

Article

Implications of Flood Risk Reduction Interventions on Community Resilience: An Assessment of Community Perception in Bangladesh

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Abstract: Bangladesh, a flat densely populated country in a dynamic delta, is vulnerable to recurring flood disasters. Various types of structural and non-structural flood risk reduction interventions have been implemented over the years to safeguard the people and assets. In that context, the present study assesses the community perception about the implications of such diverse interventions on community resilience, in three reasonably proximate settlements, with varying characteristics: the Type 1 settlement has a flood protection embankment; the Type 2 settlement has no flood risk reduction intervention, and the Type 3 settlement has non-structural interventions. Through a mixed-method assessment in selected settlements, the study results reveal both positive and negative implications of these interventions on local communities. While the embankment has contributed towards enhancing infrastructural resilience in the Type 1 settlement, it still reportedly does not provide complete flood safety. On the other hand, the non-structural measures are reported to have increased community competencies in the Type 3 settlement, but the long-term sustainability of these traits is uncertain. Furthermore, the study results uncover “connectedness among local communities” as an inherent characteristic in all three locations, whereas flood risk reduction interventions are stated to be partly associated with social tension and the marginalization of certain socio-economic groups.

Keywords: flood risk reduction; community resilience; community perception; Bangladesh



Citation: Ansari, M.S.; Warner, J.; Sukhwani, V.; Shaw, R. Implications of Flood Risk Reduction Interventions on Community Resilience: An Assessment of Community Perception in Bangladesh. *Climate* **2022**, *10*, 20. <https://doi.org/10.3390/cli10020020>

Academic Editor: Salvatore Magazù

Received: 29 December 2021

Accepted: 3 February 2022

Published: 6 February 2022

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1. Introduction

Flood disasters are widely recognized to be the most frequent and widespread of all disasters worldwide, causing substantial damage to human societies. Floods, generally, refer to the overspill of water due to a combination of meteorological and hydrological extremes, which submerges the usually dry lands. In the wake of growing population, rapid urbanization and a changing climate, the exposure to floods has considerably increased over the years, particularly in coastal areas characterized by high population density and economic assets [1]. With the impact of climate change associated with subsidence and sea level rise, the global annual flood losses are also projected to increase significantly in future [2]. To counter the growing frequency and intensity of flood disasters, a variety of flood protection and management measures have been employed worldwide, which can primarily be categorized into structural or non-structural interventions. The structural interventions (in the forms of dikes, dams and flood control reservoirs) are often the preferred solution for minimizing the potential impacts of flood hazards; however, the need for high investments often constrains their implementation, particularly in low and middle-income countries. Due to these reasons, non-structural interventions (in the form

of applying knowledge, laws or policies) are also gaining high prominence for reducing flood risks and its impacts worldwide [2,3].

Being exposed to a low-lying delta, the people of Bangladesh have traditionally experienced high-frequency, low-magnitude and low-frequency, high-magnitude floods [4,5]. Herein, the increasing population density along the low-lying geographical locations, in the delta of three major rivers, has progressively increased the vulnerability of the local population to different disasters, mainly in the form of floods [6]. The flood disasters, in particular, are also considered to be a major threat to the development of Bangladesh [4,7–9]. The floods disaster events in 1974, 1984, 1987, 1988, 1991, 1998, 2000, 2004, 2007, etc. have demonstrated the restlessness of hundreds of rivers within Bangladesh, most of which are of foreign origin. Apart from the deltaic nature of the country, the climate variability and its consequences are also intensifying the situation [10].

According to the IPCC [11], the increased volume of rainfall, due to climate variability in the past decades, has intensified the flood-related problems, having both direct and indirect impacts on the affected communities. While the immediate and direct impacts include mortality, morbidity and the destruction of critical assets such as housing, schools, hospitals, transport infrastructure and businesses, the indirect or long-term impacts on lives and livelihoods, also referred to as “losses”, affect the pace and the nature of socio-economic development [12].

To mitigate the impacts of flood disasters, a variety of structural (hard actions such as embankments) and non-structural (soft actions such as precautionary actions, land use planning, awareness raising/flood risk management) measures have, so far, been implemented by the government and non-governmental organizations (NGOs) in Bangladesh. Correspondingly, flood experts have for long underlined the potential scenarios of residual risks due to various types of interventions (e.g., embankment/dike collapse), alongside the certain benefits associated with floods, such as irrigation, fishing and flushing the soil [13]. Consequently, the state-led physical interventions in Bangladesh were not only planned for physical flood safety, but also to enable the intensification of agricultural production in flood-prone areas, such as through the introduction of high-yield varieties for achieving food security. The creation of polders through the construction of embankments has today intensified the crop production in the coastal areas of Bangladesh while reducing the adverse consequences due to storm surge and fluvio-tidal flood events [14].

Non-structural measures, on the other hand, represent the inherent strengths of the local communities, including people’s wisdom, knowledge, and traditional institutions, to live with flood [15,16]. In Bangladesh, NGOs have continually been working to enhance the coping capacities of vulnerable communities through various disaster risk reduction (DRR) and resilience interventions [1]. These interventions envision the reduction of flood disaster impacts by enhancing the coping (short-term) and adaptive (longer-term) capacity of the communities to deal with environmental risks and vulnerabilities. Herein, the notion of “resilience” refers to those capacities that provide confidence and adequate strength to vulnerable people to withstand the impacts of a flood disaster before, during and after the event, while helping them to return to their normal lives [17–21].

Brammer [22] emphasizes that the key objective of flood control projects in Bangladesh (after the 1960s) still has not been achieved, as the people remain as vulnerable as before. The flood protection engineering measures (i.e., levees, dikes, polders, embankments, etc.) in river deltas and coastal areas have, on the contrary, created challenges for river flow, siltation in water channels and proper drainage while increasing the chances of water logging, polder breach, land subsidence, etc. [16,23]. While the impact evaluation of these varying DRR interventions has thus far largely been based on technological and agricultural improvements, the social implications of these flood control projects have been mostly overlooked in the evaluation reports [15,24,25]. With the aim of bridging this research gap, the present study investigates how the variety of structural and non-structural flood risk reduction measures in Bangladesh have contributed towards enhancing the resilience of flood-vulnerable communities. Particularly, three specific and reasonably proximate

settlements (associated with various DRR structural and non-structural measures) have been taken into consideration to derive cross-case lessons. In doing so, the key purpose of this research is to enhance the grassroots-level understanding of the implications of various DRR interventions on community resilience.

Broadly, this manuscript comprises five sections, including the Introduction (Section 1). Section 2 provides a precise description of the adopted research methods, after establishing the conceptual framework and introducing the case study area. Section 3 presents the study results, which is then followed by a wider discussion in Section 4. Lastly, Section 5 summarizes the key conclusions and research limitations.

2. Materials and Methods

2.1. Conceptual Framework of DROP

To study the implications of various DRR measures on the resilience of local communities in Bangladesh, this study adopts the approach of the “Disaster Resilience of Place” (DROP) model, initially proposed by Cutter et al. [26]. The DROP model recognizes six core dimensions of resilience, namely infrastructural, institutional, social, financial, ecological and community competency. Amongst these, the ecological aspect of resilience has been excluded in the current research, as the performance of laboratory experiments to determine the status of ecological resilience indicators falls beyond its scope. Furthermore, while the indicators of resilience dimensions under the DROP model are mainly analyzed in quantitative form, this research contextualizes them in such a way that they can be used for deriving both quantitative and qualitative information from the field. For the better comprehension of readers, a precise description of the adopted resilience dimensions in the context of present research is provided below, while Table 1 highlights the associated indicators.

Table 1. Indicators associated with different resilience dimensions (adopted from [26]).

