



# Empirical evidence from Bangladesh of assessing climate hazard-related loss and damage and state of adaptive capacity to address them

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## ABSTRACT

Under changing climate, more frequent and severe extreme climate events have been causing both economic and non-economic losses and damages to local communities living in disaster-prone areas. Based on 14 focused group discussions, 20 in-depth interviews, and eight key informant interviews, this study sought to understand the losses and damages experienced by rural communities in three locations of Bangladesh, which are vulnerable to riverine and flash floods or cyclones, associated surges & coastal flooding, and salinity intrusion. This paper first captured people's perception about different extreme climate events and other climatic stressors affecting their lives and livelihoods. Considering the latest extreme climate events, the study estimated the economic loss and damage of individual households — in housing, agriculture, and health sectors — ranging from US\$ 568 to US\$ 1054 per household per event. These losses and damages were highest in the south-western coast than the two flood-prone areas in the north and north-east, since multiple hazards were causing relatively longer impacts on the coast. As non-economic losses and damages, change in productive land, stressed mental, emotional, and physical wellbeing, sacrificing celebrations, temporary migration, and permanent change in profession were common in all three locations. The study also found that increased adaptive capacity enabled households to address their extreme climate event-related impacts. Households of the study locations, who got exposed to information and communication technology, as participants of a grassroots development project, have improved their coping and adaptation strategies by using the accessed information, technologies, and training. They improved their income by changing agricultural practices and diversifying livelihood options. They also developed leadership, entrepreneurial skills, and connectivity with different social and institutional networks. Building on this evidence, this paper proposed a conceptual framework showcasing the relationships of adaptive capacity with anticipated higher loss and damage scenarios under changing climate. This research concluded that more investment on raising adaptive capacity of households living in climate vulnerable locations is highly required to minimize loss and damage in the projected climate change scenarios.

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## 1. Introduction

### 1.1. Loss and damage (L&D) in the context of climate change

Local communities experience a wide range of impacts due to their vulnerability to different climate-related hazards. When people deviate from something that they value and can no longer afford it, they see it as a loss (Barnett et al., 2016; McShane, 2017). People value things that make sense of their place and way of living, such as health, personal safety, sense of belonging, and esteem (Hards, 2011). Losses are irreversible, cannot be repaired, even its restoration is not possible (UNFCCC, 2012a; Lusk, 2017). On the other hand, when reparation or restoration is possible to a detrimental impact, such as house roof blown away by a storm or part of a mangrove forest got devastated by a coastal surge, is known as damage (UNFCCC, 2012b; Lusk, 2017). The Warsaw International Mechanism (WIM) under the United Nations Framework Convention on Climate Change (UNFCCC) has recognized Loss & Damage (L&D) as the third pillar of climate policy besides mitigation and adaptation (Serdeczny et al., 2016; Roberts and Pelling, 2018). In this paper, we use lowercase letter “loss and damage” to refer to actual losses and damages occur on the ground, while use capitalized forms “Loss and Damage” or “L&D” to refer to conceptual issues and policy agenda.

Over the last few years, the discussion on L&D has drawn significant attention to researchers. The L&D discourse in the disaster risk reduction (DRR) community, however, is not new (Surminski and Lopez, 2015). Currently, L&D is equally discussed in the research field of climate change adaptation (CCA) and DRR (Birkmann and Welle, 2015). L&D — an issue that was initially raised by the Alliance of Small Island States (AOSIS) in 1991 as unavoidable impacts of climate change — was formally introduced to the UNFCCC process through 2007's Bali Action Plan (Calliari, 2018). Research on L&D mainly focuses on categorizing, assessing, and projecting impacts in the context of disasters and climate change, including slow-onset events, like sea level rise (Prabhakar et al., 2015). L&D is broadly categorized as the economic and the non-economic ones which are also meant as tangible and nontangible L&D (Preston, 2017; Serdeczny et al., 2018). Economic L&D are replaceable, whereas Non-Economic L&D (NELD) can be replaceable or non-replaceable (Tschakert et al., 2019; Wallimann-Helmer et al., 2019). Some examples of non-replaceable, non-economic L&D are loss of cultural identity, sense of place or indigenous knowledge (Heyward, 2014; Zellentin, 2015). Loss of ecosystems services is an example of non-economic, replaceable L&D (Andrei et al., 2015). NELD can fundamentally weaken community resilience (Morrissey and Oliver-Smith, 2013). For example, climate-induced migration and displacement related non-economic matters, such as mental illness, problems and disorders, increase the exposure of community and decrease the ability of bouncing back (Hayes et al., 2018; Schwerdtle et al., 2018; Ayeb-Karlsson, 2020a). Additionally, sociopsychological impacts due to climate hazards, such as domestic abuse, hinder the mental development of children and adolescents (Ayeb-Karlsson, 2020b). Increased climate-induced hazards have potential to cause both economic and non-economic L&D to local communities who are living in disaster-prone areas (Formetta and Feyen, 2019). Assessments of loss and damage, therefore, can help to avert, minimize, and address such climate hazard-related losses and damages.

Responses to climate variability and climate change, as coping or adaptation strategies are meant to keep anticipated risks or negative effects within a range of tolerance. Loss and damage, however, occur when the risks cannot be kept within such limits (Wallimann-Helmer, 2015; Schinko et al., 2019). In other words, limits to adaptation (O'Brien, 2009) and adaptation deficits (Roberts and Pelling, 2018) — gaps between current adaptation practices and the level of adaptation required to adjust the impacts — cause negative climate change impacts. In this context, van der Geest and Schindler (2017) developed a holistic analytical framework to assess climate hazard-related losses and damages that include the information regarding the adaptation limits. Moreover, Boyd et al. (2017) identified four typological perspectives, namely adaptation & mitigation, existential, adaptation limits, and risk management, to understand L&D. Adaptation limits and risk management perspectives are covered by the analytical framework of van der Geest and Schindler (2017) for assessing L&D.

### 1.2. Adaptive capacity in changing climate

The Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) defines adaptive capacity as “*The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequence*” (Pachauri et al., 2014, p-118). Here adjustment refers to response to the effects of variability, extremes, and ability to utilize benefits from opportunities. The greater adaptive capacity ensures higher possibility of resilience to climate variability (Folke, 2006). Moreover, adaptive capacity increases the desire of the households to transform their current state to a resilient state since desire of changing current state is a socially developed attribute (Robards et al., 2011). As a result, community decides to alter the current practices or take different actions to address the impacts when climate-related hazards are unavoidable.

There are two types of approaches to measure adaptive capacity — inductive approaches are data driven, while deductive approaches are guided by theories (Matewos, 2020). In 2010, Lindsey Jones and his coworkers proposed the ‘Local Adaptive Capacity (LAC) Framework’ — based on the work under the Africa Climate Change Resilience Alliance (ACCRA) programme — which was later revisited by Jones et al. (2019). This framework identifies five distinct, but interdependent parameters, namely asset base, institutions and entitlements, knowledge & information, innovation, and flexible and forward-looking decision-making and governance, which can shape the adaptive capacity of a household or a community. Such a framework — which brings in different interconnected features within which a social entity, like a household, operates and evolves in the face of change — can be useful in measuring adaptive capacity of local community vulnerable to climate hazard under changing climate.

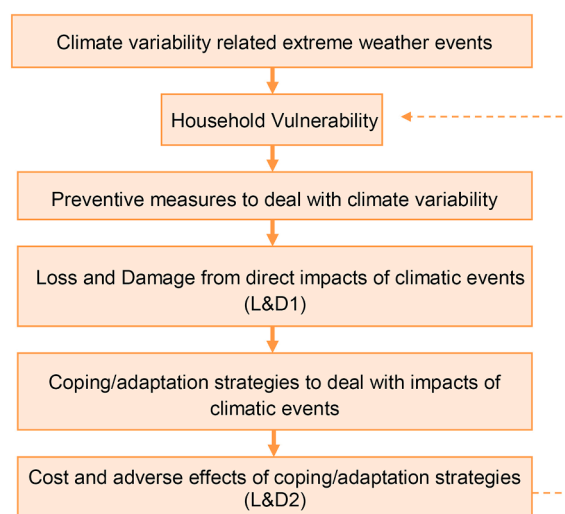
### 1.3. Interaction between L&D and adaptive capacity

The increasing frequency and intensity of extreme climate events and the vulnerability of geographic locations increase the degree of loss and damage. Therefore, ex-ante adaptive actions, such as increased adaptive capacity that qualify households to take effective preventions, may build resilience before climate extreme events or slow-onset events occur (Boyd et al., 2017). Ex-post adaptive actions, such as incorporating the actions of increasing adaptive capacity with social safety nets, may also help to those who already experienced loss and damage. Unavailability of technological or socioeconomic options, which is known as the soft limits of adaptation (Mechler et al., 2020), may be reduced through effective implementations of previously mentioned adaptive actions. There is a modest pool of global literature on L&D and adaptive capacity (Heikkilä et al., 2013; Elena and Meza, 2015; Choudhury and Haque, 2016). But it almost exclusively deals with either of these two related concepts. Therefore, an investigation into how L&D and adaptive capacity interact could give us a new insight into our understanding of resilience of climate-vulnerable local community.

Bangladesh — the seventh most-extreme-weather-events-affected country that saw 191 events during 1999–2018 (Eckstein et al., 2019) — offers an appropriate space to explore interactions between L&D and adaptive capacity. According to the special report on global warming of 1.5 °C of the IPCC, South Asia, which Bangladesh is a part of, experiences hot extremes due to the global warming (Hoegh-Guldberg et al., 2018). The report also highlights the regional anthropogenic warming on land is generally more than 1.5 °C, even when the mean global warming is at 1.5 °C. Temperature extremes and heavy precipitation in this region increased during 1991–2010 period in comparison with 1960–1979 periods due to 0.5 °C temperature rises between these two periods (Schleussner et al., 2017). In regards to such warming, an increase to rainfall-associated severe tropical cyclones and floods is projected in the Bay of Bengal region, where Bangladesh is located (Hoegh-Guldberg et al., 2018). Moreover, climate change related extreme weather events are expected to increase in frequency and intensity, which would cause severe loss and damage due to insufficient adaptation options (Hay and Mimura, 2010; Hirsch et al., 2015).

