key informants, average size of about 80% of gher in these areas is 5–8 bigha. From one gher of this size, a farmer can sell shrimp and fish up to BDT 250,000–300,000 every year in normal situation. He can make a neat

profit of up to BDT 150,000. If the gher is attacked by virus or suffers from production loss due to climate disasters once in a season, the farmer can still recuperate the loss and make little amount of profit. However, if a gher is attacked twice or more in a season, the farmer cannot make profit—he has to incur losses. He tries to recover from this type of situation by taking different income smoothing or consumption smoothing measures, as discussed earlier (Table 1).

Generally, people in shrimp communities cannot save much. Whatever amount they can save at the end of a season; they reinvest it in aquaculture or buy land. A few shrimp farmers deposit their savings in banks or NGO accounts. Some NGOs, including Jagrata Juba Sangha (JJS), Prodipan, and Brac, have deposit schemes in the area. In addition to banks and NGOs, some local cooperative associations and clubs have deposit schemes for their members. Members of those cooperatives or clubs regularly deposit various amount of money ranging from BDT 20/week to BDT 10/day.

In addition to registered cooperative associations and clubs, there are unregistered and informal collective arrangements for accumulating capital in the coastal region. The farmers who share the same arrangement for using river water create informal cooperatives among them. They form a committee comprising a president and a cashier, and generally deposit BDT 50–100/month/farmer. If any of them face any crisis, he can borrow from the common fund without paying any interest. Thus, aquaculture people have some minor channels to possess liquid asset that can be readily cashed and spent in crisis times.

Disaster resilience support amongst immediate family members is very vital. Beggs, Haines and Hurlbert [53] find that family members provide essential recovery assistance during disaster periods. One or more members from less than 10% of families in the research areas live in different cities and towns in Bangladesh for job or business purposes. They send money to their families, some of them on a regular basis and others occasionally. The amount of remittance depends on their income and savings. The households use that money for various purposes including land purchase, regular family expenditure, festivals and family occasions, shrimp cultivation etc. They also use the remittance for enhancing coping capacity of the households to weather shocks. Other than the above-mentioned household-level and small-scale group initiatives, there is no common community fund in any of the three aquaculture communities, a fact which makes collective engagements in resilience-enhancing or other community activities difficult. Therefore, any financial liability for recovering from weather shocks or disease outbreak in gher goes to the affected gher owners; the community as a whole does not take any measures.

4.4. Social Capital

Social capital—the most intangible, hard to measure, and complex part of community capital—depends on its members' networks and connectedness, membership of more formalized groups, and relationships of trust, reciprocity, and exchanges that enhance cooperation, reduce transaction costs, and provide informal safety nets for the vulnerable groups [51]. Resilience is affected by multilevel attachments, both distal and proximal, including family, peers, neighborhood, community, and society [54]. Broadly, social capital in a community develops through objective formal and informal group ties and networks, norms, and social trust [55–57].

If we look into the bonding, bridging and linking social capital in the shrimping communities, we find that bonding capital is strong among neighboring households and among households who are friends or relatives. They meet frequently on various occasions and tend to help each other in times of need. During disasters, they receive psychological, emotional, informational, and tangible supports from the close groups. These close groups are the primary source of social support in the communities. In addition to emotional and informational support, they get financial help in times of need. Thus, proximity matters. Neighboring farmers are cooperative with one another in farm related activities too. If one goes to Satkhira, Chuknagar, or Rampal to buy shrimp PL, for example, usually he also

purchases for his neighbor, if requested. While facing any gher related disturbances, the owner usually consults with the neighboring gher owners to seek advice.

Beggs et al. [53] view community bonds as ‘informal insurance’ that allows victims to receive tangible (financial, physical, logistic) and intangible (emotional, spiritual, informational) supports. Bonding social capital among the community members in shrimp areas, in general, except among close neighbors and friends, is not so high. There are several organizations and cooperatives in the communities that act as formal platforms, which connect aquaculture members with a wide range of people from their own profession, locality and beyond. A farmer can get additional tangible and intangible resources through the added connections that might be used in pursuing specific goals and solving collective crises. Our investigation shows, in Mongla, Koyra, and Shyamnagar there are a total number of 703 cooperative associations and 121 clubs of various categories.

In general, a club or association office serves as a meeting place where the members can share their individual or common problems with, and thereafter get advice from, others. In addition, some of these groups offer loan facilities, albeit often insignificant in amount, to the members. Farmers usually get loans at the start of the season when they stock shrimp PL in ghers, and they pay them back by weekly or monthly instalments with interest ranging between 10% and 12%. The association leaders also give advice on shrimp cultivation. Although these organizations do not focus on climate change issues, they sometimes arrange some awareness sessions for local youths before any disaster strikes. The youths then start helping the old, children, and the disabled. Thus, a section of shrimp farmers receives some informational, advising, and financial support from these secondary and formal groups, especially in times of financial difficulty triggered by weather shocks.

Besides the above-mentioned cooperative and club activities, bonding social capital enhances through informal get together sessions at various places on a daily basis. Aquaculture people frequently meet at the local tea-stalls or village huts where they also spend time playing cards, chess, or carom. At these sessions, the farmers share their views and ideas on various issues including diseases and disasters. These sessions largely provoke discussions on problems; the solutions, however, hardly come out.

In the traditional farming villages, community leaders usually come from the elderly, the educated class such as schoolteachers, landed class such as zaminders, and religious leaders such as the imams of local mosques. Community members usually respect these leaders and have trust in them, and consequently the latter has an informal authority over the former. However, during the last couple of decades, a change in the structure of community leadership in rural areas has been noticed, with local political elites and a newly emerged ‘moneyed class’ being the new leaders of the community. This newly emerged leadership is not well accepted by community members. Although this is a general trend throughout Bangladesh [58,59], some researchers (e.g., Ahmed [60]) associated this shift with the emergence of shrimp regimes. Along with shrimp regimes, we have discerned a number of other associated factors that are responsible for this shift: changes in political structures; changes in local level administration; influx of liquid money in rural areas; NGO interventions; the impact of media, modernity, and globalization; and so on. Rural Bangladesh has been passing through a transitional phase in which critical shifts are taking place in social structures and organizations. Generally, the elderly in a community cannot keep pace with rapid institutional transitions, and thus they lose their authority [61].

In Max Weber’s authority development scheme, legal–rational authority replaces traditional authority in modern capitalist rational society [62,63]. As our investigation shows, by subverting the traditional authority and social structure, coastal Bangladesh is going through a critical transitional phase towards a modern capitalist production relation. Although traditional leadership is losing authority, the rational structure of authority has not yet taken a complete shape. In its place, a new type of kleptocratic authority is on the rise. Thus, when asked about who the leaders are, members of the shrimp-farming

community were divergent in their response, ranging from the traditional community leaders to local political elites to elected representatives such as Union Council chairmen.