Resilience Dimensions	Key Indicators Studied
Infrastructural	<ul style="list-style-type: none"> • Existence of flood protection embankment and its maintenance • Small-scale DRR structural measures including plinth raising
Institutional	<ul style="list-style-type: none"> • Existence of disaster management committee (DMC) in communities • Functionality of DMC in terms of flood preparedness, search and rescue, relief distribution • Contribution of local government institutions to flood preparedness and recovery through service delivery • Availability of support from external agencies for flood preparedness and recovery
Community competence	<ul style="list-style-type: none"> • Flood preparedness awareness, early warning, etc. • Volunteers in disaster preparedness and response-related training • Family/individual level preparedness plan • Connections with NGOs/government/external partners
Social	<ul style="list-style-type: none"> • Social network, connectedness among families living together • Social consequences of flood risk reduction actions • Political aspects of the community
Financial	<ul style="list-style-type: none"> • Monthly average income of the population • Primary and secondary source of income • Access to loans for preparedness and recovery

1. Infrastructural resilience mainly relates to the existence and consequences of flood control/protection embankments, such as riverbank erosion protection structures and small-scale household infrastructures, including the raising of the plinth level.
2. Institutional resilience mainly relates to the existing disaster-related legislations, institutions and community groups that support the vulnerable communities in responding to and recovering from the impacts of disasters.
3. Community competence mainly assesses how well the vulnerable communities understand the potential risks of disaster and their level of preparedness. For instance, their knowledge of disaster warnings and awareness about legal obligations.

4. Social resilience is more focused on the socio-political dimensions, including education status, gender and political influence in the communities.
5. Financial resilience captures the information about income sources and the availability of financial assistance from external sources to recover from disasters.

2.2. Study Area

This research focuses on three specific settlements in Bangladesh, wherein different types of flood risk reduction interventions have been implemented by the government agencies and NGOs. Two of these villages are situated in the Tangail Sadar Upazila under Tangail District [2] (location shown in Figure 1), amongst which one area is protected by the flood protection embankment and the other does not have any intervention. The third settlement is situated in the Islampur Upazila of Jamalpur District (location shown in Figure 1), where different NGOs have implemented resilience-building interventions.

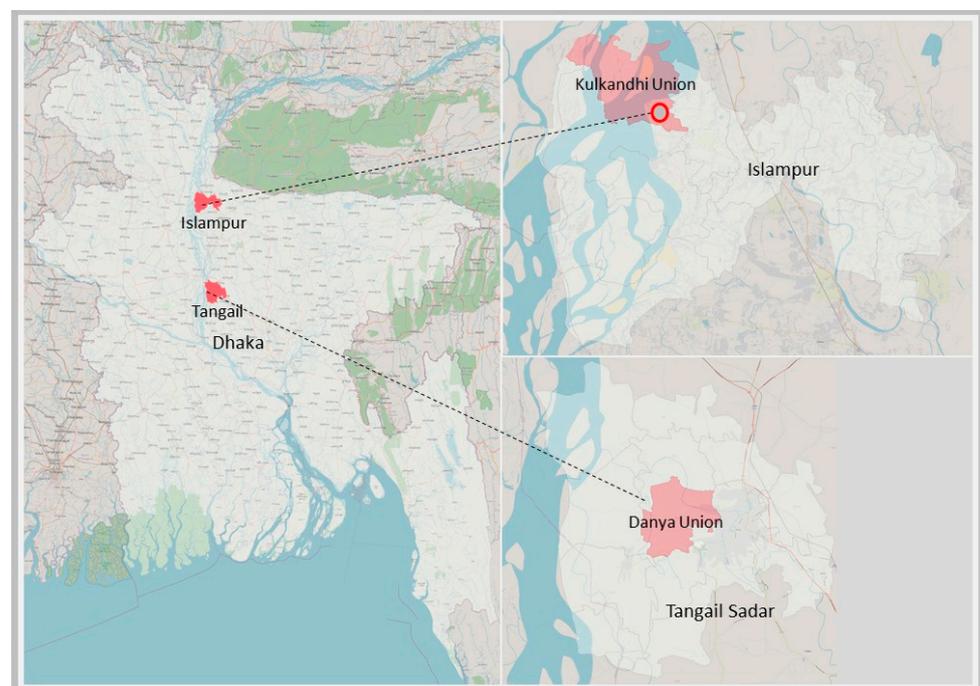


Figure 1. Location map of the study areas; The Danya Union of Tangail Sadar Upazila, Tangail District and Kulkandi Union under Islampur Upazila, Jamalpu District (Background image source: Openstreet). Herein, the Union, Upazila and District represent respectively the fourth, third and second administrative layer of the government of Bangladesh.

These specific study locations were identified through expert consultations in Bangladesh, which were based on three specific criteria: (1) identifying settlements vulnerable to floods, (2) identifying diverse settlements located at the bank/near a major river or its tributaries and (3) identifying settlements where different types of structural and non-structural flood risk reduction measures have been implemented. The precise characteristics of each of the three selected settlements are described in the following subsections.

2.2.1. Type 1 Settlement: Fatepur: Area with Structural DRR/Flood Protection Embankment

Fatepur, situated under Tangail District, is surrounded by a flood protection embankment which was constructed under the Compartmentalization Pilot Project (CPP) of the Flood Action Plan (known as FAP-20) during 1990–1995. The objective of this structural intervention was to secure infrastructural development and to intensify the agricultural production in the region to comply with the food security agenda of the government of Bangladesh [27] (Figure 2). However, according to Warner [28], FAP was widely criticized

by the local people and activists due to its negative impact on landless and fishing people in the project area and the dwellers of adjoining areas. The project is stated to be implemented without any clear perspectives of technical viability, operation, and future maintenance [29]. While a few micro-credit organizations have also implemented credit projects here, no other specific DRR interventions (apart from the embankment) are reported in this area.

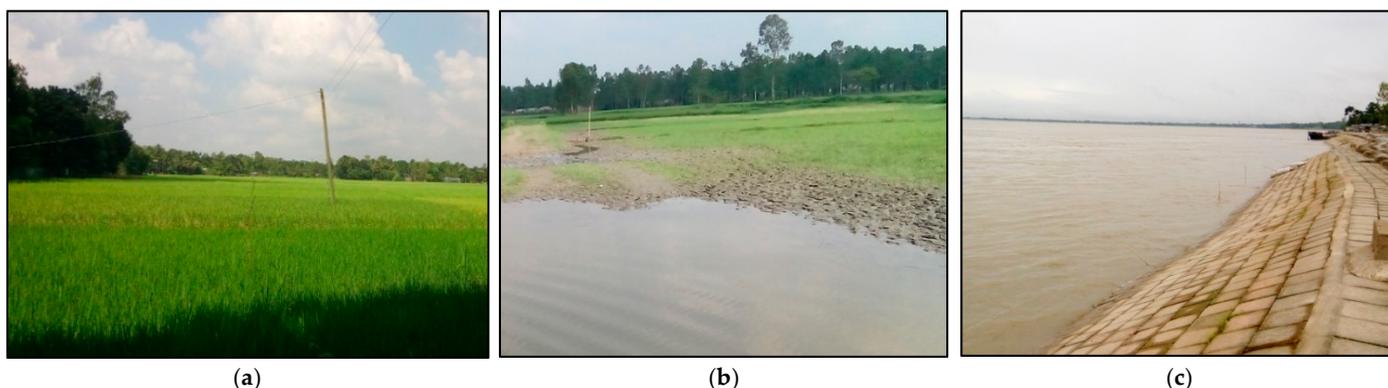


Figure 2. (a) Fatepur village; (b) Char Fatepur village; (c) Kulkandi village (Source: Authors).