In reality, Bangladesh is already experiencing climate-related extreme weather events in recent decade. Since 2013, for example, several cyclonic storms, namely Mohashen/Viyaru (May 2013), Roanu (May 2016), Mora (May 2017), Fani (May 2019), Bulbul (Nov 2019), and Amphan (May 2020), with maximum wind speed 100 to 260 km per hour hit the Bangladesh coast. In 2017, Bangladesh experienced extensively long period of flooding that inundated 42% of country affecting 6.1 million people (Davis, 2017). In 2020, as of 25 July, floods affected 24% of the country and almost 3.3 million people. Earlier, in 2013, 2014, 2016, and 2018, 21%, 28%, 33%, and 23% of the country, respectively, got flood affected (Flood Forecasting and Warning Centre, n.d.).

Against this backdrop, we designed the present study fulfilling three purposes. First, we created an evidence base of loss and damage from climate-related hazards by working with the local communities in three areas of Bangladesh prone to either flood or cyclone. We used the analytical framework proposed by van der Geest and Schindler (2017) to analyze different levels of loss and damage experienced by climate vulnerable households of those locations. We also analyzed NELD. Second, by adopting Jones et al. (2019)'s LAC Framework, we assessed the status of adaptive capacity of the same households in minimizing their climate hazard-related L&D. Finally, we showed how L&D and adaptive capacity may interplay in local communities' climate vulnerability-resilience context and proposed a conceptual framework on this interaction to add insights into community resilience conversation.



**Fig. 1.** Analytical framework to assess loss and damage due to different climate stressors, including climate variability associated risks and hazards, climate-related events or disasters, and climate change-related changes in frequency and intensity of extreme weather events. Source: Author.

## 2. Frameworks to assess loss and damage and adaptive capacity

### 2.1. Analytical framework to assess loss & damage

An assessment of L&D includes the condition of social vulnerability to climate stressors and a lack of coping and adaptive capacity to deal with those stressors (van der Geest and Schindler, 2017). Warner and van der Geest (2013) identified four L&D pathways in terms of measures taken or not taken to address L&D: i) measures to prevent, cope or adapt are not enough to avoid L&D; ii) measures have costs that are not regained; iii) erosive measures that make people more vulnerable; and iv) adopt no measures. van der Geest and Schindler (2017) developed an analytical framework to assess climate hazard-related L&D by focusing on these pathways. Fig. 1 is the adopted schematic presentation of this analytical framework. To assess extreme event-related loss and damage, we gathered qualitative and quantitative data on six research domains: i) households' perception of climatic stressors; ii) livelihood vulnerability to the impacts of those stressors; iii) preventive measures to deal with the risks; iv) first order loss & damage (L&D1) despite taking preventive measures; v) coping and adaptive strategies; and vi) loss & damage related to the costs of coping and adaptive strategies (L&D2). The feedback loop in Fig. 1 connecting L&D back to the household's vulnerability is when the intensity and magnitude of extreme events cause huge amount of losses and damages.

The framework mentioned three types of household responses, namely, preventive measures, coping, and adaptation strategies to climate-related stressors. Preventive measures are usually adopted in response to normal climate variability related extreme events, as a part of disaster risk reduction. Households' responses, such as building physical protection, risk spreading (e.g. insurance), creating buffers (e.g. savings), and establishing safety net are known as preventive measures (van der Geest and Schindler, 2017). Coping strategies are short-term responses and use location specific skills, resources, and opportunities to address adverse effects of extreme events, such as storm or drought (IPCC, 2012; Ashraf and Routray, 2013). In the field of disaster research, coping strategies are used by people in the aftermath of extreme events to survive or get back to normal life. Selling assets, engaging in petty trade, taking loans, and receiving food aid and relief are some examples of coping strategies (Aryal et al., 2020). On the other hand, adaptation strategies are long-term strategies, which are mostly changeable in broader environmental circumstances (Gallopín, 2006). Effective adaptation strategies can reduce vulnerabilities of people to adverse impacts of climate hazards and ensure sustainability. Agricultural change, livelihood diversification, and migration are some examples of adaptation strategies (Aryal et al., 2020).

Finally, a list of climate change related intangible harm, non-economic loss and damage is selected according to Mayer (2017), Hayes et al. (2018), Serdeczny et al. (2018), Tschakert et al. (2019), McNamara and Jackson (2019), Ayeb-Karlsson (2020a, 2020b), and McNamara et al. (2021), that have values important in people's lives. Climate change related intangible impacts, such as cultural, symbolic, effect on place and culture (Tschakert et al., 2017) are assessed upon context and extent of the people's lived experiences with climatic hazards.

### 2.2. Theoretical framework to map adaptive capacity

To explore the adaptive capacity of people addressing loss and damage in different locations, we adopted a theoretical framework called 'Local Adaptive Capacity (LAC) Framework' (Jones et al., 2019). The framework has five components defined as the characteristics of adaptive capacity. The first characteristic of this framework is 'asset base', which indicates the presence of a wide range of vital livelihood assets allowing a household or a community to respond to changing situations around them. The second characteristic 'institutions and entitlements' highlights the importance of suitable, evolving institutional arrangements that would permit households and communities to access as well as receive entitlement to key capitals and assets.

The third characteristics is households' or communities' ability to produce, collate, evaluate, and share 'knowledge and information' to support suitable adaptive measures. To take benefits from new opportunities, an enabling environment is crucial that fosters experimentation and learning, as well as 'innovation' — the fourth characteristics of the framework. Finally, 'flexible and forward-looking decision making and governance' is the fifth characteristic, which focuses on the ability of a household or a community to predict, include, and respond to changes in environmental, social, and political conditions they are in, in terms of governance, structure, and planning. Despite their distinctive features, these five adaptive capacity characteristics do not operate in isolation (Jones et al., 2019). The decision making and planning capacity and innovation are strongly linked with the availability of knowledge and information and supportive institutional environment, for example. The above mentioned characteristics of the adaptive capacity built on the experiences of using it in several African countries during 2009–2013—have recently been applied to map the adaptive capacity of rural households to climate change in a drought-prone region of Ethiopia (Matewos, 2020).

## 3. Methodology

### 3.1. Study areas

The topography and geographical location of Bangladesh make it particularly susceptible to different climate-related hazards, like floods, cyclones, and storm surges. Both the biophysical factors, such as flat and low-lying land (Ayers et al., 2014) and socio-economic factors, such as high dependence on agriculture, population density, and poverty (Thomas et al., 2013) make those hazards severely impactful.

In this context, the present study selected three locations, namely south-western coast, north-western floodplain, and north-eastern wetland essentially to assess extreme weather event-related loss and damage. The study areas of this research are Borokupot village,

Shyamnagar Upazila (Upazila is sub-district, the lowest administrative unit in Bangladesh) (22.3306°N, 89.1028°E), Satkhira district; Dakshin Kharibari village, Dimla Upazila (26.1278°N, 88.9250°E), Nilphamari district; and Bhobanipur and Shontoshpur villages, Tahirpur Upazila (25.0917°N, 91.1750°E), Sunamganj district. These three locations were selected as these are highly vulnerable to cyclones and tidal surges (the first area) and floods (the remaining two). These hazards cause huge loss of lives, crops, and homes and damage to infrastructure and assets in those areas.

To explore the approaches to address loss and damage, we looked into a project supported by Oxfam in Bangladesh and Monash University, Australia entitled 'Participatory Research and Ownership with Technology, Information and Change' (PROTIC) ([www.proticbd.info](http://www.proticbd.info)) since it was working in the above three areas to raise the economic condition of the poor people to address extreme weather event-related impacts. The PROTIC used technology addressing societal problems, accumulating knowledge, and using social media and other channel of communications to encourage emergence of local change agents or leaders. Information and communication technology (ICT) may address avoidable loss and damage through successful adaptation measures, by improving the effectiveness of adaptation, enhancing disaster preparedness, and adaptive capacity. We therefore considered the PROTIC for exploring the functions of ICT in increasing people's adaptive capacity.

### 3.2. Data collection

The primary data of this study was collected during July–September 2019. Qualitative information was collected to assess loss and damage and to discuss how households were addressing those losses and damages in increasing adaptive capacity and resilience. Qualitative data was collected following the frameworks described in [Section 2](#). Eight focused group discussions (FGDs) (12–15 participants in each group and two or three FGDs in each location) were held with the treatment groups (with individuals who received benefits from the PROTIC). Another six FGDs were conducted with the control groups (with individuals who did not receive benefits from the PROTIC). As the PROTIC targeted only women of the households, the study participants in the FGDs were women only. One pilot FGD was conducted with semi-structured questions. Based on the feedback, the questionnaire was finalized and used to conduct all FGDs. The FGDs were arranged by the project staff based in the respective locations. The authors alone conducted all FGDs where the discussions were recorded by using voice recorders and by taking notes on paper.

At the beginning of each FGD and interview, the authors explained the purpose of the study and the expected use of the collected information to the study participants. The FGDs gathered information on climate variability related events, household and societal impacts, coping and adapting strategies, and adaptive capacities, which are the key concepts of this research. The FGD questionnaire used open questions about coping and adaptation measures. To capture people's perception on addressing loss and damage in the light of increased adaptive capacity, the authors collected data on five adaptive capacity characteristics as outlined in [Section 2](#).

The authors also conducted 20 in-depth interviews with the women who were mostly housewives. The household heads or main income earners of these families were mostly farmers, day laborers, and fish farmers. In order to avoid the biasness of data and see the differences in adaptive capacity, primary data was collected from both the groups (treatment and control). In addition, the authors conducted eight key informant interviews (KII) with agriculture, livestock, fisheries, and project implementation officers and Upazila Nirbahi Officer (or sub-district executive officer) stationed at relevant sub-district administration offices to validate the information on losses and damages.

