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# Climate Change, Debate and Dimensions of Coping Strategies

Shah Md Atiqul Haq, Khandaker Jafor Ahmed,  
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## Abstract

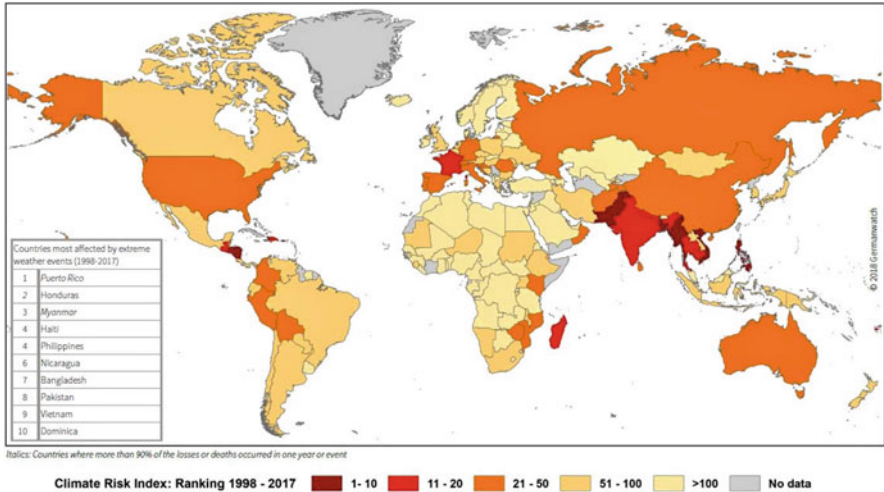
Climate change is a big challenge now. Currently, researchers, academics, and policymakers focus on coping with and dealing with the adverse effects of climate change. However, due to climate change impacts, it is impossible to determine the number of coping strategies, primarily when the appropriate coping and adaptation strategies depend on the socioeconomic and cultural context of vulnerable communities facing climate change-related extreme events. Therefore, we cannot deny the current debate between coping strategies and climate change adaptation. In this case, the chapter addresses existing definitions, discussions, and pieces of evidence on coping strategies and adaptations for dealing with the adverse impacts of climate change. It also discusses with examples how the various relationships between climate change-related events and coping strategies or adaptations are different. Researchers present theoretical backgrounds in understanding the nexus between climate change and coping strategies and adaptation contextually. The chapter also includes some discussions of the above linkage in Bangladesh's context. Finally, various empirical studies provide thoughts that the connection between climate change, tackling strategies, and adaptation varies in terms of the severity and types of climate change-related events in which socioeconomic, sociodemographic, and cultural aspects mediate the relationship.

## Keywords

Climate change perception · Coping strategy · Adaptation strategy · Debates over coping and adaptation strategy · Socioeconomic and cultural context · Bangladesh

## Introduction

Climate change is one of the biggest global concerns of the twenty-first century, as it adversely affects nature and its inhabitants, which are both simply trying to cope and adapt to the situation. However, climate parameters and extreme events are accelerating the global crisis, which has become the worst with fatalities, loss, and damages. Other forms of climate change and frequent natural disasters are common around the world. The Earth's atmospheric mean temperature has increased from about 0.15 °C



**Fig. 1** World map of the Global Climate Risk Index 2019. (Source: Eckstein et al. 2018:12)

to 0.2 °C over the past 100 years (Mendelsohn 2007). At the end of the present century, the global temperature will increase between 0.3 °C and 4.8 °C (Hartmann et al. 2013). There are positive and negative trends in global rainfall. The sequence increases over the tropical seas and decreases in some mid-latitude regions (Adler et al. 2017). However, seasonal changes in precipitation, especially in many parts of the arid tropics, see increasing uncertainty in its intensity, time, and duration (Feng et al. 2013). Given the changes in climate parameters, people's concerns about adaptation and adaptation strategies confront extreme climate events' adverse effects.