2.2.2. Type 2 Settlement: Char Fatepur: Area without Any DRR Measures

Char Fatepur, also situated in Tangail District, is located outside of the flood protection embankment, and is exposed to flooding through the river Jamuna (Figure 2). During the monsoon season, this area usually becomes isolated from the mainland, and boats are the only way to reach the village. The people of this area have experienced flood with varying intensity and severity on a regular basis. No specific DRR interventions are reported here for flood risk reduction measures. However, the local residents do receive emergency relief support after floods with the opportunity to access loans from credit organizations.

2.2.3. Type 3 Settlement: Kulkandi: Area with Non-Structural and Minimal Structural Measures

Kulkandi is located besides the river Jamuna in Islampur Upazila, under the Jamalpur District of North-Central part of Bangladesh (Figure 2). The inhabitants of this area have experienced floods of varying intensity on different occasions. Various DRR interventions have been implemented here by several national and international NGOs, including CARE and Bangladesh Red Crescent Society (BDRCS). The major activities implemented under these projects include flood awareness campaigns, development of local institutions and disaster management plans, formation and strengthening of local disaster management committees, livelihood support and small-scale infrastructural measures (i.e., plinth raising). Furthermore, the presence of credit organizations is also reported in this area.

2.3. Research Methods

Based on the adopted resilience dimensions, this study follows a mixed-method approach to collect relevant qualitative and quantitative data from the three defined study locations. The data collection was mainly initiated after the floods in November 2017, and the process continued until the end of 2018. The following sub-sections describe the three specific methods of primary data collection adopted for this research.

2.3.1. Focus Group Discussion (FGD)

A total of 9 FGDs (3 each in 3 selected study locations) were conducted with the local community members (with mixed representation of different gender and occupation groups), wherein an average of 12 participants attended in each session. To keep the findings harmonized as well as to facilitate a comparative analysis of different settlements,

a standard checklist, with a few guiding questions, was used during the FGDs, which was developed in alignment with the resilience indicators (as shown in Table 1).

The key points of discussion during the FGDs included the consequences of structural flood protection measures (i.e., infrastructural resilience), impact of DRR/resilience building interventions, community disaster management (CDM) groups and associated functionality (i.e., Institutional resilience), risk assessment capacity, localized capacity on disaster management and relief distribution, flood preparedness and survival strategies (i.e., community competency), political interferences, social aspects of floods (i.e., social resilience), income sources and external support (i.e., financial and institutional resilience). Emphasis was placed on realizing free-flow and interactive discussions wherein the participants could also raise counter questions and debate amongst themselves. To ensure clarity on the statements and explanations, the FGDs were moderated by probing/follow-up questions.

2.3.2. Key Informant Interview (KII)

A total of 20 KIIs were conducted with diverse stakeholder groups, including the representatives of local governments, government departments including the Bangladesh Water Development Board (BWDB), Disaster Response and Rehabilitation Office (DRRO), the Upazila Agricultural Office, NGOs working on DRR and public universities. Prior to conducting the KIIs, a checklist was developed with a few guiding questions, which were in line with the indicators of different resilience dimensions (as shown in Table 1). The KIIs with multi-dimensional respondents were mainly intended to accumulate diverse but related findings, while the discussions with NGOs and academic experts helped to explore the DRR interventions and their implications for capacity building (i.e., community competency), the contribution of CDM groups and access to government and NGOs (i.e., institutional resilience). The experiences of government officials help us to learn how the services accommodate for preparedness and response to floods and the management of flood protection embankments (i.e., infrastructural resilience), while local influential persons help to understand which DRR interventions are effective in the communities and what needs to be done further for enhancing community resilience (i.e., social resilience) and the financial capacity of the families for flood preparedness (i.e., financial resilience).

2.3.3. Surveys

The qualitative findings derived through the FGDs and KIIs were complemented by a survey involving representatives from 90 families (30 houses each in 3 selected study locations), including 58 male and 32 female participants, to leverage the scope for the triangulation of information by various sources and methods and to minimize the biases. A simple random sampling procedure was employed to select the families in the three villages. To collect a representative sample from the entire community, the center of the village was first defined with the help of a local elderly person. Thereafter, the surveys were initiated from the village center in all four directions (north, south, east, west) to reach out to the families.

A semi-structured questionnaire was developed for the survey, wherein the key questions were developed in line with the resilience indicators defined in Table 1. The key areas covered in the questionnaire were availability and type of DRR interventions, the contribution of flood protection embankment (i.e., infrastructural resilience), DRR/resilience building project of NGOs in reducing flood risk, connection of people with local government institutions, contribution of community groups (i.e., Institutional resilience), ability to assess and anticipate flood risk, possible damage, capacity to withstand and recover from losses (i.e., Community Competency), supporting each other while in crisis, the consequences of interventions and community groups on society (i.e., Social resilience), primary and alternative income sources and the ability to invest in flood preparedness (i.e., financial resilience).

3. Results

This section comprises three broad subsections, which are aligned with the three study locations adopted for this research. These subsections bring together the diverse research findings derived through all three research methods (FGDs, KIIs and questionnaire surveys) under the umbrella of five resilience dimensions.

3.1. Type 1 Settlement: Fatepur: Area with Structural DRR/Flood Protection Embankment

3.1.1. Infrastructure Resilience

Since 1995, the flood protection embankment has protected the entire settlement from river Jamuna-induced flooding [30]. In contrast, the people living outside of the embankment have continually experienced inundation as high as eight meters [28]. Subsequently, many people have permanently relocated inside the flood protection embankment. During the FGDs, the local participants highlighted that although the construction of the embankment has curbed large-scale flooding in the area, several small-scale breaches are still witnessed at different points of the embankment during the monsoon seasons. Further, the local community is also stated to have been experiencing water nuisance (i.e., water logging) since 2015, which was particularly severe during the 2017 floods. Through the FGDs and KIIs, it has been realized that due to heavy rainfall, the deposited rainwater often could not drain out through the sluice gates/water pass (i.e., pipelines), which are installed on different private lands. The representative of BWDB further substantiates that the water pass blockage is mostly man-made, and it is mainly attributed to the construction of houses and the cultivation of lands near the pipelines/sluice gates. The respondents of FGDs, however, state that the monitoring of water passages on a regular basis during the monsoon season could resolve this problem. The FGDs and KIIs further reveal that the occasional breaching of the embankment at some points in different years (such as 200 feet in 2004), is another reason for water logging in the area. During the 2017 monsoon season (in July), some parts of the embankment even broke down, due to which the water entering in the village caused damage to agricultural crops and the inundation of fishponds (survey results illustrated in Figure 3). While the water logging incidents did not cause any loss of lives, the local people did express concern during the FGDs that a possibly bigger embankment breach in the near future may cause a great deal of suffering as they are not prepared for flood disasters, having been flood-free for so long.