### 3.3. Data analysis

To start the data analysis, the authors transcribed all FGD and interview responses into text. The data was then organized and coded under the themes, namely preventive measures, coping and adaptive strategies, asset base, institutions and entitlements, knowledge and information, innovations, and flexible and forward-looking decision making and governance, based on the analytical and theoretical frameworks ([Section 2](#)). Finally, after a close examination, they clustered meaningful similar replies from the respondents under each of the themes.

To calculate the costs of damages in crops, the authors collected the data of the local market price of rice. Similar technique was applied for calculating the cost of damages in vegetables, fisheries, cattle, and poultry. For housing, they collected data on cost for installing structural preventive measures before the climate events and the repair cost after the events. Based on the feedback from all study participants of all FGDs in a particular location, the loss and damage was estimated for the recent most extreme event in different sectors, namely housing, agriculture, and health, for an average household. In addition to economic loss and damage, non-economic loss and damage (NELD) was also analyzed by following the classification of [Tschakert et al. \(2019\)](#).

## 4. Results

The study found agriculture as the main livelihood option in all three study areas. The FGDs revealed that farming agriculture crops (e.g. rice and corn), homestead gardening, cattle rearing, freshwater fish farming, and working as day laborer were common as well. Among aquaculture practices, prawn and crab farming was common in coastal Shyamnagar. Seasonal out-migration in search for work was also common at the study sites. Other than these livelihood options, some respondents in Shyamnagar were found to prepare the boxes for sweetmeat shops and a few participants in northern Dimla worked as tailors.



#### 4.1. Perception of climate stressors

During the FGDs, almost all participants in Dimla and Tahirpur identified flood as the most severe climate hazard — mentioning their experiences of the recent most devastating flood of 2017. After floods, most of the participants in Dimla in northern Bangladesh mentioned river-bank erosion, cold wave, and hailstorm as other major hazards. On the other hand, drought, hailstorm, and high temperature were the major climate stressors in Tahirpur in the east of Bangladesh. Respondents in coastal Shyamnagar mentioned salinity as the prime hazard, followed by cyclone, drought, and temperature rise.

#### 4.2. Preventive measures

At the beginning of most of the FGDs, participants expressed their disappointment in government initiatives in tackling hazards. They perceived that government was solely responsible for disaster preparedness. However, as the discussions progressed, the FGD participants shared the preventive measures they employed for their households. Table 1 shows different preventive measures practiced by the participants against extreme climate events. The major hazards included floods (both riverine and flash floods) and cyclones and associated surges and coastal flooding. Some preventive measures were practiced against one hazard, while some measures dealt with more than one.

#### 4.3. First order loss and damage (L&D1)

The first order loss and damage took place despite having preventive measures in place. From the FGDs, L&D1, as a direct impact of climate-related hazards, were recorded at two levels: i) harvest failure and ii) damage to infrastructure. Rice — the most commonly cultivated crop in almost all the study areas — was cultivate by a few participants on their own land, but by many on others' arable land. When respondents cultivated rice in others' land, they needed to spend extra money for borrowing the land. Failure to collect the crops before a climate hazard hit their locality means losing all their harvest as well as the investments. Most of the participants stored the harvest for family consumption and few sold in the market, if they were successful in collecting the crops without any problem.

Table 2 shows amounts of loss and damage incurred by an individual household in different sectors as a direct impact of the last extreme climate event, either flood or cyclone. Crops and fisheries were the major sectors got impacted by floods and cyclones, respectively. In all locations, agriculture was followed by damage to houses by these extreme events. The loss and damage estimation varied significantly among locations, where Shyamnagar showed highest figure with US\$ 1054 per household, followed by Tahirpur (US\$ 699 per household) and Dimla (US\$ 568 per household). The FGDs also revealed several other types of loss and damage. For example, people living in rural areas of Bangladesh use dried cow-dung, dried jute sticks, and fuel-wood as cooking fuel. Many participants lost their cooking fuel in flood water, which was not financially large in amount, but had caused great inconvenience in terms of food consumption. Based on the above-mentioned losses and damages it is understood that the preventive measures applied by the participants were not always effective in addressing negative impacts of hazards.

#### 4.4. Coping and adaptive measures to extreme climate events

Major coping strategies practiced by the participants in the study locations to deal with the impacts of extreme climate events are presented in Table 3. The most common recorded coping strategies in all three study locations included, receiving food aid and other relief materials, taking loans, and modifying food consumption besides this, selling assets and seasonal migration were also among the

**Table 1**

Preventive measures practiced by the study participants to deal with extreme climate events as revealed by FGDs in three study areas.

Preventive measures	Participants' responses <sup>1</sup>
Physical protection	<ul style="list-style-type: none"> <li>• Raise the height of houses (F)</li> <li>• Use strong pillars made from wood or cement to increase the strength of houses (C, F)</li> <li>• Put latrines in safer place or raise the latrine-base above known flood level (F)</li> <li>• Instead of straw, use corrugated iron sheet or pillar to prepare the houses (C, F)</li> <li>• Raise the edges of ponds or put net around ponds (C, F)</li> <li>• Put soil-filled sacks in front of houses to protect from the high wave (C, F)</li> <li>• Use brick on the floor of cattle-sheds and raise the base of the chicken-sheds and duck-sheds (C, F)</li> <li>• Planting trees to reduce the wind speed during cyclone (C)</li> </ul>
Risk spreading	<ul style="list-style-type: none"> <li>• Example include insurance, but was not practiced</li> </ul>
Creating buffers	<ul style="list-style-type: none"> <li>• Savings with different non-governmental organizations/Micro-finance Institutions (MFI) from which they could take loans (C, F)</li> </ul>
Build safety nets	<ul style="list-style-type: none"> <li>• Stored dry food, fuel wood, and dried cow-dung (as fuel) (C, F)</li> <li>• Stored ready-made oral rehydration solution packets and medicines</li> <li>• Portable cooking stove (C, F)</li> </ul>

<sup>1</sup>Participants' responses to extreme climate events included cyclone (C) and associated surges and coastal flooding and flood (F) (both riverine and flash floods).

**Table 2**

Estimated loss and damage incurred by individual household in different sectors because of the last extreme climate event in a study location. Data was collected through FGDs held during July–September 2019.

Extreme event	Location	Impact sector	Estimated loss and damage incurred per household per event (US\$) <sup>1</sup>
Cyclone	Shyamnagar	Housing	188
		Crop	200
		Vegetables	67
		Fisheries	488
		Cattle	43
		Poultry	25
		Health	43
Flood	Dimla	Housing	130
		Crops	228
		Vegetables	50
		Fisheries	80
		Cattle	15
		Poultry	10
		Health	55
Flood	Tahirpur	Housing	118
		Crops	250
		Vegetables	83
		Fisheries	30
		Cattle	50
		Poultry	30
		Health	38
		Traditional bed mat	100

<sup>1</sup> US\$ 1 = Bangladeshi Taka 85.

**Table 3**

Coping strategies followed by the study participants to deal with extreme climate events as revealed by FGDs in three study areas.

Coping strategies	Participants' responses <sup>1</sup>
Rely on social networks	Support from different local governmental offices, NGOs operating locally, e.g. BRAC, CNRS, Polliisree, and RDRS. These NGOs helped to build new latrines and tube-wells for drinking water supply. Relatives also provided food (C, F)
Food aid and other relief	Relief support from local NGOs, government offices, university students, and charities (C, F)
Selling assets	Gold ornaments and cattle (C, F)
Modifying food consumption	One meal in a day or modified menu with lower nutritional value (C, F)
Migration	Temporary migration to other districts to support families (F)
Use of buffers (savings or stored food)	Money they saved with different local cooperative societies (C, F)
Taking loans	From different local NGOs and micro-finance institutions (C, F)
Reducing expenses	Sacrificed celebrating religious festivals (C, F)

<sup>1</sup>Participants' responses to extreme climate events included cyclone (C) and associated surges and coastal flooding and flood (F) (both riverine and flash floods)

highly practiced coping strategies in Tahirpur located in the flash flood-prone north-eastern part of Bangladesh.

*I sold cow and with the help of that money, my husband repaid loans, bought grass for the remaining cows. During natural hazards we are forced to sell our cattle in cheaper price.*

Pronoti Rani Devi, Tahirpur (name changed)

Besides the coping measures, few participants also adopted some adaptation measures, such as cultivating salt-tolerant rice varieties and hybrid vegetables in coastal Shyamnagar, and early-ripening or short-term rice varieties in flood-prone Dimla and Tahirpur. Many participants mentioned that they were unable to diversify their main livelihoods. They had to produce rice anyhow despite the risk of losing harvest associated with it; otherwise, they would need more money to buy rice, which was sometimes beyond their capacity. Therefore, majority of the people tried to cultivate rice either on their own land or on borrowed land.

#### 4.5. Second order loss and damage (L&D2)

This second order impact of loss and damage is related to costs incurred, even after the previously mentioned coping and adaptation measures (Section 4.4). The FGDs and interviews showed that the labor crises and cost of cultivation increased in the study locations. This was due to labor shortage during the rice cultivation period as people were migrating to big cities in search of livelihoods. Significant costs, therefore, were added to rice cultivation at normal times as well as after any extreme event. Some study participants also noted that the crop yield and income from hybrid varieties were lower than the regular varieties to some extent.

Many participants stated that some families resettled themselves from risk-prone low land to safer higher land after experiencing flood repeatedly. Although this resettlement reduced their physical exposure to flood, they needed to spend a significant amount of

money to resettle, which stressed their family expenses and savings. Moreover, the soil fertility of the relocated area was not satisfactory and they were unable to produce food. Some families just shifted their houses and still cultivated in their old land. However, this wasted their time and energy as they had to commute long distances between their new and old places. Nevertheless, the risk of losing crops remained the same, if a flood would strike again.