Although trust is an important component of social capital, the newly emerging leadership is not very trustworthy to the community members. Trust can be defined as “socially learned and socially confirmed expectations that people have of each other, of the organizations and institutions in which they live, and the natural and moral social orders that set the fundamental understandings for their lives” ([64], p. 165). Stern and Baird [65] discern four types of trust: dispositional (depends on a trustors’ inclination to trust or distrust in a given situation), rational (depends on trustors’ assessment about what they believe to be the expected outcomes of potential trustees’ anticipated actions), affinitive (depends on the amount of meaningful personal relationships between trustors and trustees), and systems-based (depends on a set of procedures and rules or systems). In addition to these types, there may be ‘lack of trust’ or ‘distrust’. Lack of trust indicates a situation where a trustor cannot make a judgment about a likely trustee’s action because the trustor does not have ample information. Distrust, on the other hand, implies an individual’s explicit negative expectation about the prospective trustee. The importance of trust lies in the fact that it enables people to undertake actions that otherwise would not have been possible without its presence. A shrimp farmer’s resilience to climate change, his motivation to learn and plan, and his concern in changing behavior may all be influenced by the degree to which he trusts others in his community and beyond.

Our study shows that shrimp farmers in coastal Bangladesh, however, have very high level of trust in family members. They trust their fellow community members to a great extent. These people include their friends, neighbors, relatives, and people of their own village, regardless of religion. They have less confidence in people from other communities and villages. Except the traders themselves, other stakeholders (farmers and fry collectors) have very low level of confidence in businesspersons and traders. The shrimp-farming community, in general, has very low trust, lack of trust, or distrust on politicians, government officials, local government representatives, the police, and the courts. This ‘trust deficit’ significantly hinders the coastal community from attaining meaningful social capital to face disasters.

The study also shows that vertical linking social capital in the shrimp farming community is very weak. Community leaders are somewhat connected to upazila level administrative and political authorities, but only few of them have connections with district or national level ones. If shrimp farmers inform the community leaders about any aquaculture-related problem, they generally approach the Union or the upazila administration. However, farmers hardly receive effective solutions at these levels, especially if their gher are under threat from climate change or environmental perturbations.

In addition to the above bonding, bridging, and linking aspects, there are disaster management committees (DMCs) at the upazila (headed by an upazila chairman), Union (headed by union council chairman), and Ward levels (headed by a Ward member) for addressing specific weather extremes such as cyclones. If there is any warning for cyclone, the DMCs meet and decide on likely measures to adopt. The DMCs then make the community aware through circulating the warnings. Thus, event-specific measures are taken only for extreme disasters. These actions also do not address the problems that shrimp farmers might face.

From the above discussion, we can draw the following conclusions on the role of community in building resilience in the commercial shrimp sector in Bangladesh.

- If a shrimp farm is affected by weather shock or environmental and climate change, the responsibility of adaptation and recovery rests solely on the gher owner or cultivating farmer in charge.
- The community as a whole does not take any measure to build resilience to climate perturbations in the sector in general.

- The community has disaster management committees (DMCs) which take event-specific measures only for extreme weather events. Their actions generally do not address the problems that shrimp farming might face during the disasters.
- The capability of the community in addressing climate issues is very low.
- The capability of the community has changed over time since various categories of community capital have changed (increased or decreased).
- Whatever tangible and intangible resources the community has are not utilized properly for the benefit of the whole community.
- Bonding social capital within primary groups is still effective in resilience-enhancing initiatives in the community. Although the sole responsibility of adaptation to and recovery from climate shocks and other calamities lies in individual farmers, the affected farmer often receives tangible and intangible supports from his close neighbors, relatives, or friends.
- Thus, we can say that the community role in building resilience is moderate in some aspects and low in other aspects.

5. Governmental Interventions

Given the enormous convoluted and multiplicity of climate change hazards, and implications for lives and livelihoods of local communities, it is hard for the communities alone to face its manifold challenges. Although a resilience approach emphasizes the self-organization of the communities, by promoting the idea that resilience comes within them, it risks underestimating the challenges of creating this type of internal shift [66]. Thus, outside interventions are essential to address the internal challenges and boost resilience of a community. In order to increase community resilience, it is important to enhance positive relationships within and among communities and, for the local government service providers, to capitalize on existing relational resources and encourage their further development [44]. Synergy between the state and community social capital is significant in the sense that state–society linkages are important both for wider sustainable development and for the co-management of resources. State institutions such as the government and formal laws play a pivotal role in determining access to resources and defining the architecture of entitlements, which are based on material and social aspects of resource use [30]. State authorities can augment sustainable and resilient resource management and boost coping capacity of the communities [67]. Here, we have discussed some national policies and local level interventions.

5.1. National Policies

With the aim of addressing the adverse impacts of climate change in Bangladesh, the consecutive governments have adopted a series of policies, programs, and action plans. Moreover, there are several policies adopted by different ministries to address coastal or aquaculture issues. Although these policies directly or indirectly address at least one of the themes—coastal zone, aquaculture, and adaptation to climate change—here we have reviewed two of them, which are the most relevant for the topic of this research (Table 3).

Table 3. A tale of two national policies.

National Policies	Central Goals	Key Roadmaps
1. The Coastal Zone Policy 2005	to create conditions, in which the reduction of poverty, development of sustainable livelihoods and the integration of the coastal zone into national processes can take place [68]	<ul style="list-style-type: none"> • declaration of shrimp culture as a priority livelihood sector for the coastal zone; investing in it can enhance the living standard of the coastal communities. • exploration of economic provisions based on local resources, treating the provision of bagda culture in brackish water as an opportunity in resource utilization. • promotion of collateral-free credit with simple terms and conditions, recommending loan facilities for the coastal communities. • discouragement of an arbitrary halt on shrimp fry catching or other employment opportunities in the zone without ensuring alternative employment. • improvement of the condition of built structures with an integrated network of communication including highways, major roads, rural roads, railways, and waterways. • recommendation to address the vulnerability of the coastal poor by introducing an insurance plan for improving their social security. • suggestion of, to protect the community from climate change and natural disasters, the construction and maintenance of cyclone shelters, road systems, multi-purpose embankments, and cyclone warning systems, as well as the planting of trees in the coastal region through social forestry schemes. • recommendation of special adaptive measures for the coastal zone against climate change and implementation of the identified resilience schemes.
2. The National Shrimp Policy 2014	enhancement of the production of shrimp in the country through culturing shrimp in a planned way that incorporates the application of appropriate technologies and the consideration of economic, social, environmental, and climate change issues in the farming zone [69]	<ul style="list-style-type: none"> • adoption of vertical or horizontal or both techniques in expanding the production of shrimp; fulfilment of the national demand of animal protein through sustainable development and management of available resources. • emphasis on environmentally friendly integrated shrimp farming, crop diversification, and crop rotation management. • appropriation of proper measures for alleviation of poverty and improvement of socio-economic conditions of small-scale and marginal farmers, fishers, and other people engaged in production, procurement, processing, and marketing of shrimp. • adoption of necessary measures to effectively stop shrimp fry collection from natural sources by providing alternative livelihoods for the existing shrimp fry collectors. • production of healthy and disease-free shrimp PL through specific pathogen-free (SPF) brood stock. • development and application of suitable techniques for tackling climate change risks. • institution of protective system against diseases in shrimp through development and application of modern and sustainable management systems. • areas of implementation include shrimp production and sustainable management, creation of employment opportunity and poverty alleviation, improvement of socio-economic conditions of the people engaged in shrimp industry, and training and research on shrimp culture.