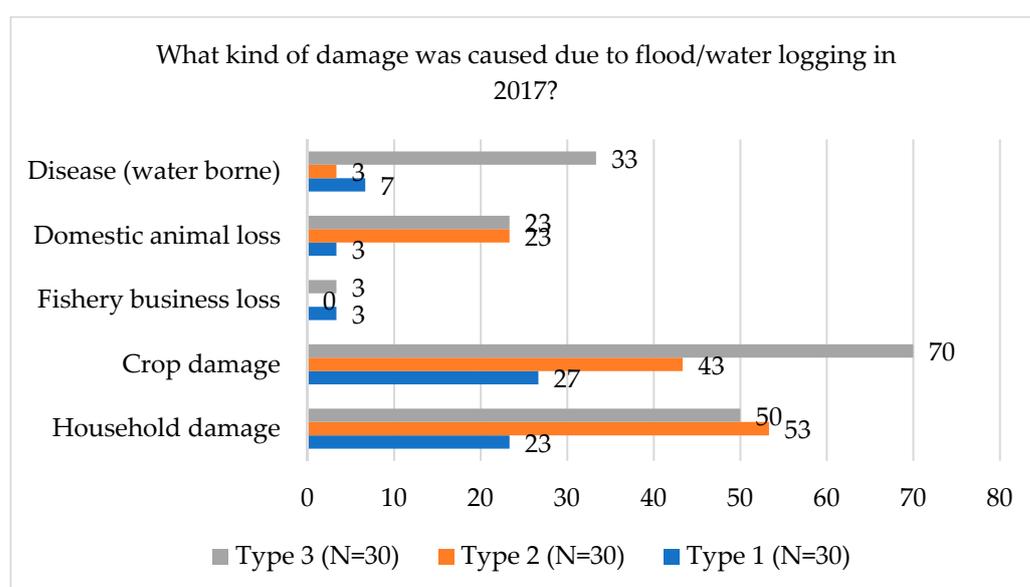


Figure 3. Type of damages caused by the flood/waterlogging due to embankment breach in 2017, as reported by the respondents (%) in questionnaire survey.

The small-scale breaches at different points of the embankment and continuous water logging in the entire area imply that the structural DRR intervention has not been able to provide complete safety to the people. According to the FGD respondents, the capacity of the structure has also changed over time, due to the lack of adequate maintenance and man-made erosion. While this research investigated the basic preparedness of local households against the flood disaster (such as in terms of raising plinth levels and sanitation structures), the respondents expressed more confidence in the flood protection structures as their savior rather than their own preparation. It has been inferred that the perceived reliance on the flood risk reduction structures is a likely reason why the people living inside the flood protection embankment are not motivated to take preparedness measures on their own to face floods in future.

3.1.2. Institutional Resilience

The local people are reported to have easy access to agricultural department, BWDB and microcredit originations for seeking support. The KIIs with agricultural officers revealed that the Upazila Agricultural Office is continuously working with the local farmers to increase their agricultural production with improved varieties, as well as to educate the farmers. From granting quality seeds to farmers with suitable lands to providing the necessary training for preserving and managing the seeds, the agricultural office has been playing a facilitative role for the farmers. As a result, this area has become a food self-sufficient area, in contrast to the severe poverty situation during the 1980s.

Apart from constructing the embankment, the BWDB has also reportedly sought to promote ownership among local people by forming water management committees to take care of the infrastructure and manage local water challenges in the long term. Even though these committees are independent, they run under the supervision of representatives from the BWDB as and when necessary. It has further been uncovered that the local people are highly motivated to repair the weak spots in the embankment during monsoon season by themselves without waiting for the representative of the Board (also found by [28]), even though there is a limited possibility of reimbursement of the expenditure from the BWDB. During the FGDs, the participants mentioned that the local people along with the committee also continuously monitored the situation of the embankment during the monsoon season in 2017 and helped to place additional protection materials, including putting extra mud and plastic bags at risky places, etc. The KII with BWDB representatives further highlighted that there is no earmarked budget for the maintenance of the entire embankment, which raises concerns about the long-term sustainability of the structure, as also stated much earlier by Khalequzzaman [4].

3.1.3. Community Competency

Through the FGDs, it has been uncovered that the majority of the local families maintain some stock of locally made dry foods, including *Chira* (flattened rice), *Muri* (puffed rice) and locally made biscuits. Here, the culture of holding dry food items serves as a survival strategy for the local people immediately after a disaster, when there is limited external relief assistance. The female respondents, in particular, highlighted that storing dry food at home also helps to entertain guests and children and requires minimal investment.

The FGD respondents duly acknowledged that the flood protection embankment has contributed to increasing rice production by extending the cultivation periods, which was also reported earlier by Faaland [31]. Before 1990, due to heavy rainfall, the areas were flooded frequently, paddy fields were often inundated, and rice crop was damaged. According to the BWDB [27], the flood protection embankment has served to save around 9427 hectares of agricultural areas from Jamuna river flooding, due to which the rice cultivation has been enhanced to up to two harvests per year. For instance, the construction of embankments enabled *Irri* (a variety) rice cultivation as well more vegetable cultivation, since the land does not flood anymore. This can also be linked with the community

competency as the local people gain more confidence to cultivate a variety of crops without any flood risk [25].

However, the local farmers point out that the soil fertility and rice production are decreasing over time, mainly within the areas protected by the embankment. Due to the closed sluice gates, the regular/annual inundation of the rice-cultivable lands has been hindered, and there is a very limited scope for new nutrient deposition on the cultivable lands. While the farmers have been utilizing the same lands for paddy production, the fertility of the lands has degraded, which is ultimately impacting the rice production. The elderly respondents in the FGDs also reported that in the earlier stages, when the embankment was not constructed, they used to get a good crop harvest [22]. The annual monsoon flood was a regular phenomenon in this area, which brought fish for the fishermen and benefited agricultural production as it brought along nutrients (also earlier found by [28,30,32]). During the FGDs, the respondents involved in farming also reported that the crop production is now better in areas outside of the embankment, as compared to the areas inside.

3.1.4. Social Resilience

The FGDs reveal that the water management committees (involving local people) have been set up to monitor the flood protection embankment, to manage the sluice gates during monsoon season and to ask the BWDB for support when necessary. The KIIs with the key BWDB and committee members also pointed out that the members located in different villages are assigned to observe the respective embankment areas and communicate any possibilities of breach. As part of this monitoring system, the committee members also perform small repair works as the actions serve all the people in the area.

While the opening of sluice gates can increase the water levels inside the embankment, the committees usually take the decision on when and for how long these gates should remain open. In that context, the FGD participants stated concerns regarding miscommunication and decision-making without proper consultation (among the committee members and with the farmers) regarding opening and closing the gates. It has been reported that the increased level of water within the embankment is damaging for the farmers who have already cultivated land with Ropa Aman, mainly for those located at closer proximity gates, as the crops cannot tolerate more water. However, opening the gates during monsoon is beneficial for all the farmers, as water coming from outside also brings along nutrients that enhance the soil fertility. In the interest of all farmers, the gates need to remain open for a while, and a landowner who is at the edge of the area usually pushes the committee for longer opening, which sometimes is not the preferences of other farmers who started cultivation earlier. In that context, it has emerged from the FGD that there is a certain conflict between various farmers' groups. A few elderly respondents reported that the prevailing unhealthy relationship among many farmers could have negative consequences on social cohesion. As the reasons for both opening and closing the gates are valid from the perspectives of farmers' livelihoods, many respondents underlined the need for negotiation among the farmers groups in order to balance the need for water through effective sluice gate management and to develop a common understanding of crop plantation timeframe among the farmers. Even though, the KII with the water management committee reveals certain established arrangements to facilitate negotiation/consensus-building; however, their efficiency is reportedly not optimal.

3.1.5. Financial Resilience

In the selected settlement, farming is stated to be the dominant source of income, along with other occupations including day laborer/rickshaw/van puller. The average monthly income is found to be 35.85 USD within a broader range of 15–150 USD. A third of the FGD respondents stated that in the aftermath of any crisis, they do have access to loans from micro-credit organization. The heavy focus on physical safety and agriculture production through the embankment has actually opened the window for well-off farmers within the

settlement to cultivate fish as there is less chance for inundation. In FGDs, the participants highlighted that some farmers have already started cultivating various types of fish and earning money by selling fish in the local markets.