#### 4.6. Non-economic loss and damage (NELD)

In addition to economic loss and damage, study participants also expressed their losses and damages in non-economic terms. Table 4 captures evidence of these NELD from the study locations. The nature of NELD varied between locations and climate hazards in question. The study participants in coastal Shyamnagar — facing severe salinity intrusion, cyclones and surges — appeared to experience more NELD than the other two sites. Some issues were common in more or less all locations, such as change in productive land availability, stressed mental and emotional well-being, pressure on health from disaster-associated diseases, sacrificing ceremonies and celebrations, temporary migration, and permanent change in profession.

#### 4.7. State of adaptive capacity

The PROTIC provided project participants with smart phones and internet facilities in the treatment villages in all study locations to increase their adaptive capacity. In addition to the devices and monthly internet-data support, the project also enhanced the knowledge and skills of those participants through training in using social media platform (e.g. Facebook) and mobile apps on agriculture, fisheries and cattle rearing that contain information on diseases and advanced agricultural techniques. Fig. 2 shows the impact of ICT-based services and training to the participants' lives and the relationship with the five characteristics of adaptive capacity. The following sections describe the pathways in terms of different characteristics of adaptive capacity.

##### 4.7.1. Increased access to information and knowledge improved livelihood assets

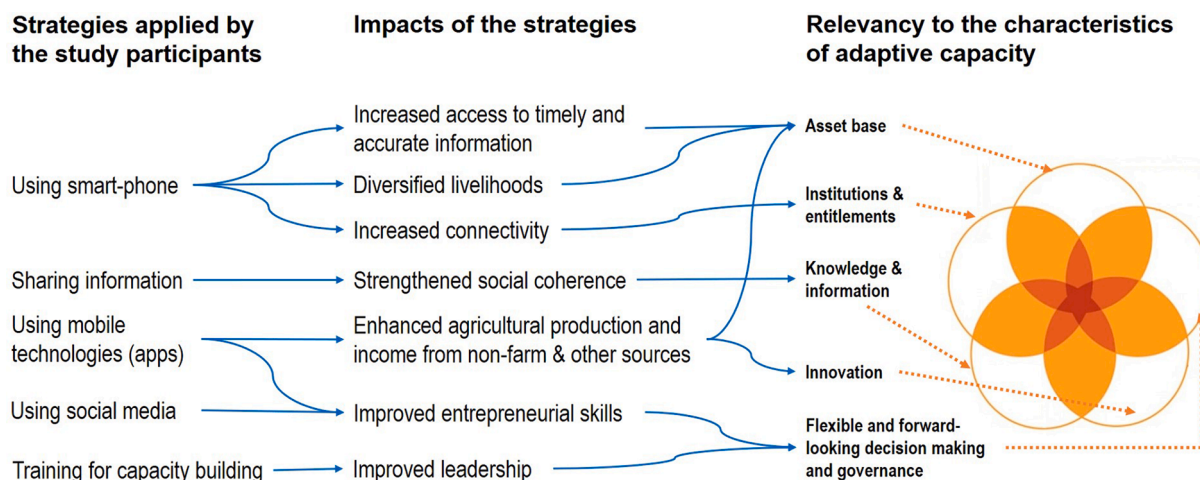
From the FGDs in the treatment villages, two major changes were identified that improved adaptive capacity through better livelihoods assets. The first change was direct access to weather information and its utilization. Since 2017, the study participants started receiving early warning messages about climatic events, like heavy rainfall, high temperature, hailstorms, and floods, on their project-supported mobile phones. As a result, they became well-prepared to calamities more than before. For example, in 2019, the

**Table 4**

Lived experiences of non-economic loss and damage (NELD). Cyclones and associated surges and coastal flooding were major climate hazards in coastal Shyamnagar, whereas floods (riverine and flash flood) were the dominant hazards in Dimla and Tahirpur.

Domains of NELD ( <i>Examples of intangible harm</i> )	Lived experiences with harm
Biodiversity ( <i>Loss of animal, loss of land for crops and animal husbandry, diminished living spaces for animals</i> )	Participants from coastal Shyamnagar mentioned about their loss land and diminished living spaces for animals. They also mentioned that they were unable to grow any vascular plants after the cyclone due to increased salinity. They hardly had any sources of drinking water.
Productive land and habitat ( <i>Cropland and saltwater intrusion onto arable land</i> )	Participants from coastal Shyamnagar mentioned that they were unable to cultivate rice for more than five years after the Cyclone Aila (2009) and at this moment (2019) they could grow only one crop per year, whereas before could have twice a year. The grazing land became saline and as a result they had to give up cattle farming. In flood-prone areas, flood-affected people also experienced scarcity of food for their surviving cattle as the grazing fields got inundated.
Mental and emotional well-being ( <i>Existential threats, Trauma due to witnessing huge loss</i> )	A participant in coastal Shyamnagar mentioned that her husband started crying after discovering the loss in their fisheries business. He was mentally depressed for more than a month. Another participant from Dimla mentioned about the mental stress on repaying loan that she borrowed to recover from floods.
Physical health ( <i>Disease, Malnutrition, food insecurity</i> )	Many participants in all the study locations suffered from diarrhea during and after the disasters and they had to buy a lot of medicines.
Culture ( <i>Lack of money for ceremonies</i> )	Many participants in all the study locations were forced to give up the joy of religious festivals after the disasters. One participant from Dimla mentioned that she had to cancel the wedding ceremony of her daughter as her house got totally damaged.
Territory ( <i>Disappearance of indigenous land, temporary migration</i> )	Some participants from coastal Shyamnagar and Tahirpur mentioned that a few household heads temporarily moved to big cities, like capital Dhaka and port-city Chittagong, to work as rickshaw-pullers, masons, or day laborers. Several people who were once farmers, now pull rickshaw-van and left farming profession. On the other hand, several participants from Dimla informed that shifting to a safer place within the same locality could not ensure that the new site would be beneficial for agriculture.
Self-determination and Influence: People's capacity to exert control over their lives ( <i>Feeling of being at the mercy of nature, without any control; Feeling of helplessness</i> )	Almost all participants from all locations mentioned their helplessness during and after disasters. They also told that the disasters would harm them no matter how much they try to increase their ability to deal with disasters, since they had no power to prevent disasters.





**Fig. 2.** Pathways to increase adaptive capacity as revealed by the present study in three locations of Bangladesh facing climate hazards, like floods, cyclones, and salinity. The adaptive characteristics and circular diagram are adopted from Jones et al. (2019) as outlined in Section 2 of this paper. Source: Author.

respondents of Dimla and Tahirpur were able to cut their crops, thus saved their harvest, before starting of heavy rain as they got early warning messages directly on their mobile phones in Bangla (local language). Weather updates were also helping them to harvest their vegetables before any hazard hit the area and reduced the amount of losses from aquaculture.

This new scenario represents a significant change in the early warning dissemination system in these villages. Previously, the early warning message sending-system took longer to send the update on a hazard to the villagers. First, the message went from Upazila (sub-district) to Union Parishad (UP). (Union is the smallest local government unit in Bangladesh and made up of several villages, and several unions make up an Upazila or sub-district. A UP is the elected council of a union.) The message then went to the members of an UP or the local mosque. Finally, the villagers got the message through public announcement system from the mosque. But, by that time, the severity of the hazard reached to a higher magnitude, causing asset and livelihood loss and damage.

The second change was seen when improved access to digital information and knowledge and better advisory services by using ICT protected livelihood assets. Livestock rearing, for example, is a very important source of non-farm income, mostly managed by women, in all study locations. But in the past, when their cattle got sick, the women were unable to tackle it as the social norm did not allow them to go outside and seek advice from veterinarians and get treatments for the livestock. They often used the same medicine for all types of veterinary diseases. During the present study, it was learnt that information received from the agriculture-based mobile apps and consultation with veterinary doctor through video call were enabling participating women to provide proper treatment to their cattle as well as poultry.

Similarly, with the help of training and knowledge on advanced technology to cultivate vegetables, households improved their production system. Due to saline soil, vegetable cultivation is a challenge in coastal Shyamnagar. Learning from the mobile apps, participants there started cultivating vegetables in sacks full of fertile, less saline soil. Furthermore, agriculture-based mobile apps increased the knowledge on crop diseases and allowed to get and apply the remedies as needed. Improved knowledge subsequently increased vegetables production in all localities. After meeting family demands, excess vegetables were sold in the local market. This extra income often became part of the household savings by the women to be used after disasters. Case study 1 captures a story of a woman who saved crop loss and gained better market access by using updated information on agriculture.

### Case Study 1

“Pochmer batash” in local dialect of Sunamganj area (north-eastern wetland) means the “wind blowing from the west”. Like many other women in this area, Fahima Begum believed that blast disease of rice (a fungal disease) occurred due to “Pochmer batash” and, with that belief, her family had been cultivating rice for years. However, scientific information received by using mobile helped Fahima to understand the fact. The information helped her to eliminate superstition and prevent rice blast. She used smart phone to check the symptoms from the online resources. She also cross-checked it by consulting with an expert over phone facilitated by a call center-based agricultural support provider. As a result, Fahima could now take care of rice blast disease in her fields, which was not possible earlier. Moreover, now she was contacting with the wholesalers directly to sell her vegetables and was negotiating for good prices as she had access to market information. Thus, access to information through information technology raised her coping capacity to overcome climatic hazard-related damages.