From the brief review of the most important two government policies, it is notable that the Bangladesh government takes a uni-linear top-down technical approach for improving the shrimp sector. It lacks, in general terms, specific strategies to encourage and augment people's participation in the projects. It puts little emphasis on enhancing community capacity to build resilience from within to weather shocks and climate change in the shrimp culture zone. Moreover, though the National Shrimp Policy 2014 encourages public and private financial organizations to sanction loans to shrimp cultivating community, it says nothing on regular disbursement of loans through the Department of Fisheries (DoF), the sole government authority in charge of governing the shrimp industry.

5.2. Local-Level Interventions by the Department of Fisheries

From the government level, the DoF provides various supports to the shrimp-farming community in order to adapt with or be resilient to climate disruptions. As part of farmers' capacity building, Upazila (sub-district) Fisheries Offices (UFOs) organize training for shrimp cultivators on a somewhat regular basis on various subjects including using and operating new technologies, shrimp farm preparation and management, post larvae (PL) nursing, quality control, good aquaculture practice, sustainable farming, coping with climate hazards etc. These trainings are generally conducted before the start of a new farming season every year. Training on disaster management in shrimp is very rare and generally organized after a severe natural calamity affects the sector. For example, after the cyclones Sidr and Aila, UFOs organized awareness building and recovery training workshops in the affected regions. The DoF finances these training programs that cover only selected shrimp farmers in a community. The DoF, through its field-level UFOs, also provide technical assistance to the farmers in the forms of soil and water quality test and diagnosis of diseases. To enhance the financial capital of the shrimp farming communities, the DoF often helps the farmers to obtain bank loans.

The DoF has a micro-loan scheme for small-scale aquaculture. The scheme is established with the departmental revenue budget that runs as a revolving fund. However, this loan scheme is largely of no use to the aquaculture community. The farmers hardly know about this facility. Although there is no definitive instruction from the DoF, the UFOs normally disburse only up to BDT 50,000. Disbursing BDT 50,000 to a farmer is extremely rare; generally, the loan amount ranges between BDT 10,000 and BDT 20,000. The DoF policy is to sanction this loan to people who are currently cultivating fish (including shrimp) or who are willing to start fish culture. However, since this loan has a very low interest rate (only 5% as service charge) and it can be repaid in five annual instalments that are very easy terms and conditions—this loan is sanctioned under political influence. Local political leaders, especially from the party in power, pressurize the UFOs to offer this loan to those leaders' followers.

Generally, the farmers who get loan through political channels are not willing to refund it. The UFOs also cannot pressurize them to pay the loan back since they are vulnerable to political pressure as well. Along with political pressures, lack of monitoring and inadequate manpower in the UFOs are among the reasons behind turning this scheme into 'bad loans'. The UFOs have very little work force, generally only 3–4 staffs. It is quite hard for them to manage time, after finishing all the official jobs, to go to a borrower's home frequently to monitor his situation. Due to this lower rate of recovery, the DoF introduced a new loan scheme system few years ago in which the sanctioning officer is personally responsible for recovering the loan. If the concerned officer cannot recover the loans, the entire aggregated amount is deducted from his/her pension. Thus, this loan has become a liability for the field-level officials, and therefore they are now very reluctant to disburse, and even to disclose, this micro-loan to farmers. In very rare cases, the UFOs sanction this loan to just 1–3 lucky persons per year. In summary, this loan is highly out of the reach of the shrimp farming community and it does not help them much.

The DoF also sometimes provides inputs support (lime, fertilizer, feed etc.) to selected farmers. In addition to formal training, assistance, and supports, the field-level DoF officials

organize informal discussion sessions with local farmers. In these sessions, the officers give advice and suggestions on sustainable aquaculture practice, among other things. All these supports, both hard and soft, can enhance, with only limited capacity, the adaptability and resilience of the commercial shrimp sector.

6. NGO Interventions

With a density of 3.5 foreign NGOs (branches) per square mile [70], it would not be any exaggeration if we call Bangladesh a 'land of NGOs'. In Bangladesh, over 22,000 NGOs are in operation in 80% of villages contacting about 35% of total population of the country [59,71]; most of them are small, local organizations with only very few large-scale national NGOs on the scale of the internationally known agencies [72]. NGOs have become an indispensable development actor in Bangladesh. The most notable feature of NGOs in Bangladesh is that they pioneered micro-credit as a poverty alleviation tool. NGOs in Bangladesh work on different issues including human rights, hazard management, empowerment of women, education, poverty reduction, etc. Their recent priority area is adaptation to climate change.

More than 50 NGOs are working in Mongla, Koyra, and Shyamnagar, and most of them have projects in these areas. Since these are a disaster-prone zone, majority of the NGOs address climate change adaptations in one way or another. However, one striking fact is that none of the NGOs exclusively approach the shrimp farming community, even though shrimp is the mainstay of the coastal economy and as many as 95% of population depends on shrimp culture directly or indirectly for earning their livelihoods [73]. In the absence of any exclusive project on climate change resilience of the shrimp farming community, we have reviewed three selected NGO projects that deal with climate change adaptation in the locality as a whole (the projects usually keep shrimp farmers outside their scope). The case studies are based on information gathered from the respective project managers (Table 4).

BRAC focused on livelihood support and diversification through the DECC project in Mongla, Koyra, and Shyamnagar area. Since they supported only 100 persons from each upazila and support amount was very little (only about USD 180), this initiative has very weak (almost zero) impact on local people's adaptation to climate change. One important aspect of this project is that it included shrimp PL collectors and focused on their rehabilitation, though the effort is negligible if we consider from the beneficiary number and support amount. Nevertheless, BRAC's role in enhancing climate change resilience of shrimp-farming community can be termed as 'very low'. Jagrata Juba Shangha (JJS) did not focus on shrimp farmers in its climate change projects. Almost all of the beneficiaries of the Paribartan project were non-shrimp households. Moreover, this project had very little impact even on the target groups. From the point of view of enhancing resilience in shrimp culture, we can say that this project had nearly zero contribution. LEDARS, on the other hand, is working on livelihood diversification as a means of strengthening resilience of the local people to climate change in selected villages in Shyamnagar and Koyra. Their initiatives are also very little in scope. Moreover, during field investigation, it was found that LEDARS deliberately exclude shrimp farmers from their projects.