While the fishery business has created a few jobs for local people, a few community members are also working as laborers to transport fish to other areas. Around 65–100 families in this area were partially dependent on catching, eating, and selling fish in the local market, as their key livelihood strategy before the embankment was constructed (as earlier found by [33]). However, the scope for action of other socio-economic groups has thereafter been compromised (see [34,35]). The fishery business has reportedly stopped open water fishing for local fishermen. Due to the closure of sluice gates, the movement of fish between the inside and outside of the embankment has also been obstructed, meaning that the diversity and quantity of fish in open waters have plummeted (see [30]). The surveys also found that the fishing community is now engaged in other occupations, including day labor in the agricultural field during cultivation and harvesting period along with fishing, and a few fishermen have also changed their occupation for survival. It can likely be inferred that the structural flood risk reduction has promoted the further marginalization of the fishing community in Tangail District. Thus, the hard measures against flood disaster are found to have certain negative impacts on financial resilience. Furthermore, the issue of the marginalization of socio-economic groups is also found to be linked to the inadequate inclusion of public awareness into FAP (see [30,36]), even though it aimed at representing local stakeholders by including representatives into the flood control interventions (see [37]).

3.2. Type 2 Settlement: Char Fatepur: Area without Any DRR Measure

3.2.1. Infrastructure Resilience

Herein, the FGD respondents are reported to have been executing small-scale structural measures against flood disasters, including raising the plinths of house and building toilets and tube wells with mud to curb the damages due to floods (also shown in Figure 4). While there is limited or negligible assistance from the government and NGOs, the respondents of the FGD report that they often manage to get support from their neighbors. Such traditional flood protection measures are also now reported to have evolved as local adaptive strategies due to their continued and long-standing flood experience.



Figure 4. (a) Mud house with elevated plinth; (b) person denoting the flood water height in 2017 in Type 2 settlement (Image source: Authors).

3.2.2. Institutional Resilience

The FGD respondents could not recall any specific DRR interventions that were implemented in this area. However, they confirmed that they had occasionally been receiving emergency relief assistance during and after flood events. They also shared that a few national NGOs have been implementing credit projects in this village, where they provide loans with interest to the people. Markedly, it has been observed that the links

between these communities and the local government is very poor, as the FGD participants report that the representatives of agricultural and other government departments rarely make any visits to their settlement, and there is also no adequate support for them when needed. Besides, the local community groups had minimal institutional awareness and training on search and rescue or disaster management.

3.2.3. Community Competency

Herein, the FGDs did not reveal any organized initiatives against flood disasters, such as awareness, early warning and capacity enhancement training on search and rescue or disaster management, etc., that were being supported by the community or even by the disaster management agencies. Still, the local communities have continually been able to survive the flood disasters through their self-created way of dealing with flood stress, which is found to be linked to the inherent capacity of the people. The respondents highlight the importance of taking flood preparedness actions on their own to reduce the damages, including raising the plinths of houses, latrines and tube well and taking loans from the credit organizations to revitalize their livelihoods after a flood disaster. However, it has also been underlined that the preparedness works cost substantial money, which they lack. As the majority of the family heads in this settlement are day laborers, living hand to mouth, they often find it hard to invest in preparing for floods.

3.2.4. Social Resilience

In this settlement, the majority of the people are found to be illiterate; as such, they cannot write and read, and only a few people can barely put their name on paper. More than half of the respondents of FGDs highlighted that if needed, for a few days immediately after the flood, they can manage to stay with their relatives and neighbors. Amongst them, the majority of the respondents referred to the flood protective embankment in Type 1 settlements as a safe place to stay for a few days. Further, this research also found political influences associated with the humanitarian assistance by the government and NGOs. The respondents reported that immediately after the flood in 2017, the NGOs came in and discussed the situation with a locally elected person, who eventually coordinated the preparation of the beneficiary list for assistance, and thus the list often tended to become biased or influenced. This type of situation has also been creating mistrust among the locals.

3.2.5. Financial Resilience

In this area, the average monthly income is found to be 35 USD within a broader range of 10–120 USD, which is similar to that of people living inside of the embankment. Around 85% of the households are dependent on agriculture for their livelihood. Non-farming occupations in this area include business, day laborers and government and non-government workers. The FGDs found that the flood is a recurrent event for the people living in this area. Thus, the local people regularly suffer from crop loss, as farming is the major income-generating source for most of the people. The recurring flood disasters therefore present a serious challenge for farmers to recover from or start over again, without any proper support from external sources. The majority of the farmers have to take out loans on interest from the credit organizations. Even though people acknowledged receiving agricultural assistance from the Upazila Agricultural Office for the farmers, the provided support is stated to be very minimal in relation to the total number of affected farmers. Furthermore, the local agricultural office is reported to be investing in agricultural development only inside the embankment, where there is limited flood risk, due to which there are disproportionate impacts on farmers living in other areas.

3.3. Type 3 Settlement: Kulkandi: Area with Non-Structural and Minimal Structural Measures

3.3.1. Infrastructural Resilience

In Kulkandi, the NGOs have been investing substantial financial resources and technical expertise to design and construct flood resilience structures for the local community,

which includes raising the plinths of houses, shelters, latrines, tube wells and community centers. These structures are designed in due consideration of the previous flood water height to ensure adequate safety and the possibility for use in the aftermath of floods. According to the participants in FGDs, the NGO-introduced structures have been useful; however, during the 2017 floods, the water level quickly surpassed the danger level, due to which almost all the structures were submerged and were partially damaged. The FGD respondents mentioned that the local people did not have any prediction of the flood water height in 2017; however, because of their better preparedness as compared to previous floods, the disaster losses were stated to be less. Thus, the local community still sees the positive implications of flood-resistant structures made by the NGOs towards infrastructural resilience. Apart from NGOs, the local government (GO) has also invested in resilient house construction over the years. The representative of the Disaster Relief and Rehabilitation Office (DRRO) office in Jamalpur District [3] also shared critical views regarding the budgeting of disaster resilience initiatives by the government and NGOs:

“While the government and NGOs are assisting in the plinth raising of the households, they should calculate all the associated costs including managing mud, which may not be possible by the poor family for free, and if they need to buy the mud for raising the plinth, then the cost would generally be higher than what is expected and budgeted by the organization providing financial assistance. In many cases, families who received a grant could not complete the house structure with that money, and they seek loans from a microcredit organization/local well-off person with interest. Considering this, stakeholders are doing harm instead of helping them as they often miscalculate the total cost of building a flood resilience shelter”.

In 2015, BDRCS/IFRC built a Community Information Centre (CIC), in consideration of the previous flood water height in the community. The local people have thereafter used this concrete building for multiple purposes, such as a flood shelter and a common place to hold meetings, sharing events or any other social events, etc. Many households also took shelter here at the beginning of the 2017 flood. However, as the flood water rose to higher levels, as compared to the previous flood water level in Kulkandi village, the platform of CIC was inundated. In light of that, the FGD participants suggested that due consideration needs to be given to the future forecasting of floods and the height of water by analyzing the historical events while constructing flood resistant structures in vulnerable communities. The participants further reported that the small-scale infrastructural assistance provided by the NGOs for the installation of sanitary latrines and tube wells has greatly contributed to reducing water and sanitation-related diseases in the community.

Further, the “Cash for Work (CFW)” program, introduced by the NGOs and approved by the Union Parishad, has also provided local people with daily remuneration for different types of works, such as building or repairing damaged roads. Regardless of the socio-economic differences, the whole society has been benefiting from this construction scheme. However, when identifying potential groups of people to do this, the NGO representatives always tend to focus on poor families for the CFW, rather than other groups in the society.