#### 4.7.2. Developed innovation skills

Micro-level technical innovation, such as digital marketing and learning new techniques from YouTube videos helped the study participants in treatment villages to reduce shocks to livelihood and ensured a dynamic and functioning livelihood. This increased households' economic ability and enabled them to take risks and find investments for innovative technologies. Many participants in all the locations started using digital technology to learn new things to increase their income:

*Before, I used to get 20 Taka (25 cent in USD) only for sewing one piece of blouse. Other than this, I didn't know how to sew any other dresses. Now-a-days YouTube is helping me to earn more money by applying the updated design and technique of sewing kamij (a local dress), blouse, and other women dresses. I am now contributing to the household expenses of my family. Moreover, once my sewing machine had some defect and I was unable to sew anymore. I took it to the local market to fix it. Unfortunately, the mechanic was unable to fix it. With the help of machine fixing video documentary on YouTube, I finally succeeded to fix it by myself.*

Mosammat Salma Akter, Tahirpur (name changed)

Participants started altering existing practices, resources, and behavior and got involved in earning to strengthen their capacity to face environmental changes. Access to internet brings the online platform to the participants and turns them into successful entrepreneurs. A participant from Shyamnagar mentioned that she did not own land. However, she used to cultivate some crops by borrowing land from others. During the Cyclone Aila in 2009, she lost all her harvest and left cultivating crops. Later, she started preparing paper-made boxes for local sweetshops. With the help of smart phone and internet connection, she opened her Facebook account and advertised her hand-made boxes for sweets. Different sweetshop owners from other villages directly contact with her to buy the sweet-box, which raised her income. Thus, a simple vulnerable woman of a remote coastal village turned into an entrepreneur and raised her adaptive capacities to face future disasters better.

#### 4.7.3. Increased leadership in flexible decision making and connectivity with institutions

Many study participants who engaged themselves in income generating activities and got involved with wider world through internet, also broadened their perception towards societal norms and practices. Previously single-headed families, therefore, transformed into multi-headed families. Engagement with multi-dimensional work also increased the voice and leadership of the study participants. One participant from Tahirpur noted that she was not brave enough to go out of her village during or after hazards. However, knowledge, information and access to market raised her courage and now she thought to sell her products in big cities as well. Similarly, after seeing one participant, others also got involved in improving income generation (Case Study 2).

Study participants also established connection with different government officials, such as livestock and fisheries officers of respective sub-districts. If they faced any problem related to their livelihoods, crop diseases or early warning, they directly contacted the respective officials. Participants now maintain a strong relationship with different local institutions.

FGD participants from the control groups in three locations did not receive any support from the PROTIC. They did not receive any capacity building training on agriculture and information technology. They were not introduced with mobile phone-based or internet-based weather and agricultural services. Moreover, their connection with different local governmental officials and service providers was not quite developed. All these acted as constraints to increase adaptive capacity among the control groups.

## 5. Discussion

### 5.1. Relationship between extreme climate events and climate change

Bangladesh is situated on the delta of the Ganges-Brahmaputra-Meghna (GBM) river basin with only 10% land is above 1 m mean sea level (Karim and Mimura, 2008). Low-lying land and dense tributaries of the GBM basin make the country vulnerable to floods, which originate from the precipitation on the whole GBM basin. The present study has showcased the evidence of 2017 floods-related loss and damage from north-western Dimla and north-eastern Tahirpur. According to Rimi et al. (2019), in reference to the 1986–2015 rainfall data, the pre-monsoon extreme 6-day rainfall event seen in March–April of 2017 causing early floods was attributed to

#### Case Study 2

Pravati Rani is a role model for others in her community. Her husband was a poor fish farmer who worked in his “chingri gher” (shrimp-farming pond). He was facing repeated losses from his gher due to several climatic events (e.g. increase in temperature and salinity). Therefore, he wanted to lease the gher out to another person. At that time Pravati asked him to give her the gher as she received training on advanced shrimp farming techniques. This knowledge developed ambition and courage inside her to take the decision of taking the responsibility of their gher and now she was doing very well in shrimp farming. Thus, a loss aquaculture project in her family turned into a successful one.

anthropogenic climate change. The authors further concluded that, human-induced climate change doubled the likelihood of extreme pre-monsoon rainfall in Bangladesh.

Analyzing data for the period of 1977–1998 showed that the relative sea levels in the Bay of Bengal had increased by 4 mm per year and the western and eastern coasts have also increased by 7.8 mm per year (Alam et al., 2018). Historical records of cyclone from the last 100 years show that Bangladesh experienced 50% of all global casualties and damages (Alam et al., 2018). Modeling suggests that climate change induced rises in sea surface temperature (SST) will increase tropical cyclone intensity. Moreover, 2 °C rises of SST would increase the height of storm surges by 23% (Alam et al., 2018). Sea level rise and cyclone induced storm surges lead to salinity and salt water intrusion (Mahmuduzzaman et al., 2014). Future projection on sea level rise shows that it may increase from 0.77 m to 1.5 m by the end of 21st Century compared to 1986–2005, which may inundate 29% of total area of Bangladesh (Hasan et al., 2020), therefore, has higher potential to increase future loss and damage.

The incidence of extreme climate events is therefore increasing due to the changing climate and variability in the global and regional weather. Therefore, the assessment of loss and damage that has been shown in this study may guide to assess the loss and damage for future climate events as well.

### 5.2. Loss and damage due to adaptation limits

Despite applying a number of preventive, coping, and adaptive measures to tackle climate-induced hazards, like floods and cyclones, most of the study participants faced first and second orders L&D in the study locations. A systematic analysis of their economic and non-economic loss and damage indicates the study participants are apparently trapped in the study locations. Lack of resources, such as little financial capacity (Black et al., 2011), poor social capital (Schwerdtle et al., 2018) and place attachment (Ayeb-Karlsson et al., 2020) due to land ownership or inheritance, forced them to stay at those vulnerable locations, which act as barriers to escape from environmental stress. However, relocation does not ensure limiting loss and damage although improved livelihoods, strong cultural and kinship connections and access to resources to ensure basic needs enable people to create opportunities to stay well (McNamara et al., 2018). Further, impacts on income creates additional burden to poor families and forces them to take different erosive coping strategies, such as selling livestock, ornaments, and consuming seed stock, which exacerbate their poverty (Warner et al., 2012).

Relying on off-farm income sources is an important coping measure to deal with impacts of extreme events. People can spread their risk through reducing the dependence of their food and income from one source to other sources (Tanner et al., 2015). Moreover, it enables household to buy foods and spend money to meet other expenses even if their harvest is destroyed (Roberts et al., 2014). However, off-farm income generation was not common in the study locations, especially before the PROTIC. Some of the coping strategies that participants adopted, such as reconstructing house from the savings, failed them to invest in their future cultivation. Moreover, participants who forced to sell their cattle at cheaper price during or after a hazard struck, faced problem during the next year's cultivation as they needed cattle to plough the land.

Practicing diversified adaptation measures were also not visible in the study locations, except cultivating hybrid varieties. Moreover, this was less effective as cultivation costs of hybrid crop varieties were similar to regular varieties, even in some cases higher, but the production was not satisfactory. In this context, the additional costs of coping and adaptation measures, including the erosive coping mechanisms, increased the cost of loss and damage for the households. "Limits to adaptation" and "Existential" perspectives of L&D hypothesize that residual impacts including NELD are inevitable for vulnerable communities and are happening now which is required empirical evidence (Boyd et al., 2017; McNamara and Jackson, 2019). In this context, this study has clearly recorded that L&D is occurring now in the three study locations despite adopting coping and adaptation strategies that are not enough to prevent L&D from climate-related events and climate change-related increasingly severe and frequent extreme weather events.

### 5.3. Improved adaptive capacity of the treatment participants

Regarding the adaptive capacity, almost all participants from the treatment FGDs expressed their positive attitude towards the modified adaptive capacity defined by adaptive capacity parameters. Recovery from the climatic hazards depends on appropriate knowledge on future threats and a clear understanding of capacities or options that are required to adapt. Moreover, social constructs of knowledge and power enable people's decision-making ability to adopt new skills (Ayeb-Karlsson, 2020b). On the other hand, access to accurate and relevant information on weather forecast, crops and fisheries diseases, market conditions, and early warning helps to implement suitable measures during and after the climatic events (Shiferaw et al., 2014). Access to wide range of information accurately and on time is a key step to successful disaster management (Cutter, 2003). Such information could be generated and shared locally as informal information, while formal pieces of information are received from external bodies, like state or private service provider. Participants of the treatment FGDs of the present study had access to both types of information, for example, experience of a new livelihood option shared with a livelihood group and accurate early warning message received from relevant agencies on mobile phone, respectively. With the help of information, they also developed knowledge on new crop species and agricultural change that further helped them to modify the current livelihood practices and engage in additional or modified income generation processes.

Accurate information is also helpful to get advanced knowledge on different livelihood options that ensure diversifying local livelihoods as well as raising awareness (Ospina and Heeks, 2010). The ability to cope with and respond to change depends strongly on having access to or control over assets (Daze et al., 2009). Capacity of diversifying and accessing assets in time of extreme weather events is useful for the households to address the negative impacts (Ospina and Heeks, 2010). An increase in asset therefore allowed study participants in the treatment villages to use that asset base to respond during and after the extreme weather events.

Engagement of income generation by fostering innovation and supporting new practices increase the ability of community to

recover well after extreme events (Smith et al., 2003). Moreover, mobility and functionality of a system depend on the application of effective innovation. According to Nassef (2020), focusing on preemptive action, such as awareness raising and capacity building on new technologies and establishing contingent arrangements, such as introducing households with financial instruments, may be helpful to reduce the costs of losses and damages. Participants who had learnt innovative skills and applied those in their livelihoods were now more dynamic than before. It broadened their thoughts that raised their interest to learn new things, search new markets to sell their products, and increase their capacity to harness the opportunities from the big cities, which they did not access before. Communication of knowledge also help to develop innovation skill and individual starts thinking to utilize the opportunities presented by a changing environment in best possible way (GebreMichael et al., 2011). Successful innovative ideas change the mindset and economic ability of people to take risks and motivate to take new livelihood initiatives. Many study participants, for example, invested the profit of one livelihood sources to another livelihood option, such as buying cows from the income of sewing clothes.

In terms of connectivity with local institutions, participants maintained a strong relationship with different local institutions, including service providers. A strong maintained chain of command at different levels of the local intuitions is helpful to take action against disaster challenges as it reduces the distance between institutions and local community (Karim and Thiel, 2017). The capacity of a society depends on the ability to act collectively and institutions grow social relation among people at multiple scales to respond and recover after the events (Jones et al., 2019). Additionally, prevention of maladaptive practices is also possible by keeping active connection with different local institution and decision-making process (Ayers and Huq, 2009).