Examining the above-mentioned and other NGO projects on climate change vulnerability, adaptation, and resilience, we can conclude that NGOs do not have any significant contribution in building resilience in shrimp farming communities. A shrimp farmer from Mongla succinctly pointed to the inadequacy of support from public and private institutional structures, "There is no research [on shrimp] in our region; the government does not highlight our needs; there is no activity of NGOs [on shrimp sustainability]. The NGOs are expert in extortion by lending money to poor people; but they don't have any initiative for enhancing the production and marketing of shrimp."

Table 4. Selected NGOs and their modus operandi.

NGO 1: Bangladesh Rural Advancement Committee (BRAC)
<p>Project Title: Disaster, Environment and Climate Change (DECC) Project area: Mongla, Bagerhat Number of beneficiaries: 500 (in Mongla) Main Activities:</p> <ul style="list-style-type: none"> • One-time inputs support to the direct beneficiaries up to the value of BDT 14,000/person, no cash support available. • Training for the beneficiaries about their respective support type. • Various supports to the beneficiaries based on the suitability of the activity in the beneficiary's neighborhood such as small grocery shops, rickshaw van, goat raising, crab farming, and tailoring (sewing machine for women). • Rehabilitation of shrimp PL collectors (total 75) through input supports (mainly grocery shop).
NGO 2: Jagrata Juba Shangha (JJS)
<p>Project Title: Increasing Resilience and Reducing Risk of Coastal Communities to Climate Change and Natural Hazards in the Bay of Bengal (Paribartan) Project area: Koyra, Khulna Number of beneficiaries: 1080 (Koyra) Main Activities:</p> <ul style="list-style-type: none"> • Campaign in schools: A total of 75 students from three schools were trained on how to adapt to climate change and reduce risks during disasters. • Public awareness programs through observing environment day, disaster reduction day etc.; arranging stage shows about climate change adaptation; and publishing articles in national and local dailies. • Pilot programs implementation: A total of eight agricultural farmers were provided with support for cultivation of rice, fish (non-shrimp) and vegetables. Supports were provided to four women in building disaster resilient house, rainwater preservation and vegetable cultivation through management of saline water. Ten eco-friendly, lower fuel-consuming stoves were distributed. A total of five homesteads were raised in order to make them safe from storm surge water. A total of 1500 seedlings of various saline tolerant fruit species were distributed. • Six sets of disaster warning equipment were supplied to three unions and three villages, one set each.
NGO 3: Local Environment Development and Agricultural Research Society (LEDARS)
<p>Project title: Strengthening Livelihood Security of Climate Change Vulnerable People Project area: Shyamnagar, Satkhira Number of beneficiaries: 670 families (in Shyamnagar) Main Activities:</p> <ul style="list-style-type: none"> • Formation of climate resilient groups: 31 climate resilient groups have been formed consisting of 140 vulnerable people. LEDARS conducts regular monthly meetings with the groups. • In order to strengthen organization of tiger widows, a total of 4 tiger victim groups were formed comprising of 80 tiger widows (whose husbands got killed by tigers). • Three Union climate resilient committees (UCRC) were formed to enhance the access of poor on <i>khas</i> water bodies and to re-excavate those for preservation and use of rainwater during dry season for second crop cultivation. • Organizes three farmers' innovation fairs to disseminate and inspire adaptive innovations by local farmers. • Supports to observe national and international days at community level like World Water Day, Village Women Farmers Day, Climate Action Day, and Food Day. • In order build awareness among the local youths, LEDARS organized one youth environmental camp. • A number of information, education and communication materials including crop calendars, posters, and billboards were distributed or hung in different places. • A two-day long training session was conducted on saline, flood, and drought resilient paddy and vegetable cultivation. • Seeds of saline, drought, and flood tolerant crop varieties were distributed once to 400 most vulnerable farmers up to 1 acre of land each. • Saline tolerant fruit seedlings were distributed among the beneficiaries. • To develop carbon sensitive families, LEDARS distributed improved cooking stoves among the beneficiaries. • Under the project, LEDARS excavated 27 small ponds in the beneficiaries' land to reserve freshwater for crop cultivation. • The project constructed a small-scale production house where 10 women work. • Introduced river ambulance to provide medical services to islands in the Sundarbans.

7. Comparative Role of the Stakeholders

If we analyze the comparative roles of different stakeholders in building resilience to climate changes in the shrimp-farming communities, we find that through both anticipatory (proactive) and autonomous (reactive) adaptive measures, the shrimp households tend to adopt resilience enhancing initiatives, with more or less success. Through gher management and household management, the household-level actions focus on 'high' or 'moderate' level resilience strategies.

As discussed, shrimp communities are rich in community capitals in various degrees: they are quite rich in natural and bonding social capital, moderate in built and bridging social capital, and weak in financial and linking social capital. Community leadership does not take necessary resilience actions horizontally or vertically. In general, community people are not of much support for a given household (except close friends, neighbors, and relative) in building resilience to weather shocks and climate change, especially if we consider the number of tangible supports provided. Thus, as mentioned earlier, community endeavors in building resilience to climate change may be dubbed as 'moderate' or 'low'.

Governmental and non-governmental institutions and organizations have little interventions, which are mainly devised to address specific events. The governmental institutions have policies on climate change, capacity building and awareness raising programs, technical and inputs supports, and very limited-scale loan facility. However, the initiatives of the governmental institutions lack effective funding and support throughout the year. Even the fisheries officers from both national and local levels revealed this fact. They commented during interview sessions that the fisheries department receives poor funding from the ministry, so they cannot run projects throughout the year. Thus, if we consider the government's role in building resilience of the shrimp industry in Bangladesh, we can term its role as 'weak' or 'low'.

In terms of building resilience to climate change in shrimp farming communities, NGOs have divergent roles. In the shrimp farming regions, we can find three groups of NGOs considering the level of their support to shrimp culture: pro-shrimp, anti-shrimp, and neutral. An interesting fact is that the so-called pro-shrimp NGOs, who support shrimp cultivation in Bangladesh like ASA and BRAC, also do not have any project directly addressing shrimp aquaculture. As we found in the case study of a BRAC project (Table 4), they provide support to shrimp-farming community in a very low degree. They just provide loan services under microfinance schemes, which is again a part of their profit-oriented business trade. The neutral NGOs, such as JJS and Rupantor, have no say to shrimp. They maintain distance from this sector and remain busy with other activities—their role in building resilience in the shrimp sector is zero.