The KIIs with NGO representatives also corroborated the need for focusing on both household structure (e.g., plinth raising) and community development activities (e.g., construction of roads) for community resilience building. For instance, BDRCS repaired a damaged road along with increasing the height of the road and plinth level of houses in the study area. The FGDs showed that the same road saved many families during the 2017 floods by blocking the flood water as well as providing a safe shelter. The NGO members also stated that the infrastructure-related actions need to be well-coordinated with the local government and other organizations. While the local governments have aligned plans for community development with the strategic plan of the government of Bangladesh, NGOs can complement this with additional resources. For instance, the NGOs supported the government of Bangladesh to prepare the Standing Order on Disaster (SoD). Likewise, the annual plan of the Union Parishad can jointly be prepared, including all the local actors.

3.3.2. Institutional Resilience

The NGOs have formed two committees, namely the Community Disaster Management Committee (CDMC) and Community Disaster Response Team (CDRT), wherein the community members participate and receive training on different aspects of disaster management, including search and rescue (S&R). The core objective of this capacity development training is to develop skilled manpower so that the trained people can help themselves and others during flood disasters. The NGOs have also facilitated the formulation of a disaster management plan, in consideration of the historic flood disasters, which was operationalized during the 2017 floods.

The community disaster management committees are linked to the Union Disaster Management Committees (UDMC), where they can raise their voice on the flood situation during bimonthly meetings (also earlier stated by [30,38]). In that manner, the NGOs have also tried to make a bridge between the local committees and the UDMCs of the government of Bangladesh. However, the representatives of NGOs and the local government stated during the KIIs that the UDMCs in most cases are not functional, which is similar to Russell's [39] findings. There are counterarguments, however, that these disaster institutions have been formed after the devastating flood in 1998, and therefore it would be important to assess the effectiveness of these organizations in terms of managing the disaster risks of present times [40].

It has also been noted that a few international and national agencies including Care Bangladesh, Unnayan Songhstha (a national-level organization) and BDRCS, IFRC (International Federation of Red Cross and Red Crescent Societies) and Caritas International have implemented DRR/resilience building interventions in this area. Apart from DRR, a few national credit organizations, namely Grameen Bank and Association for Social Advancement (ASA), run credit programs that are also providing loans with interest to the people. The FGD participants reported that ultra-poor families receive various types of assistance from these organizations, which include financial or material assistance for plinth raising, house repair, installing tube wells and latrines, tree saplings, agricultural support through creating a seed bank (to preserve seeds of rice, wheat, plus, vegetables, etc.), livelihood support including training and seed money to start up small businesses including handicraft. These organizations select beneficiaries through community consultation and survey, as explained by the FGD respondents. The NGOs' DRR and resilience interventions in that manner contribute to enhancing community resilience [41].

The involvement of NGOs in the dissemination of early warning messages and the development of disaster management plans and flood awareness through courtyard meetings are also linked to preparedness at the community and family level. The FGDs showed that the participants consider themselves to have a better understanding and to be more prepared for what to do during the flood disasters, specifically due to the above-mentioned support from the NGOs over the years (also found by [41]).

3.3.3. Community Competency

Most of the respondents in this settlement confirmed that they know and practice basic flood preparedness measures, including raising the plinths of household structures, acquiring updated information about potential floods and discussing with neighbors regarding family safety and plans to save assets. They also stated that while they have already been familiar with many preparedness aspects since their childhood, the NGOs' awareness campaigns have helped them to sharpen that learning and put it to practice. It is found that the people living with floods know how to deal with the disaster, which in terms of the DROP model can be called an inherent capacity. However, the connection between people and NGOs dealing with DRR is reported to provide flood-vulnerable people with necessary knowledge and logistics towards enhancing their self-preparedness, more than for people without any connection or external supports. For instance, the respondents mentioned "mock drills" for disaster preparedness and response organized by different NGOs in this area. Such public events are designed in a way that different

socio-economic groups of the entire community play a similar role designed towards flood disaster preparedness, including what to do before, during and after the flood disaster. The whole event visualizes the situation starting from flood onset, its impact and what the community itself can do to reduce the loss of lives and assets. The respondents also acknowledged the effectiveness of courtyard meetings with small groups of people organized by the NGOs where the facilitators talk about different aspects of flood disaster, including how to be prepared. Another community preparedness measure is the way that NGOs have assisted the people of Kulkandi village to formulate a disaster management plan wherein they determine the responsibilities of different socio-economic groups in the community before, during and after the flood disaster. An implication of this plan also materialized during the flood of 2017, when the local community partially executed it and conducted a small-scale search and rescue operation to safeguard people.

The FGD participants mentioned that there is an adequate level of flood preparedness; for instance, being updated on flood warnings, storing dry food, keeping a small amount of money and arranging transportation for families to go to a safe place. The KII with CDMC members revealed that the local people conducted small scale S&R during the flood time after ensuring a safe place for them and their families. The CDMC members reported that a few members have been given basic training on S&R organized by the BDRCS; however, there are limitations in terms of the resources and skills to conduct proper S&R in the area.

3.3.4. Social Resilience

The local disaster management committees (i.e., CDMC, CDRT) were mainly formed to increase the localized flood preparedness and response capacities. However, the respondents stated a negative impact associated with these committees, which has emerged in the form of its members becoming more authoritarian in making decisions without proper communication and discussion with the community. This has also led to a growing mistrust among the people living in the community, which is one of the reasons why the Disaster Response Emergency Fund (DREF), initiated by the BDRCS and IFRC in Kulkandi village, did not continue after the initial phase of the DRR project in 2016. The DREF was a community-based initiative where the flood-vulnerable people deposited a small amount of money in the local bank (per month) to facilitate emergency relief assistance for the most affected families during the emergency situation. The initiative worked well during the floods of 2015 and 2016, wherein they distributed relief to the families; however, the money collection stopped at the beginning of 2017. Two key reasons have been identified for this: namely, the phasing-out of the five-year resilience project implemented by BDRCS and the Swedish Red Cross, and the people becoming reluctant to keep the process moving forward without any formal monitoring. Thus, the issue of the effective functionality of local disaster management committees came into being, which is linked to the second reason: growing mistrust on the members of the committee by the public. The study participants further raised concerns about the transparency and accountability of the management committee members regarding the handling of the deposited money. The community members did not have enough confidence in the committee members regarding whether the deposited money will be safely handled. During the floods of 2016, the DREF was used to provide assistance to the worst sufferers, rather than all the families of the entire community. There was an expectation from the families who deposited money in the bank account monthly that they all would be receiving DREF assistance. However, the families who did not receive any assistance blamed the committee members for this. Therefore, the findings of this research also raise questions regarding the functionality of community committees and the long-term sustainability of the DRR interventions (see [32]) in flood-vulnerable communities.

Notably, the study also found emerging negative social consequences of community committees that could become a hindrance in strengthening the capacity of the people living in flood-prone areas. For instance, empowering some people by including them in the community committees sometimes creates an elite class within an already existing hier-

archical society in Bangladesh. In addition, this initiative has brought about a domination in decision making over others and even a misrepresentation of the actual requirements of entire community. Moreover, there is a lack of follow-up or monitoring of the intervention after phasing out. Even though the government and NGOs aim to institutionalize the interventions by forming and training community people, the ownership remains hard to achieve due to various factors.

3.3.5. Financial Resilience

The average monthly income in the Type 3 settlement is found to be 70 USD within a broader range of 30–150 USD, which is more than double compared to the other two settlement areas. Here, farming is also the dominant source of income, and a few respondents mentioned fish cultivation/fishery business, which is a likely reason behind the high income of local people. The livelihood support from the NGOs, including financial and capacity development assistance for vulnerable groups, including women, has also provided alternative sources of income for families in the study area. The participants in FGDs mentioned that the financial contribution from the DRR projects to the selected beneficiaries has served as an investment to start up small-scale businesses, including handicraft and fishing boats, and many families have purchased domestic animals. The interviewed families mentioned that the financial assistance becomes an asset for them to face and recover from the critical situation, especially after the floods. The female participants who received handicraft support are now able to produce and sell warm clothes (*Katha*) in the local market, and thus they are earning money and contributing to their family income. The beneficiaries who received small business, fishing boat and seed bank support are also earning money for their families. Thus, livelihood assistance of various kinds turns into financial benefits for flood-vulnerable families, which is linked to financial resilience. In that manner, the income-generating strategies eventually contribute to strengthening the livelihood of flood-vulnerable families (also see [42]).