#### 5.4. Limited adaptive capacity of the control participants

We found significant gaps in the state of adaptive capacity of all the participants of control FGDs who were not involved with the PROTIC. We identify three reasons for that. First, the participants from the control groups did not have access to fast early warning message on extreme climate events, updated information and advanced knowledge that can increase their livelihood asset. Second, they did not receive any capacity building training on advanced farming methods in climate change context. As a result, the fallow land around their houses was left vacant and there was no additional income. Finally, due to lack of connectivity with local government officials and technology, there was no opportunity for them to come up with any new ideas on raising their existing income or modify livelihoods. Thus, the leadership and decision-making skills also did not develop in the control group participants.

A lack of above-mentioned capacities is related to adaptation limits. Factors such as economic development, technology use, and behavior act as limits to adaptation (Preston et al., 2013) and hinder transformation of individual, community or entity (Pelling et al., 2015). Thus, limits to adaptation cause irreversible losses to individual's things that they care about (Mechler et al., 2019) except the household heads, other family members of the control groups were not involved in any income generation activities. However, they heard the success stories of participants of the treatment groups through their neighbors. Additionally, they thought that if they had access to technology, training and information, they would have the same capacity like the treatment participants.

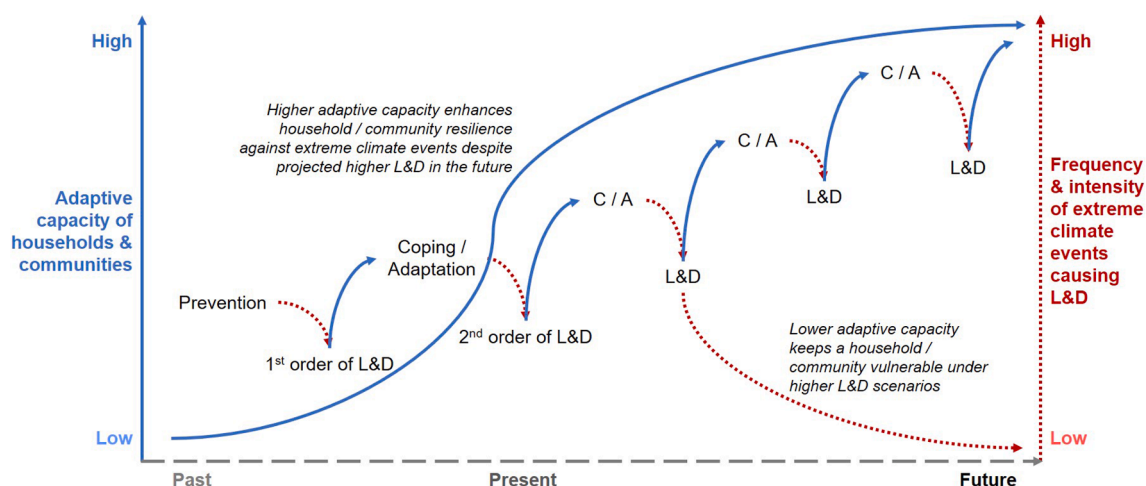
#### 5.5. Conceptual framework capturing interplay between L&D and adaptive capacity

The findings and discussions of the present study allow us to develop a conceptual framework to show how L&D and adaptive capacity may interact within local community resilience context. Fig. 3 shows the interaction between L&D and adaptive capacity over time in a local community vulnerable to climate change. Households and communities take preventive measures as a part of disaster risk reduction to protect them from regular risk of extreme climate events, like floods, cyclones, and surges, and other expected uncertainties within the range of climate variability. The limit to these measures, however, causes the first order loss and damage). After a disaster, communities follow different coping strategies, like receiving food aid, selling assets or relying on networks, to address the negative impacts of climate-related events. As the climate is changing and transforming the average climatic conditions and changing the frequency and intensity of extreme climate events, coping therefore is not enough, long-term adaptive strategies have to be employed. But, adaptation has its limits. Therefore, local communities may experience the second order loss and damage due to the limitations of coping and adaptation measures.

But, such failure is not a one-time matter. As climate change continues and extreme climate events and slow-onset changes, like sea level rise and salinity intrusion continue as well, adaptive capacity of households and communities in climate vulnerable areas needs to match those changes and needs to be strengthened as a continuous process. Such enhanced adaptive capacity can be characterized by increased and diversified livelihood opportunities leading to better asset base, improved connection with institutions and attaining sufficient entitlements, efficient and timely access to and use of wide range of information and knowledge, enabling environment sustaining innovation and improvisation, and strong leadership with flexible and forward looking decision-making and planning capacity (Jones et al., 2019). In absence of such an evolving adaptive capacity in place, the households and communities will remain vulnerable in the predicted higher loss and damage scenarios in the coming years. With higher adaptive capacity, on the other hand, households, and communities as a whole, may show better climate resilience despite the loss and damage from increased extreme climate events and other climate change stressors, as projected by different models (Hoegh-Guldberg et al., 2018).

## 6. Conclusion

The study assessed the extreme climate events related loss and damage and the condition of adaptive capacity by using an analytical and a theoretical frameworks. Both frameworks used several parameters to assess the loss and damage and adaptive capacity of the participants. The assessment of loss and damage clearly demonstrates that the preventive measures were not fully effective in reducing



**Fig. 3.** Relationship between extreme climate event-related loss & damage (L&D) and local adaptive capacity. A household / community take preventive measures to reduce risks from such events, like floods and cyclones. A failure in prevention results into the first order of L&D. Once household's coping (C) and adaptive (A) strategies further fail against such events, the second order of L&D occurs. If a household, or a community for that matter, shows adaptive capacity, it can express resilience against extreme climate events despite projected future L&D scenarios. In absence of such adaptive capacity characteristics, a community continues to remain vulnerable. Solid lines represent adaptive capacity; dotted lines represent extreme climate event-related L&D; dashed line represents time. Source: Author.

the impacts from high magnitude climatic hazards. Except relief, many of their coping measures were erosive that raised the cost of overall loss and damage. Consequently, the condition of their vulnerability has accelerated extensively. Additionally, debt has become a burden for majority of the participants as taking loan is very common coping measures in all the study locations. The practice of diverse adaptive measures among participants was relatively low. However, participants were keen to accept and adopt diversified adaptive measures to bring positive changes in their livelihoods.

Modified adaptive capacity enables treatment groups to adopt multiple adaptive measures, such as changing agricultural process, livelihood diversification, and accessing early warning messages. The participants practiced such adaptive measures successfully have grown confidence and leadership. On the other hand, an absence of opportunities for increasing adaptive capacity left the control groups vulnerable to extreme climate events and climate change. The ability to address avoidable loss and damage mostly depends on the adaptive capacity of the households and communities and it needs to evolve as a continuous process matching the projected climate change and extreme climate events scenarios.

If a disaster sufferer knows where to find the solution, that knowledge might help him/her to address the damages. We have noticed enthusiasm and spirit when we asked the study participants about their future activities after the end of the PROTIC. Previously, the experience and nature of adaptive capacity was unknown to the study participants, but now they were aware of the disaster preparedness that might be helpful to reduce some loss and damage from climate stressors. Reducing the frequency and intensity of extreme climate events requires drastic climate mitigation actions by all nations, at global level. Nevertheless, continuous investment in building the adaptive capacity of households and communities of climate vulnerable locations is crucial to minimize climate hazard-related loss and damage in the projected climate change scenarios.

### Declaration of Competing Interest

The authors declare that they do not have any competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