The anti-shrimp NGOs, like Islamic Relief Bangladesh (IR) and LEDARS, blatantly oppose the growth of industrial shrimp farming in their projects or campaigns. The manager of an IR project during the interview session fiercely opposed shrimp cultivation in the locality, mainly on the ground of perceived (rightly or wrongly) negative effects of shrimp on the environment and livelihoods. LEDARS also profoundly oppose the very existence of shrimp culture in the region. Under their project 'Campaign for prevention of saline water to restore agriculture in coastal region of Bangladesh', for example, they organized activist movements against shrimp farming at local and national levels. From an absolute anti-shrimp position, one of the objectives of the project is 'to set up a model village in the coastal area to show how people can survive without a shrimp-based economy'. In a poster, the LEDARS portrayed shrimp as a monster that swallows everything in the locality. Thus, since they question the very existence of shrimp aquaculture and since they campaign to abolish it, their role in resilience building in the sector is certainly negative. Considering the above-mentioned diverse role of NGO interventions, we can dub them as 'very low', 'zero', or 'negative'. Taken as a whole, we can present the comparative roles of shrimp farming households, communities, government agencies, and NGOs in building resilience to climate change in a resilience gradient (Figure 2).

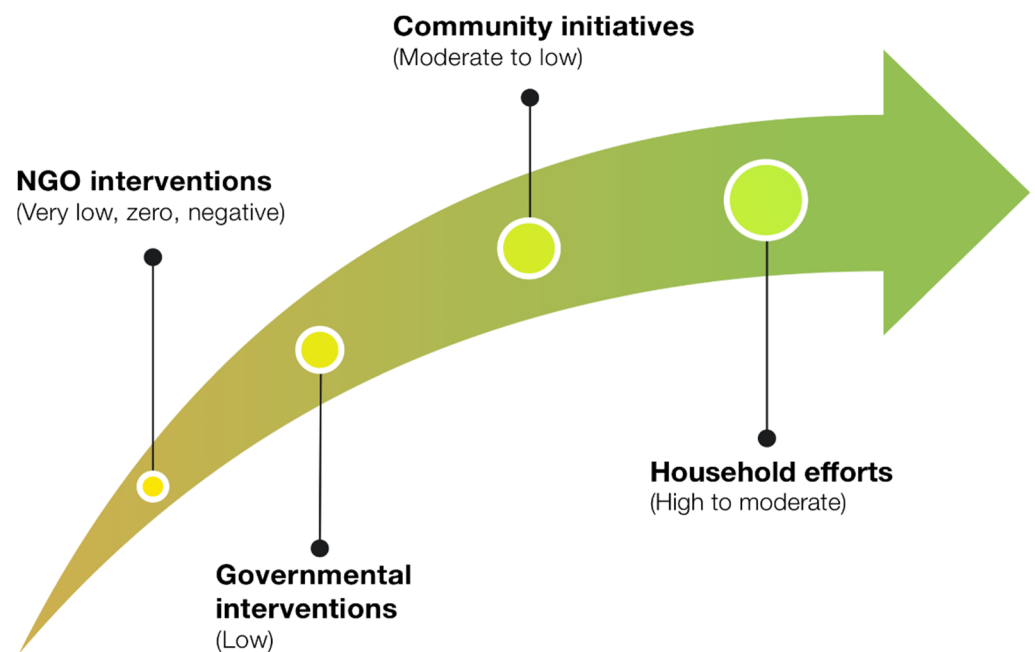


Figure 2. Resilience gradient in shrimp aquaculture in Bangladesh.

8. Conclusions and Recommendations

It is obvious that since Bangladesh is at the receiving end of global climate disasters, the only viable option for it is to devise adaptive measures in response to those disasters. People living in coastal ecosystems have just three options for adaptive response to climate shocks and variability: protection, accommodation, and retreat [74–78]. Since ‘protection’ through construction and maintenance of coastal infrastructure and ‘retreat’ through emigration from the whole area (at least 25 million people would need to evacuate from the exposed coastal areas in Bangladesh) are neither within reach nor feasible for the local communities, the coastal shrimp farmers in Bangladesh have the only option to accommodate by reducing sensitivity and enhancing their own adaptive capacity in order to offset the negative impacts of climate change on the shrimp sector. Through effective resilience efforts at local and community levels, Bangladesh can minimize the loss from the brunt of global climate change. Shrimp farming communities in coastal Bangladesh have their own adaptive and resilience mechanisms through which they fight against and cope with environmental and climate hazards in order to have a sustainable shrimp industry.

It is evident that the shrimp farming community in Bangladesh does not receive sufficient outside assistance in order to build community-level resilience. Right through the history, the people of Bangladesh have shown their guts and innovative intelligence in fighting against all odds and wrath of nature. Since the first human settlement in the Sundarbans region by Chand Sadagar around 200–300 AD [66], the ever-fighting people are always coping with the harsh and dynamic natural environment. As part of their coping schemes, they introduced shrimp culture in the area. Now, since the sustainability and existence of shrimp are in question due to human-induced global warming, the local stakeholders are devising their specific strategies with more or less success on trial-and-error basis. It is likely that alternative development interventions can secure people’s resilience and promote a future generation that will be able to cope with climate change extremes and variability.

This study is motivated by a concern for understanding how the use of community capitals and institutional interventions shape the actions that create and enhance resilience of the shrimping community to ongoing climate crisis. Resilience to climate change is an intricate subject that presents a number of challenges. This entails a process of viable adjustment in response to new and shifting environmental scenarios. Therefore, resilience

of shrimp industry cannot be treated as a standalone issue and the future pathways should be directed by institutional and policy measures. The study recommends the followings:

- *Introduction of shrimp insurance:* The whole shrimp industry needs to be brought under public and private insurance schemes so that the farmers can have financial compensations in case of damage or loss of production due to adverse climate conditions or hazards.
- *Increased technical assistance:* The DoF should provide shrimp farmers with technical assistance including salinity and pH tests of soil and water, and diagnosis of disease in shrimps. Increased technical assistance could enhance the production of shrimp.
- *Aiding capacity enhancement:* The UFOs should aid shrimp farmers and local traders with trainings and workshop sessions for capacity enhancement. The workshops and trainings should be on a variety of sustainable shrimp cultivation related topics such as enhancement of shrimp production, use of new technology and scientific methods, gher preparation, hatchery (or nursery) operation, disease control, gher management, harvesting and post-harvesting works, processing, etc. In addition, farmers and other local stakeholders should be trained on how to cope with and adapt to sudden weather shocks and gradual climate shifts. Currently, farmers do not receive any systematic training on climate hazards from public or non-governmental organizations. Various awareness building workshops should be arranged.
- *Increased financial and inputs support:* In order to enhance the economic capital of the farming people, public and private institutions should offer more financial and inputs support to the shrimp-farming communities. Financial supports could be in the form of direct sanctioning of loans, helping the farmers in receiving loans from banks, offering grants, and awards. Financial supports need to be provided at the start of the season and immediately after a sudden disaster. More inputs support in the form of feed, seeds, equipment, and fertilizer need to be provided.
- *Implementation of the national shrimp policy:* Although the National Shrimp Policy 2014 adopts a top-down technical approach with substantial drawbacks and it puts little emphasis on enhancing community capacity to build resilience from within to weather shocks and climate change in the shrimp culture zone, full-fledged implementation of the Policy could support shrimp farming in a number of ways.
- *Integrated coastal management:* The adaptation approach in the coastal saline zone should be embedded in an integrated coastal management framework that seeks out win-win situations. In order to avoid land-use conflicts between different sectors, including agriculture, aquaculture, and forestry, and to enhance the ability of the coastal communities to respond to the impacts of environmental and climate stressors, the land zoning scheme proposed by the Ministry of Land in 2011 should be implemented.
- *Avoidance of maladaptation:* In addressing large-scale coastal problems like salinity intrusion, cyclones, and storm surges in order to support shrimp and non-shrimp livelihoods, planned interventions from the Bangladesh Government is required. However, policy makers, local-level implanting authorities, and members of society should be attentive about maladaptation, in which adaptation programs benefit one group or sector of the society at the expense of increasing the risk to another group or sector (see, Barnett and O'Neill [78]).
- *Public funding in research and monitoring:* A significant increase in public funding in research and monitoring the changing trends in climate in the country and in the region is required.
- *Increased positive role of NGOs:* Environmental NGOs should keep the local ecosystems context in mind and advocate for pro-shrimp campaigns in the brackish-water zone.
- *International collaboration in controlling global warming:* In order to make Bangladesh less vulnerable to anthropogenic climate crisis, the Bangladesh Government should take more initiatives for effective collaboration with countries with similar interests for jointly dealing with the climate change impacts and implement adaptation strategies.

- *International negotiations for binding emissions targets:* The Bangladesh Government should support strong, binding GHG emissions reduction targets for developed countries so that the Bangladeshi people face a lesser amount of climate vulnerability.
- *Ensuring fair share for climate change adaptation for Bangladesh:* Since the current regime of anthropogenic climate change is mostly caused by the developed nations, the Bangladesh Government should strongly claim fair share of climate change adaptation costs from the emitters. In international negotiations Bangladesh can advocate for a ‘polluters pay principle’.

Author Contributions: Conceptualization, S.M.K. and M.S.I.; formal analysis, S.M.K. and M.S.I.; funding acquisition, M.S.I.; investigation, S.M.K. and M.S.I.; methodology, S.M.K. and M.S.I.; project administration, S.M.K.; supervision, M.S.I.; writing—original draft, S.M.K.; writing—review and editing, S.M.K. and M.S.I. All authors have read and agreed to the published version of the manuscript, and claim equal authorship.

Funding: This research was partly funded by a Tier-1 grant from the Ministry of Education, Singapore (Grant No. RG67/18).

Institutional Review Board Statement: Ethical review and approval were waived for this study as no ethical issue or concern related to human subjects and other species was reported.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to some privacy issues.

Acknowledgments: The authors thank the reviewers for their thoughtful comments and suggestions that significantly improved the structure and quality of this paper. They also thank Rawsab Said for designing the Figure 1.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Brander, K.M. Global fish production and climate change. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 19709–19714. [[CrossRef](#)]
2. Handisyde, N.T.; Ross, L.G.; Badjeck, M.-C.; Allison, E.H. *The Effects of Climate Change on World Aquaculture: A Global Perspective*; Final Technical Report, DFID Aquaculture and Fish Genetics Research Programme; Stirling Institute of Aquaculture: Stirling, UK, 2006.
3. De Silva, S.S.; Soto, D. Climate change and aquaculture: Potential impacts, adaptation and mitigation. In *Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge*; Cochrane, C.K., De Young, D.S., Bahri, T., Eds.; FAO Fisheries and Aquaculture Technical Paper No. 530; FAO: Rome, Italy, 2009; pp. 151–212.
4. Chand, B.K.; Trivedi, R.K.; Dubey, S.K.; Beg, M.M. *Aquaculture in Changing Climate of Sundarban: Survey Report on Climate Change Vulnerabilities, Aquaculture Practices & Coping Measures in Sagar and Basanti Blocks of Indian Sundarban*; West Bengal University of Animal & Fishery Sciences: Kolkata, India, 2012.
5. FAO (The UN Food and Agricultural Organization). *The State of World Fisheries and Aquaculture 2018: Meeting the Sustainable Development Goals*; FAO: Rome, Italy, 2018.
6. FAO (The UN Food and Agricultural Organization). *The State of World Fisheries and Aquaculture 2020: Sustainability in Action*; FAO: Rome, Italy, 2020.
7. Cutter, S.L. The landscape of disaster resilience indicators in the USA. *Nat. Hazards* **2016**, *80*, 741–758. [[CrossRef](#)]
8. Cutter, S.L.; Barnes, L.; Berry, M.; Burton, C.; Evans, E.; Tate, E.; Webb, J. A place-Based model for understanding community resilience to natural disasters. *Glob. Environ. Chang.* **2008**, *18*, 598–606. [[CrossRef](#)]
9. Reid, R.; Botterill, L.C. The Multiple Meanings of ‘Resilience’: An Overview of the Literature. *Aust. J. Public Adm.* **2013**, *72*, 31–40. [[CrossRef](#)]
10. Rose, A. Defining and measuring economic resilience to disasters. *Disaster Prev. Manag.* **2004**, *13*, 307–314. [[CrossRef](#)]
11. Rose, A. Economic resilience to natural and man-made disasters: Multidisciplinary origins and contextual dimensions. *Environ. Hazards* **2007**, *7*, 383–398. [[CrossRef](#)]
12. Cimellaro, G.P.; Renschler, C.; Reinhorn, A.M.; Arendt, L. PEOPLES: A framework for evaluating resilience. *J. Struct. Eng.* **2016**, *142*, 04016063. [[CrossRef](#)]
13. Kais, S.M.; Islam, M.S. Community Capitals as Community Resilience to Climate Change: Conceptual Connections. *Int. J. Environ. Res. Public Health* **2016**, *13*, 1211. [[CrossRef](#)] [[PubMed](#)]
14. Hoque, M.Z.S.; Cui, X.; Lilai, I.; Islam, G.; Ali, G.; Tang, J. Resilience of coastal communities to climate change in Bangladesh: Research gaps and future directions. *Watershed Ecol. Environ.* **2019**, *1*, 42–56. [[CrossRef](#)]