4. Discussion

In alignment with the five core resilience dimensions adopted in this research, this section discusses the research findings along the same directions in five subsections.

4.1. Infrastructural Resilience

In the Type 1 settlement, it was noted that the structural measures (embankment) have led to both positive and negative implications on the community resilience. Talukder and Shamsuddin [25] also found that the embankment has protected the community from Jamuna river flooding since its construction in 1995 and has increased the rice production. Other similar studies also suggest that the polders in south-west coastal areas of Bangladesh have protected more lands from severe fluvial–tidal flooding and storm surge, as compared to the areas without any polders [14]. However, through this research, it has been revealed that several small-scale embankment breaches still occur at various points during the monsoon season, which are attributed to the inadequate maintenance of sluice gates and the embankment. The consequent water logging situation also causes damage to the crops and household structures, as substantiated by Gupta [43]. Herein, the limited involvement of BWDB, along with inadequate resources, has posed a hindrance to making the area free of floods (also found by [44]). Besides, the cultivable lands in the Type 1 settlement are also gradually losing productivity due to enclosed embankment boundaries, and farmers have also reported less rice production compared to the lands outside of the embankment [22].

In Type 2 and Type 3 settlements, small-scale structural flood protection measures have been observed, which include the plinth raising of shelters, tube wells, toilets, etc. through their own resources and with support from NGO-led DRR interventions respectively. However, considering the changing severity along with the water height of the flood, these structural improvements were found to be partly inefficient during the 2017 floods.

4.2. Institutional Resilience

The existence of formal and informal institutions, including local government, NGOs and community-based committees for agriculture, disasters and water management support, has been observed in all the selected settlements. In the Type 1 settlement, the water management committees formed by the BWDB were found to be involved in the monitoring of the embankment and sluice gates and coordination with local BWDB office during critical situations. The local agricultural department was also found to be investing more resources in farmers to accelerate the production in this area. In the Type 3 settlement, the people have been receiving DRR and resilience building support for flood preparedness, livelihood improvement and emergency relief from NGOs, which has substantially contributed to enhancing community resilience [41]. The community DMC formed by the NGOs has also raised community awareness in terms of early warning, protecting village roads, search and rescue, relief distribution and communicating with NGOs, which was notable during the 2017 floods. However, for these informal communities to accountably carry forward with such roles, the NGOs and government need to have a sensible attitude with a well-defined exit strategy so that appropriate measures can be taken to avoid frustration among the general people on the committees (see social resilience, Section 4.4). In the Type 2 settlement, the vulnerable families themselves are found to be the prime institutions for help, along with the limited agricultural assistance from local government. In all three types of settlements, the credit agencies are found to be active where local people have access to loans at times of emergency need.

4.3. Community Competency

According to Kirschenbaum [45] and Gaillard [46], the people affected by disasters are often the first to respond, with existing resources, to save themselves and subsequently others. In that context, this study also found several indigenous practices to be prevalent in the case study settlements, helping them to recover/restart their livelihoods after flood disasters (refer to Figure 5); however, a certain support is required from the external agencies to ensure long-term sustainability. In the Type 3 settlement, the people are found to be more aware of flood risks and early warnings and have achieved a better understanding of what to do before, during and after the flood disaster (see [41]). However, the scenario is quite opposite in the Type 1 settlement: due to their dependency on flood protection embankment, the individual and family level of preparedness is reported to be less [47].

In the Type 2 settlement, the vulnerable families have also been managing to achieve some structural improvement on shelters by communicating with neighbors for relocation and without any external assistance. Thus, it cannot be said that vulnerable people are not taking measures to save themselves; rather, they use traditional knowledge and individual/family bonding to ensure preparedness to secure them (see [48]). Even though these actions are done on a need basis considering the very risky situation, these actions have still helped the community to save assets (see [49]).

4.4. Social Resilience

Social networks and embeddedness among the families, in terms of reaching out and helping each other during the crisis situation, were found in all three communities, representing what Shaw [32] called “culture of coping with crisis” and “culture of disaster reduction”. According to Kuhlicke and Steinführer [38], social cohesion is an inherent characteristic of communities that needs to be strengthened to promote social bonding in the field of natural hazards. However, the study did not reveal any specific activities designed to enhance community cohesion in the DRR and resilience building interventions implemented in any of the three settlements. In some cases, it even raised contrary concerns. For instance, empowering a few local people through membership in DMCs and water management committees (in Type 1 and Type 3 settlements, respectively) developed social elite groups who became authoritarian in terms of decision without consulting the commu-

nity. The construction of an embankment in the Type 1 settlement also inequitably benefited certain socio-economic groups, while certain groups were further marginalized (see [17]); for instance, fishermen, who used to catch and sell fish as an income source for livelihood earlier but had to shift fishing locations and change their occupation within the community (see [35]). In addition, in the Type 2 settlement, the people faced struggles due to the politicization of governments and NGO assistance, including emergency relief and agricultural support, after the flood, which developed mistrust in receiving adequate assistance.