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## References

- Alam, E., Momtaz, S., Bhuiyan, H.U., Baby, S.N., 2018. Climate change impacts on the coastal zones of Bangladesh: perspectives on tropical cyclones, sea level rise, and social vulnerability. In: *Bangladesh I: Climate Change Impacts, Mitigation and Adaptation in Developing Countries*. Springer, Cham, pp. 145–166. [https://doi.org/10.1007/978-3-319-26357-1\\_6](https://doi.org/10.1007/978-3-319-26357-1_6).
- Andrei, S., Rabbani, G., Khan, H.I., 2015. Non-economic loss and damage caused by climatic stressors in selected coastal districts of Bangladesh. Bangladesh: Bangladesh Centre for Advanced Studies. Supported by the Asian Development Bank. Retrieved June 28, 2020 from <http://www.iccd.net/wp-content/uploads/2016/02/ADB-Study-on-Non-Economic-Losses-and-Damages-Report-Final-Version-Reduced-File-Size.compressed1.pdf>.
- Aryal, J.P., Sapkota, T.B., Rahut, D.B., Krupnik, T.J., Shahrin, S., Jat, M.L., Stirling, C.M., 2020. Major climate risks and adaptation strategies of smallholder farmers in coastal Bangladesh. *Environ. Manage.* 66 (1), 105–120.
- Ashraf, M., Routray, T., 2013. Perception and understanding of drought and coping strategies off farming households in north-west Balochistan. *Int. J. Disaster Risk Reduct.* 5, 49–60. <https://doi.org/10.1016/j.ijdr.2013.05.002>.
- Ayeb-Karlsson, S., 2020a. When we were children we had dreams, then we came to Dhaka to survive: urban stories connecting loss of wellbeing, displacement and (im) mobility. *Clim. Develop.*, 1–12. DOI: 1080/17565529.2020.1777078.
- Ayeb-Karlsson, S., 2020b. 'I do not like her going to the shelter': stories on gendered disaster (im)mobility and wellbeing loss in coastal Bangladesh. *Int. J. Disaster Risk Reduct.* 50, 101904. <https://doi.org/10.1016/j.ijdr.2020.101904>.
- Ayeb-Karlsson, S., Kniveton, D., Cannon, T., 2020. Trapped in the prison of the mind: Notions of climate-induced (im) mobility decision-making and wellbeing from an urban informal settlement in Bangladesh. *Palgrave Commun.* 6 (1), 1–15. <https://doi.org/10.1057/s41599-020-0443-2>.
- Ayers, J.M., Huq, S., 2009. Supporting adaptation to climate change: What role for official development assistance. *Develop. Policy Rev.*, 6, 675–692. DOI:10.1111/j.1467-7679.2009.00465.x.
- Ayers, J., Huq, S., Wright, H., Faisal, A.M., Hussain, S.T., 2014. Mainstreaming climate change adaptation into development in Bangladesh. *Clim. Develop.* 6 (4), 293–305.
- Barnett, J., Tschakert, P., Head, L., Adger, W.N., 2016. A science of loss. *Nat. Clim. Change* 6 (11), 976–978.
- Birkmann, J., Welle, T., 2015. Assessing the risk of loss and damage: exposure, vulnerability and risk to climate-related hazards for different country classifications. *Int. J. Global Warm.* 8 (2), 191–212. <https://doi.org/10.1504/IJGW.2015.071963>.
- Black, R., Bennett, S.R.G., Thomas, S.M., Beddington, J.R., 2011. Migration as adaptation. *Nature* 478 (7370), 447–449.
- Boyd, E., James, R.A., Jones, R.G., Young, H.R., Otto, F.E.L., 2017. A typology of loss and damage perspectives. *Nat. Clim. Change* 7 (10), 723–729.
- Calliari, E., 2018. Loss and damage: a critical discourse analysis of Parties' positions in climate change negotiations. *J. Risk Res.* 21 (6), 725–747.
- Choudhury, M.-U.-I., Haque, C.E., 2016. "We are more scared of the power elites than the floods": adaptive capacity and resilience of wetland community to flash flood disasters in Bangladesh. *Int. J. Disaster Risk Reduct.* 19, 145–158.
- Cutter, S.L., 2003. GI science, disasters, and emergency management. *Trans. GIS* 7 (4), 439–446.
- Davis, R., 2017. Floodlist. Retrieved July 20, 2020 from <http://floodlist.com/asia/bangladesh-floods-august-2017>.
- Daze, A., Ambrose, K., Ehrhart, C., 2009. Climate vulnerability and capacity analysis, care international. London. Retrieved April 10, 2020 from [http://www.careclimatechange.org/cvca/CARE\\_CVCAHandbook.pdf](http://www.careclimatechange.org/cvca/CARE_CVCAHandbook.pdf).
- Eckstein, D., Künzel, V., Schäfer, L., Wings, M., 2019. Global climate risk index 2020. Germanwatch Retrieved 31 July, 2020 from [https://germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global\\_20](https://germanwatch.org/sites/germanwatch.org/files/20-2-01e%20Global_20).
- Elena, L., Meza, R., 2015. Adaptive capacity of small-scale coffee farmers to climate change impacts in the Soconusco region of Chiapas, Mexico. *Clim. Develop.* 7 (2), 100–109. <https://doi.org/10.1080/17565529.2014.900472>.
- Flood Forecasting & Warning Centre. (n.d.). Retrieved July 20, 2020 from <http://www.ffwc.gov.bd/>.
- Folke, C., 2006. Resilience: The emergence of a perspective for social-ecological systems analyses. *Global Environ. Change* 16 (3), 253–267.
- Gallopin, G.C., 2006. Linkages between vulnerability, resilience, and adaptive capacity. *Global Environ. Change* 16 (3), 293–303.
- GebreMichael, Y., Magagi, S., Bayer, W., Bayer, A.W., 2011. More than climate change: pressures leading to innovation by pastoralists in Ethiopia and Niger. Future of Pastoralism. University of Sussex and Feinstein International center of Tufts University. Retrieved November 22, 2019 from [https://www.prolinnova.net/sites/default/files/documents/news/gebremichael\\_et\\_al.pdf](https://www.prolinnova.net/sites/default/files/documents/news/gebremichael_et_al.pdf).
- Formetta, G., Feyen, L., 2019. Empirical evidence of declining global vulnerability to climate-related hazards. *Global Environ. Change* 57, 101920. <https://doi.org/10.1016/j.gloenvcha.2019.05.004>.
- Hards, S., 2011. Social practice and the evolution of personal environmental values. *Environ. Values* 20 (1), 23–42.
- Hasan, M.K., Kumar, H., Gopalakrishnan, T., 2020. Inundation modeling for Bangladesh coasts using downscaled and bias-corrected temperature. *Clim. Risk Manage.* 27, 100207. <https://doi.org/10.1016/j.crm.2019.100207>.
- Hay, J., Mimura, N., 2010. The changing nature of extreme weather and climate events: risks to sustainable development. *Geomatics, Nat. Hazards Risk* 1 (1), 3–18.
- Hayes, K., Blashki, G., Wiseman, J., Burke, S., Reifels, L., 2018. Climate change and mental health: risks, impacts and priority actions. *Int. J. Mental Health Syst.* 12 (1), 1–12. <https://doi.org/10.1186/s13033-018-0210-6>.
- Heikkilä, T., Gerlak, A.K., Bell, A.R., Schmeier, S., 2013. Adaptation in a transboundary river basin: linking stressors and adaptive capacity within the Mekong River Commission. *Environ. Sci. Policy* 25, 73–82.
- Heyward, C., 2014. Climate change as cultural injustice. In *New waves in global justice* (pp. 149–169). Palgrave Macmillan, London. DOI: 10.1057/9781137286406\_8.
- Hirsch, T., Kreft, S., Künzel, V., Schäfer, L., Minninger, S., Wirsching, S., 2015. Climate-related Loss and Damage—Finding a Just Solution to the Political Challenges. Berlin: Brot für die Welt/Germanwatch/Act Alliance. Retrieved July 31, 2020 from [https://reliefweb.int/sites/reliefweb.int/files/resources/Profil19\\_E\\_LossAndDamage.pdf](https://reliefweb.int/sites/reliefweb.int/files/resources/Profil19_E_LossAndDamage.pdf).
- Hoegh-Guldberg, O., Jacob, D., Bindi, M., Brown, S., Camilloni, I., Diedhiou, A., Hijioka, Y., 2018. Impacts of 1.5 C global warming on natural and human systems. Global warming of 1.5° C. An IPCC Special Report (pp.175–311). IPCC Secretariat. Retrieved July 31, 2020 from [https://helda.helsinki.fi/bitstream/handle/10138/311749/SR15\\_Approval\\_Chapter\\_3.pdf?sequence=1](https://helda.helsinki.fi/bitstream/handle/10138/311749/SR15_Approval_Chapter_3.pdf?sequence=1).
- Intergovernmental Panel on Climate Change (2012). Field, C. B., Barros, V., Stocker, T. F., & Dahe, Q. (Eds.). Managing the risks of extreme events and disasters to advance climate change adaptation: special report of the intergovernmental panel on climate change. Cambridge University Press. Retrieved July 20, 2020 from [https://www.ipcc.ch/site/assets/uploads/2018/03/SREX\\_Full\\_Report-1.pdf](https://www.ipcc.ch/site/assets/uploads/2018/03/SREX_Full_Report-1.pdf).
- Jones, L., Ludi, E., Jeans, H., Bariha, M., 2019. Revisiting the Local Adaptive Capacity framework: learning from the implementation of a research and programming framework in Africa. *Clim. Develop.* 11 (1), 3–13.
- Karim, M., Mimura, N., 2008. Impacts of climate change and sea-level rise on cyclonic storm surge floods in Bangladesh. *Global Environ. Change* 18 (3), 490–500.
- Karim, M.R., Thiel, A., 2017. Role of community based local institution for climate change adaptation in the Teesta riverine area of Bangladesh. *Clim. Risk Manage.* 17, 92–103.
- Lusk, G., 2017. The social utility of event attribution: liability, adaptation, and justice-based loss and damage. *Clim. Change* 143 (1–2), 201–212.
- Mahmuduzzaman, M., Ahmed, Z.U., Nuruzzaman, A.K.M., Ahmed, F.R.S., 2014. Causes of salinity intrusion in coastal belt of Bangladesh. *Int. J. Plant Res.* 4 (4A), 8–13. <https://doi.org/10.5923/s.plant.201401.02>.
- Matewos, T., 2020. The state of local adaptive capacity to climate change in drought-prone districts of rural Sidama, southern Ethiopia. *Clim. Risk Manage.* 27, 100209. <https://doi.org/10.1016/j.crm.2019.100209>.
- Mayer, B., 2017. Migration in the UNFCCC workstream on loss and damage: an assessment of alternative framings and conceivable responses. *Transnat. Environ. Law* 6 (1), 107–129.
- McNamara, K.E., Westoby, R., Chandra, A., 2021. Exploring climate-driven non-economic loss and damage in the Pacific Islands: loss and damage in the Pacific Islands. *Curr. Opinion Env. Sust.* 50, 1–11. <https://doi.org/10.1016/j.cosust.2020.07.004>.