15. Kais, S.M.; Islam, M.S. Impacts of and resilience to climate change at the bottom of the shrimp commodity chain in Bangladesh: A preliminary investigation. *Aquaculture* **2018**, *493*, 406–415. [CrossRef]
16. Kais, S.M. Climate Change: Vulnerability and Resilience in Commercial Shrimp Aquaculture in Bangladesh. In *Environmental Sustainability and Climate Change Adaptation Strategies*; Wayne, G., Wendy-Ann, I., Eds.; IGI Global: Hershey, PA, USA, 2017; pp. 162–187. [CrossRef]
17. Ahmed, N. Linking prawn and shrimp farming towards a green economy in Bangladesh: Confronting climate change. *Ocean Coast. Manag.* **2013**, *75*, 33–42. [CrossRef]
18. Ahmed, N. Coastal Aquaculture must adapt to Climate Change in Bangladesh. *Glob. Aquac. Advocate* **2015**, *2015*, 42–43.
19. Ahmed, N.; Glaser, M. Can Integrated Multi-Trophic Aquaculture (IMTA) adapt to climate change in coastal Bangladesh? *Ocean Coast. Manag.* **2016**, *132*, 120–131. [CrossRef]
20. Ahmed, N.; Thompson, S.; Glaser, M. Integrated mangrove-shrimp cultivation: Potential for blue carbon sequestration. *Ambio* **2018**, *47*, 441–452. [CrossRef] [PubMed]
21. Ahmed, N.; Thompson, S.; Glaser, M. Global Aquaculture Productivity, Environmental Sustainability, and Climate Change Adaptability. *Environ. Manag.* **2019**, *63*, 159–172. [CrossRef] [PubMed]
22. Ahmed, N.; Glaser, M. Coastal aquaculture, mangrove deforestation and blue carbon emissions: Is REDD+ a solution? *Mar. Policy* **2016**, *66*, 58–66. [CrossRef]
23. Pokrant, B.; Reeves, P. Work and labour in the Bangladesh brackish water shrimp export sector. *J. South Asian Stud.* **2003**, *26*, 359–389. [CrossRef]
24. Islam, M.S. From pond to plate: Towards a twin-driven commodity chain in Bangladesh shrimp aquaculture. *Food Policy* **2008**, *33*, 209–223. [CrossRef]
25. GED (General Economics Division). *Bangladesh Delta Plan 2100: Abridged Version*; GED, Bangladesh Planning Commission: Dhaka, Bangladesh, 2018.
26. Nath, S.; van Laerhoven, F.; Driessen, P.; Nadiruzzaman, M. Capital, rules or conflict? Factors affecting livelihood-strategies, infrastructure-resilience, and livelihood vulnerability in the polders of Bangladesh. *Sustain. Sci.* **2020**, *15*, 1169–1183. [CrossRef]
27. Allen, M. *The SAGE Encyclopedia of Communication Research Methods*; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2017. [CrossRef]
28. Kais, S.M.; Islam, M.S. Perception of Climate Change in Shrimp-Farming Communities in Bangladesh: A Critical Assessment. *Int. J. Environ. Res. Public Health* **2019**, *16*, 672. [CrossRef]
29. Roy, S.; Rahman, M.M.; Sarkar, S.N.; Mondal, B. *Training Manual on Improved Shrimp Culture in Gher*; WorldFish Centre: Dhaka, Bangladesh, 2011.
30. Adger, W.N.; Kelly, P.M. Social Vulnerability to Climate Change and the Architecture of Entitlements. *Mitig. Adapt. Strateg. Glob. Chang.* **1999**, *4*, 253–266. [CrossRef]
31. Nguyen, M.C.; Wodon, Q. Coping and adaptation. In *Climate Change Adaptation and Social Resilience in the Sundarbans*; O'Donnell, A., Wodon, Q., Eds.; Routledge: London, UK, 2015; pp. 107–122.
32. UN (United Nations Organization). *Cyclone Aila: Joint UN Multi-sector Assessment & Response Framework*; UN: New York, NY, USA, 2010; Available online: http://www.lcgbangladesh.org/derweb/Needs%20Assessment/Reports/Aila_UN_AssessmentFramework_FINAL.pdf (accessed on 5 March 2016).
33. Wodon, Q. Focus of the study and data. In *Climate Change Adaptation and Social Resilience in the Sundarbans*; O'Donnell, A., Wodon, Q., Eds.; Routledge: London, UK, 2015; pp. 35–64.
34. Ellis, F. *Rural Livelihoods and Diversity in Developing Countries*; Oxford University Press: New York, NY, USA, 2000.
35. Roy, P. Coastal Bangladesh Turns Too Salty for Salt-Tolerant Rice. *Thethirdpole.net*. 2014. Available online: <http://www.thethirdpole.net/2014/12/08/coastal-bangladesh-turns-too-salty-for-salt-tolerant-rice/> (accessed on 12 February 2016).
36. Islam, M.R.; Rahman, M.S.; Salam, M.A. Coastal saline environment and rice variety development in Bangladesh. *Eco-Friendly Agric. J.* **2008**, *1*, 37–47.
37. Barnett, J.; Webber, M. *Accommodating Migration to Promote Adaptation to Climate Change*; Secretariat of the Commission on Climate Change and Development: Stockholm, Sweden, 2009.
38. Scheffran, J.; Marmer, E.; Sow, P. Migration as a contribution to resilience and innovation in climate adaptation: Social networks and co-development in Northwest Africa. *Appl. Geogr.* **2012**, *33*, 119–127. [CrossRef]
39. World Bank Group. *Economics of Adaptation to Climate Change: Bangladesh*; The World Bank Group: Washington, DC, USA, 2010.
40. Nelson, D.R.; Adger, W.N.; Katrina, B. Adaptation to environmental change: Contributions of a resilience framework. *Annu. Rev. Environ. Resour.* **2007**, *32*, 395–419. [CrossRef]
41. Pelling, M.; High, C. Understanding adaptation: What can social capital offer assessments of adaptive capacity? *Glob. Environ. Chang.* **2005**, *15*, 308–319. [CrossRef]
42. Magis, K. Community Resilience: An Indicator of Social Sustainability. *Soc. Nat. Resour.* **2010**, *23*, 401–416. [CrossRef]
43. McCrea, R.; Walton, A.; Leonard, W. A conceptual framework for investigating community wellbeing and resilience. *Rural Soc.* **2014**, *23*, 270–282. [CrossRef]
44. Murphy, B.L. Locating social capital in resilient community-level emergency management. *Nat. Hazards* **2007**, *41*, 297–315. [CrossRef]