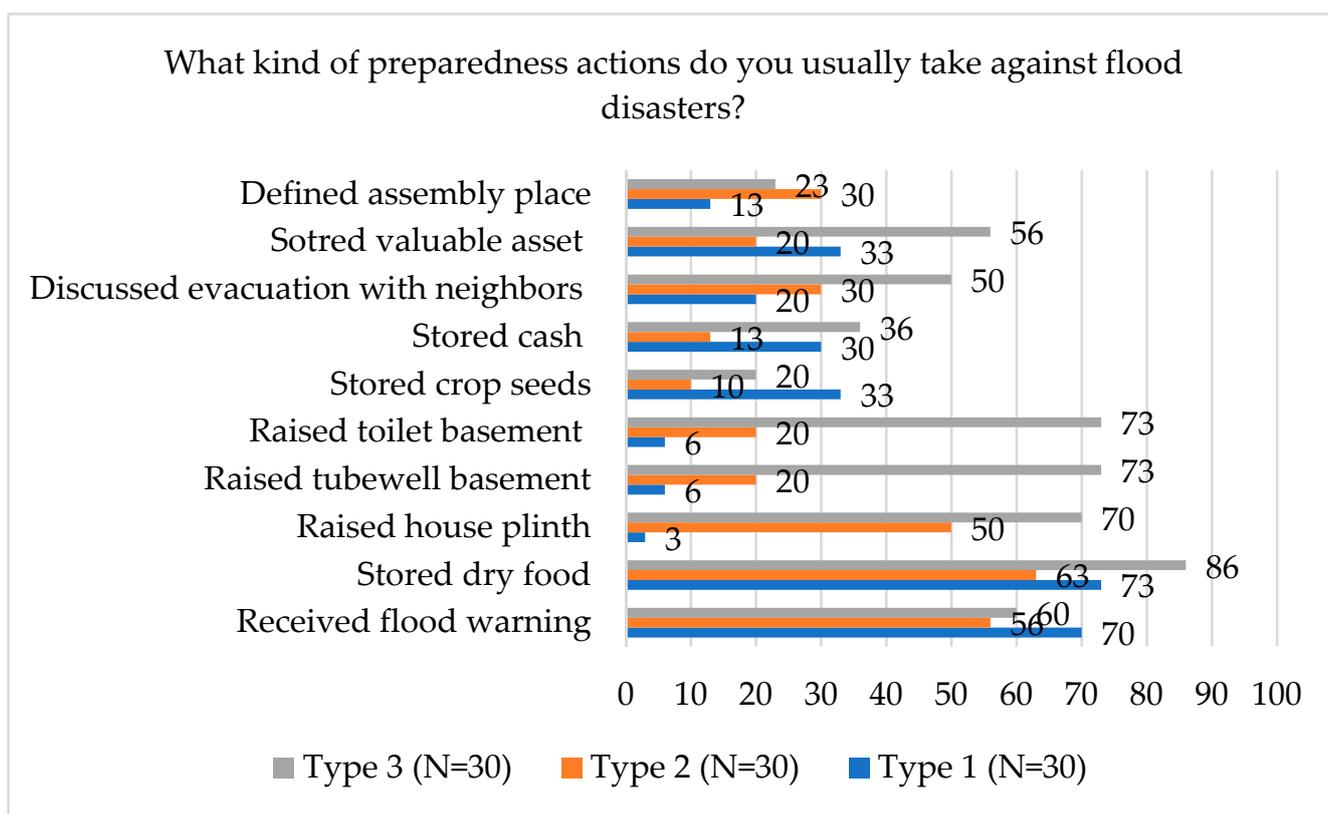


Figure 5. Status (in percentage) of flood preparedness actions taken by respondents in all three settlements (source: questionnaire survey).

4.5. Financial Resilience

The monthly average earning for the families in Type 1 and Type 2 settlements was found to be 35 USD, while in the Type 3 settlement, it was found to be double (70 USD); likely for this reason, most people are unable to invest in resilience building on their own. Farming is found to be the primary earning source in all three settlements, with a very few groups possessing alternate sources of income. During the flood situations, the affected people, who lose valuable assets, often need to take out loans to recover from the loss and start their livelihood over again (refer to Figure 6).

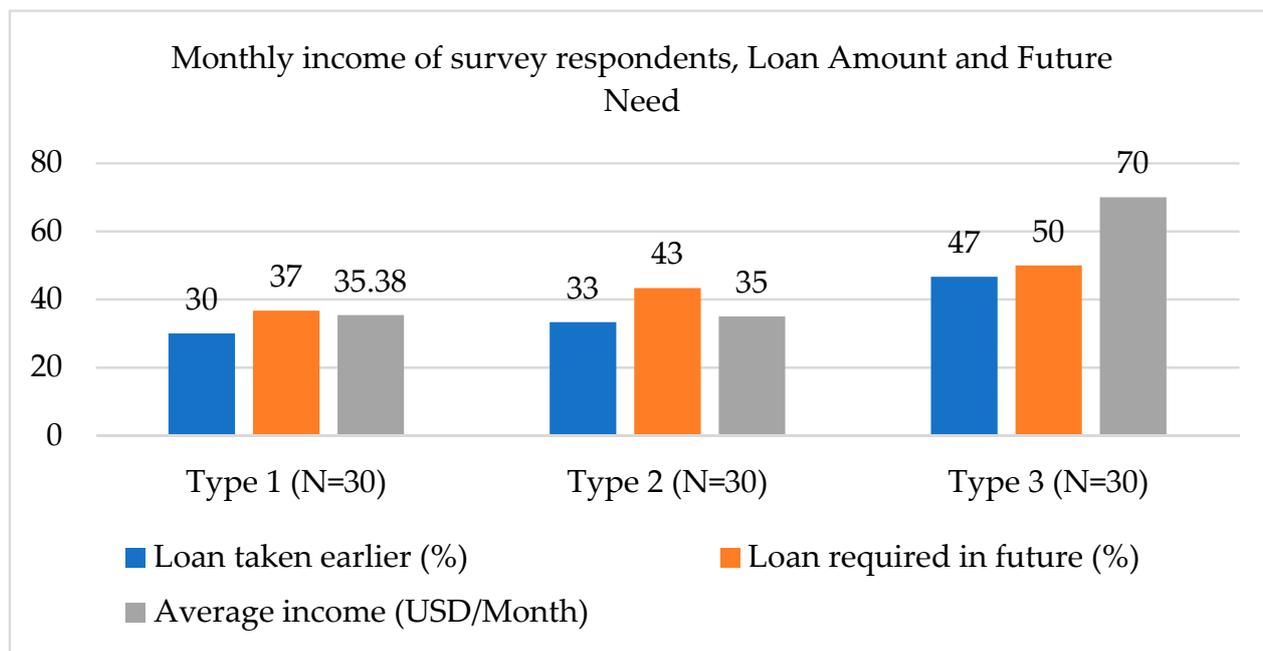


Figure 6. Status of average monthly income and loan taking by respondents in all three study areas.

Even though local people are aware that these credit organizations are taking advantage of flood disasters, they duly acknowledge the need for financial support to start over in the aftermath of floods (see [3,40]). Regardless, the local people are faced with the challenge of paying weekly/monthly interest on that loan, even though the credit organizations hold up the installments for a few weeks during and after the flood disaster.

5. Conclusions

With a focus on three defined settlements in Bangladesh, this research has highlighted the implications of various structural and non-structural measures aimed towards enhancing community resilience. Herein, it is important to highlight that similar studies have also been conducted around the world previously; however, the focus of our investigation on various flood risk reduction interventions on resilience dimensions in three different types of settlements in the specific context of Bangladesh makes this study unique as well as contributory to the research domain.

In the Type 1 settlement, varying implications of flood protection embankment have been observed on infrastructural resilience. While the flood vulnerability has considerably declined (despite the few breaches), the crop production has intensified. The institutional resilience component has also been strengthened through the active engagement of local people in embankment management. However, the structural intervention has also induced negative consequences, such as in terms of the marginalization of fishing groups.

In the Type 3 settlement, the non-structural DRR interventions, led by the NGOs, have been found to be influential in enhancing “community competency”, including flood early warning, awareness, family level preparedness and response actions and creating local DMCs. In contrast, in the Type 2 settlement, the inherent capacity and traditional methods of flood preparedness actions remain the key survival strategies for the local people in the absence of external DRR measures.

In all three settlements, the connection and connectedness among families during crisis is found to be an inherent characteristic that demonstrates social resilience to a certain extent. In light of that, the externally induced DRR interventions need to be accordingly designed to further enhance the capacity of the communities to better prepare for and respond to floods and bounce back to normal status after a flood.

Finally, the authors acknowledge that this research is subject to certain limitations. Firstly, this study largely builds on a qualitative research approach, which correspondingly uncovers a huge scope of future research in terms of deriving quantitative evidence to corroborate the research findings. Furthermore, this study is mainly based on three specific settlements in Bangladesh, due to which further explorations across different geo-spatial settings and in the context of other disasters are imperative to determine the wider applicability of the derived findings. While the field surveys in this study are mainly conducted in the aftermath of the 2017 flood disaster, the future scope of this research also entails the assessment of the implications of COVID-19 on various flood risk reduction measures.

Author Contributions: Conceptualizing, investigating, review, and editing was done by all authors. The original draft was prepared by M.S.A. and J.W.; V.S. has assisted with review and restructuring of the paper; and R.S. has provided overall guidance and supervision. Moreover, all authors have contributed significantly to the development of this paper. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: The field work of this research was funded by the Resilience Brigade project of Wageningen University, Netherlands. The Bangladesh Red Crescent/IFRC Dhaka office provided support to access the DRR/Resilience intervention area (Type 3 Settlement) and local Red Crescent volunteers extended support in making schedule with local elite for interviews. The third author (V.S.) is also thankful to the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, for the provided scholarship.

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

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