- McNamara, K.E., Jackson, G., 2019. Loss and damage: A review of the literature and directions for future research. *WIREs Clim. Change* 10 (2). <https://doi.org/10.1002/wcc.2019.10.issue-2>.
- McNamara, K.E., Bronen, R., Fernando, N., Klepp, S., 2018. The complex decision-making of climate-induced relocation: adaptation and loss and damage. *Clim. Policy* 18 (1), 111–117.
- McShane, K., 2017. Values and harms in loss and damage. *Ethics, Policy & Environ.* 20 (2), 129–142.
- Mechler, R., Calliari, E., Bouwer, L.M., Schinko, T., Surminski, S., Linnerooth-Bayer, J., Fuglestedt, J.S., 2019. Science for loss and damage. findings and propositions. In: Mechler, R., Bouwer, L., Schinko, T., Surminski, S., Linnerooth-Bayer, J. (Eds.), *Loss and Damage from Climate Change*. Climate Risk Management, Policy and Governance. Springer, Cham, pp. 3–37. [https://doi.org/10.1007/978-3-319-72026-5\\_1](https://doi.org/10.1007/978-3-319-72026-5_1).
- Mechler, R., Singh, C., Ebi, K., Djalante, R., Thomas, A., James, R., Tschakert, P., Wewerinke-Singh, M., Schinko, T., Ley, D., Nalau, J., Bouwer, L.M., Huggel, C., Huq, S., Linnerooth-Bayer, J., Surminski, S., Pinho, P., Jones, R., Boyd, E., Revi, A., 2020. Loss and Damage and limits to adaptation: recent IPCC insights and implications for climate science and policy. *Sustainability Sci.* 15, 1245–1251. <https://doi.org/10.1007/s11625-020-00807-9>.
- Morrissey, J., Oliver-Smith, A., 2013. Perspectives on non-economic loss and damage: understanding values at risk from climate change. *Loss and Damage Series*. United Nations University Institute for Environment and Human Security, Bonn.
- Nassef, Y., 2020. The PCL Framework: A strategic approach to comprehensive risk management in response to climate change impacts. Retrieved April 20, 2020 from <https://arxiv.org/abs/2004.06144v1>.
- O'Brien, K.L., 2009. Do values subjectively define the limits to climate change adaptation. *Adapting to climate change: Thresholds, values, governance*, 164–180. DOI: 10.1017/CBO9780511596667.011.
- Ospina, A.V., Heeks, R., 2010. Linking ICTs and climate change adaptation: a conceptual framework for e-resilience and e-adaptation. Manchester: University of Manchester. Retrieved January 20, 2020 from <http://hdl.handle.net/10625/44416>.
- Pachauri, R.K., Allen, M.R., Barros, V.R., Broome, J., Cramer, W., Christ, R., Dubash, N.K., 2014. Climate change 2014: synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change (p. 151). IPCC. Retrieved April 10, 2020 from [https://epic.awi.de/id/eprint/37530/1/IPCC\\_AR5\\_SYR\\_Final.pdf](https://epic.awi.de/id/eprint/37530/1/IPCC_AR5_SYR_Final.pdf).
- Pelling, M., O'Brien, K., Matyas, D., 2015. Adaptation and transformation. *Clim. Change* 133 (1), 113–127.
- Prabhakar, S.V., Kamat, K., Hakimov, A., Chiba, Y., Nakata, M., 2015. Loss and damage associated with climate change: What and why, stakeholder perspectives, and a way forward. *The Paris Climate Agreement and Beyond*, 103. Retrieved July 20, 2020 from <https://www.jstor.org/stable/pdf/resrep02928.14.pdf>.
- Preston, C.J., 2017. Challenges and opportunities for understanding non-economic loss and damage. *Ethics, Policy & Environ.* 20 (2), 143–155.
- Rimi, R.H., Hausteil, K., Allen, M.R., Barbour, E.J., 2019. Risks of pre-monsoon extreme rainfall events of Bangladesh: is anthropogenic climate change playing a role? *Bull. Am. Meteorol. Soc.* 100 (1), S61–S65. <https://doi.org/10.1175/BAMS-D-18-0152.1>.
- Robards, M.D., Schoon, M.L., Meek, C.L., Engle, N.L., 2011. The importance of social drivers in the resilient provision of ecosystem services. *Global Environ. Change* 21 (2), 522–529.
- Roberts, E., Pelling, M., 2018. Climate change-related loss and damage: translating the global policy agenda for national policy processes. *Clim. Develop.* 10 (1), 4–17.
- Preston, B.L., Dow, K., Berkhout, F., 2013. The climate adaptation frontier. *Sustainability*, 5(3), 1011–1035. DOI: 10.3390/su5031011.
- Roberts, E., Kees V.D.G., Warner, K., Andrei, S., 2014. Loss and damage: When adaptation is not enough. UNEP. Retrieved January 20, 2020 from [https://na.unep.net/geas/archive/pdfs/GEAS\\_Apr2014.Climate\\_Change.pdf](https://na.unep.net/geas/archive/pdfs/GEAS_Apr2014.Climate_Change.pdf).
- Schinko, T., Mechler, R., Hochrainer-Stigler, S., 2019. The risk and policy space for loss and damage: integrating notions of distributive and compensatory justice with comprehensive climate risk management. In: *Loss and Damage from Climate Change*. Springer, Cham, pp. 83–110. [https://doi.org/10.1007/978-3-319-72026-5\\_4](https://doi.org/10.1007/978-3-319-72026-5_4).
- Schleussner, C.F., Pfeleiderer, P., Fischer, E.M., 2017. In the observational record half a degree matters. *Nat. Clim. Change* 7 (7), 460–462. <https://doi.org/10.1038/nclimate3320>.
- Schwerdtle, P., Bowen, K., McMichael, C., 2018. The health impacts of climate-related migration. *BMC Med.* 16 (1), 1–7. <https://doi.org/10.1186/s12916-017-0981-7>.
- Serdeczny, O.M., Bauer, S., Huq, S., 2018. Non-economic losses from climate change: opportunities for policy-oriented research. *Clim. Develop.* 10 (2), 97–101.
- Serdeczny, O., Waters, E., Chan, S., 2016. Non-economic loss and damage in the context of climate change: understanding the challenges (No. 3/2016). discussion paper. Retrieved July 20, 2020 from [https://www.die-gdi.de/uploads/media/DP\\_3.2016.pdf](https://www.die-gdi.de/uploads/media/DP_3.2016.pdf).
- Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M., Menkir, A., 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: technological, institutional and policy options. *Weather Clim. Extremes* 3, 67–79.
- Smith, J.B., Klein, R.J.T., Huq, S., 2003. *Climate Change, Adaptive Capacity and Development*. Imperial College press, London.
- Surminski, S., Lopez, A., 2015. Concept of loss and damage of climate change – a new challenge for climate decision-making? a climate science perspective. *Clim. Develop.* 7 (3), 267–277.
- Tanner, T., Lewis, D., Wrathall, D., Bronen, R., Cradock-Henry, N., Huq, S., Lawless, C., Nawrotzki, R., Prasad, V., Rahman, M.A., Alaniz, R., King, K., McNamara, K., Nadiruzzaman, M.D., Henly-Shepard, S., Thomalla, F., 2015. Livelihood resilience in the face of climate change. *Nat. Clim. Change* 5 (1), 23–26.
- Thomas, T.S., Mainuddin, K., Chiang, A., Rahman, A., Haque, N., Islam, N., Quasem, S., Sun, Y., 2013. Agriculture and Adaptation in Bangladesh: Current and Projected Impacts of Climate Change. IFPRI Discussion Paper 01281. Retrieved December 20, 2019 from <https://pdfs.semanticscholar.org/3529/4a6ebadb0bde7e32aac5f9ceb383f35ed30.pdf>.
- Tschakert, P., Barnett, J., Ellis, N., Lawrence, C., Tuana, N., New, M., Elrick-Barr, C., Pandit, R., Pannell, D., 2017. Climate change and loss, as if people mattered: values, places, and experiences. *WIREs Clim. Change* 8 (5). <https://doi.org/10.1002/wcc.2017.8.issue-5>.
- Tschakert, P., Ellis, N.R., Anderson, C., Kelly, A., Obeng, J., 2019. One thousand ways to experience loss: a systematic analysis of climate-related intangible harm from around the world. *Global Environ. Change* 55, 58–72.
- United Nations Framework Convention on Climate Change (UNFCCC). (2012a). A literature review on the topics in the context of thematic area 2 of the work programme on loss and damage: A range of approaches to address loss and damage associated with the adverse effects of climate change. United Nations Framework Convention on Climate Change (UNFCCC). Subsidiary Body for Implementation (SBI), FCCC/SBI/2012/INF.14. Retrieved Jun 30, 2020, from <http://unfccc.int/resource/docs/2012/sbi/eng/inf14.pdf>.
- United Nations Framework Convention on Climate Change (UNFCCC). (2012b). Current knowledge on relevant methodologies and data requirements as well as lessons learned and gaps identified at different levels, in assessing the risk of loss and damage associated with the adverse effects of climate change. Bonn: Author. Retrieved January 23, 2020, from <http://unfccc.int/resource/docs/2012/tp/01.pdf>.
- van der Geest, K., Schindler, M., 2017. *HANDBOOK FOR ASSESSING LOSS AND DAMAGE IN VULNERABLE COMMUNITIES*. Bonn, Germany: United Nations University. Retrieved September 05, 2019 from [https://www.preventionweb.net/files/57350\\_online21handbook170510w.pdf](https://www.preventionweb.net/files/57350_online21handbook170510w.pdf).
- Wallimann-Helmer, I., 2015. Justice for climate loss and damage. *Clim. Change* 133 (3), 469–480.
- Wallimann-Helmer, I., Meyer, L., Mintz-Woo, K., Schinko, T., Serdeczny, O., 2019. The ethical challenges in the context of climate loss and damage. In: *Loss and Damage from Climate Change*. Springer, Cham, pp. 39–62. [https://doi.org/10.1007/978-3-319-72026-5\\_2](https://doi.org/10.1007/978-3-319-72026-5_2).
- Warner, K., van der Geest, K., 2013. Loss and damage from climate change: local-level evidence from nine vulnerable countries. *Int. J. Global Warm.* 5 (4), 367–386. <https://doi.org/10.1504/IJGW.2013.057289>.
- Warner, K., Van der Geest, K., Huq, S., Harmeling, S., Kusters, K., de Sherbinin, A., Kreft, S., 2012. Evidence from the frontlines of climate change: Loss and damage to communities despite coping and adaptation. United Nations University-Institute for Environment and Human Security (UNU-EHS). Retrieved July 31, 2020 from <http://lib.riskreductionafrica.org/bitstream/handle/123456789/716/evidence%20from%20the%20frontlines%20of%20climate%20change.pdf?sequence=1>.
- Zellentin, A., 2015. Climate justice, small island developing states & cultural loss. *Clim. Change* 133 (3), 491–498. <https://doi.org/10.1007/s10584-015-1410->