45. Norris, F.H.; Susan, S.P.; Pfefferbaum, B.; Wyche, K.F.; Pfefferbaum, R.L. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *Am. J. Community Psychol.* **2008**, *41*, 127–150. [[CrossRef](#)]
46. Poortinga, W. Community resilience and health: The role of bonding, bridging, and linking aspects of social capital. *Health Place* **2012**, *18*, 286–295. [[CrossRef](#)]
47. Sherrieb, K.; Norris, F.H.; Galea, S. Measuring Capacities for Community Resilience. *Soc. Indic. Res.* **2010**, *99*, 227–247. [[CrossRef](#)]
48. Ungar, M. Community resilience for youth and families: Facilitative physical and social capital in contexts of adversity. *Child. Youth Serv. Rev.* **2011**, *33*, 1742–1748. [[CrossRef](#)]
49. Wilson, G.A. Community resilience, globalization, and transitional pathways of decision-making. *Geoforum* **2012**, *43*, 1218–1231. [[CrossRef](#)]
50. Wilson, G.A. Community resilience, policy corridors and the policy challenge. *Land Use Policy* **2013**, *31*, 298–310. [[CrossRef](#)]
51. DFID (Department for International Development). *Sustainable Livelihoods Guidance Sheets*; DFID: London, UK, 1999.
52. Crooks, S.; Herr, D.; Tamelander, J.; Laffoley, D.; Vandever, J. *Mitigating Climate Change through Restoration and Management of Coastal Wetlands and Near-shore Marine Ecosystems: Challenges and Opportunities*; Environment Department Paper 121; World Bank: Washington, DC, USA, 2011.
53. Beggs, J.J.; Haines, V.A.; Hurlbert, J.S. Situational contingencies surrounding the receipt of informal support. *Soc. Forces* **1996**, *75*, 201–222. [[CrossRef](#)]
54. Greene, R.R.; Galambos, C.; Lee, Y. Resilience Theory: Theoretical and Professional Conceptualizations. *J. Hum. Behav. Soc. Environ.* **2003**, *8*, 75–91. [[CrossRef](#)]
55. Coleman, J.S. Social Capital in the Creation of Human Capital. *Am. J. Sociol.* **1988**, *94*, S95–S120. [[CrossRef](#)]
56. Putnam, R.D. Bowling alone: America's declining social capital. *J. Democr.* **1995**, *6*, 65–78. [[CrossRef](#)]
57. Smith, J.W.; Anderson, D.H.; Moore, R.L. Social Capital, Place Meanings, and Perceived Resilience to Climate Change. *Rural Sociol.* **2012**, *77*, 380–407. [[CrossRef](#)]
58. Mozumdar, L.; Ali, R.N.; Farid, K.S.; Kabir, M.S. Changing leadership and rural power structure. *J. Bangladesh Agric. Univ.* **2008**, *6*, 429–436. [[CrossRef](#)]
59. Lewis, D.; Hossain, A. *Understanding the Local Power Structure in Rural Bangladesh*; Sida: Stockholm, Sweden, 2008.
60. Ahmed, M.B. *Shrimp Farming: Impact on Socio-Economic, Agriculture and Environmental Conditions in the South-Western Coastal Region of Bangladesh*; LAMBERT Academic Publishing: Saarbrücken, Germany, 2011.
61. von Rueden, C.; van Vugt, M. Leadership in small-scale societies: Some implications for theory, research, and practice. *Leadersh. Q.* **2015**, *26*, 978–990. [[CrossRef](#)]
62. Weber, M. *Economy and Society*; Bedminster Press: Bedminster, NJ, USA, 1968.
63. Ritzer, G. *Classical Sociological Theory*; The McGraw-Hill Companies, Inc.: New York, NY, USA, 1996.
64. Barber, B. *The Logic and Limits of Trust*; Rutgers University Press: New Brunswick, NJ, USA, 1983.
65. Stern, M.J.; Baird, T. Trust ecology and the resilience of natural resource management institutions. *Ecol. Soc.* **2015**, *20*, 14. [[CrossRef](#)]
66. Martin, C.; O'Donnell, A.; Joseph, G.; Wodon, Q. Three approaches to climate change adaptation. In *Climate Change Adaptation and Social Resilience in the Sundarbans*; O'Donnell, A., Wodon, Q., Eds.; Routledge: London, UK, 2015; pp. 9–34.
67. Adger, W.N. Social Capital, Collective Action, and Adaptation to Climate Change. *Econ. Geogr.* **2003**, *79*, 387–404. [[CrossRef](#)]
68. MoWR (Ministry of Water Resources). *Coastal Zone Policy 2005*; MoWR, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2005.
69. MoFL (Ministry of Fisheries and Livestock). *National Shrimp Policy 2014*; MoFL, Government of the People's Republic of Bangladesh: Dhaka, Bangladesh, 2014. (In Bangla)
70. Islam, M.S. The Role of NGOs in Promoting Christianity: The Case of Bangladesh. *Intellect. Discourse* **2001**, *9*, 183–202.
71. DFID (Department for International Development). *Partners in Development: A Review of Big NGOs in Bangladesh*; DFID Bangladesh: Dhaka, Bangladesh, 2000.
72. Lewis, D. Disciplined Activists, Unruly Brokers: Exploring the Boundaries between Non-Governmental Organizations (NGOs), Donors, and the State in Bangladesh. In *Varieties of Activist Experience: Civil Society in South Asia*; David, N.G., Ed.; Sage: New Delhi, India, 2010; pp. 159–180.
73. Farzana, S.; Hossain, M.U. *Climate Change Impacts on Shrimp Farming: Climate Change Impacts on Shrimp Farming in the Coastal Areas of Bangladesh*; LAMBERT Academic Publishing: Saarbrücken, Germany, 2015.
74. Klein, R.J.T.; Nicholls, R.J.; Ragoonaden, S.; Capobianco, M.; Aston, J.; Buckley, E.N. Technological options for adaptation to climate change in coastal zones. *J. Coast. Res.* **2001**, *17*, 531–543.
75. Sterr, H. Assessment of vulnerability and adaptation to sea-level rise for the coastal zone of Germany. *J. Coast. Res.* **2008**, *24*, 380–393. [[CrossRef](#)]
76. Tol, R.S.; Klein, R.J.; Nicholls, R.J. Towards successful adaptation to sea-level rise along Europe's coast. *J. Coast. Res.* **2008**, *24*, 432–442. [[CrossRef](#)]
77. Saroar, M.M.; Routray, J.K. Climate Refugee' is Not a Hoax. But We can Avoid it. Empirical Evidence from the Bangladesh Coast. In *Climate Change Adaptation in Practice: From Strategy Development to Implementation*; Schimdt-Thome, P., Klein, J., Eds.; John Wiley and Sons Ltd.: Chichester, UK, 2013; pp. 283–301.
78. Barnett, J.; O'Neil, S. Maladaptation. *Glob. Environ. Chang.* **2010**, *20*, 211–213. [[CrossRef](#)]