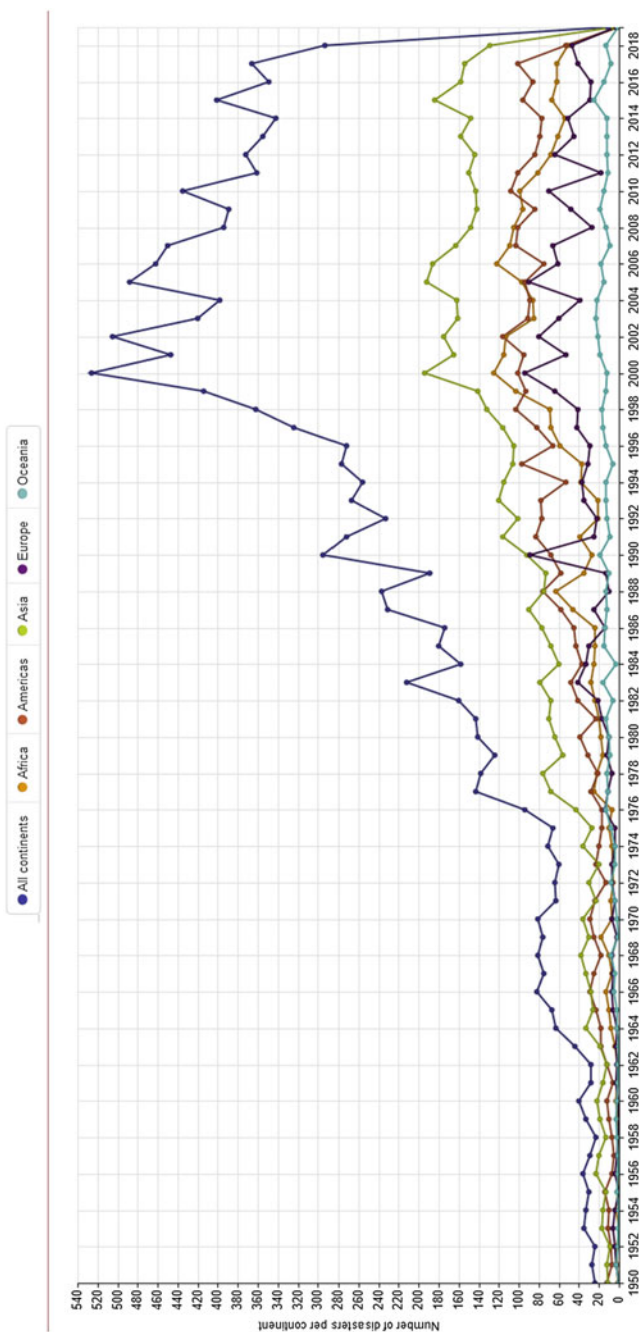
Based on the results from 171 countries to identify the hotspots of climate change, Li et al. (2019) find that the average rate of increase in the vulnerability index from 1996 to 2008 was 0.30%. They argued that climate change is more likely to bring adverse impacts on many economic, societal, and ecological services directly or in synergy with other processes. However, the effects can vary sharply from one country to another country. According to the Global Climate Risk Index (CRI) of 2019, between 1998 and 2017, more than 11,500 extreme weather events caused more than \$3.47 trillion in losses (in purchasing power parities), leaving more than 526,000 people dead. The top ten countries (Fig. 1) most affected by extreme events from 1998 to 2017 are Puerto Rico (number of events 25, death toll 150.05), Honduras (number of events 66, death toll 302.45), Myanmar (number of events 47, death toll 7048.85), Haiti (number of events 77, death toll 281.30), Philippines (number of events 307, death toll 867.40), Nicaragua (number of events 45, death toll 163.60), Bangladesh (number of events 190, death toll 635.50), Pakistan (number of events 145, death toll 512.40), Vietnam (number of events 220, death toll 296.40), and the Dominican Republic (number of events 8, death toll 3.35). Out of

ten affected countries and regions (1998–2017), eight developing countries are low-income or low-middle-income, one is classified as high-middle-income (Dominica), and one is a developed economy with a high income (Puerto Rico) (Eckstein et al. 2018).

Disasters are increasing worldwide, with a higher concentration in Asia. Figure 2 shows the upward trend from 1950 to 2019. According to the Centre for Research on Epidemiology of Disaster (CRED), the number of natural disasters in 2017 totalled 335 where 136, 93, 42, 39, and 8 were in Asia, America, Africa, Europe, and Oceania, respectively. Between 2007 and 2016, there were 354 natural disasters, while in 2017 alone, there were 335 worldwide. Floods and storms are the two most common natural disasters worldwide. For example, there were 126 floods and 127 storms out of 335 natural disasters in 2017 (CRED 2018).

Due to global climate change, the average rate of vulnerability worldwide has risen about 0.30% between 1996 and 2008 (Li et al. 2019). The world has responded to the global climate to control climate change's adverse effects. According to Elum et al. (2017), there are two broad feedback mechanisms: mitigation and adaptation. Given the growing adverse effects of climate change and extreme events, researchers and practitioners emphasize the understanding of coping and adaptation practices across levels of social organization (Adger et al. 2009; Moser 2010). It is essential to systematically identify human reactions to climate change and distinguish between adaptation and coping with evaluating policy and social progress (Adger et al. 2005). There are plenty of studies (Foguesatto et al. 2018; Alam et al. 2017; Tripathi and Mishra 2017; Ali and Erenstein 2017; Makuvaro et al. 2018; Islam 2016; Jørgensen and Termansen 2016; Below et al. 2012; Suwanmontri et al. 2018) dealing with population vulnerable to climate change and investigation strategies in a variety of settings. Islam (2016) argues that coastal people in Bangladesh depend on rain, surface water, and groundwater for their agricultural production, making them more vulnerable to climate change impacts. Therefore, vulnerability to and coping with the adverse effects of climate variability in extreme weather events – such as floods and drought – is the primary concern for the country (Islam 2016). Societies use two types of responses or strategies to reduce the vulnerability of the effects of climate change. These two response types to the crisis that overlap across temporal scales are coping strategies and adaptive strategies. However, dealing with coping strategies versus adaptation methods in terms of definitions and typologies remains debatable.

The structure of the paper is as follows. The next section describes the definitions, debates, and differences in climate change perceptions, coping strategies, and adaptation strategies. We then present the typologies of coping and adaptation strategies by reviewing existing literature. Next, we offer the research conducted in Bangladesh as a case study to show how people-driven coping strategies vary from region to region in extreme weather environments.



**Fig. 2** Total number of reported natural disasters between 1950 and 2018. (Source: EM-DAT 2019)

## **Climate Change Perception, Coping, and Adaptation Mechanisms: Definitions, Debates, and Differences**

### **Climate Change Perception**

Climate change is characterized as a threat factor that exacerbates several challenges (e.g., environmental, social, and economic) at the local and global levels. Understanding climate change perception is multidimensional, influenced by different sociodemographic, cultural, political, and economic determinants (Poortinga et al. 2019). Understanding climate change is important, as it is one factor that influences the adaptation process. Smith and Mayer (2018) have discovered that people who consider climate change a threat to them are more likely to act and support climate change policies.

Perception should be correct; otherwise, actions taken based on misconceptions may have adverse effects (Tripathi and Mishra 2017; Alam et al. 2017). Thus, it is crucial to understand the level of human perception, its accuracy, and how climate change perception stimulates adaptation (Tripathi and Mishra 2017). Various studies worldwide have explored people's perceptions of climate change and its impact on society. In Nepal, Khanal et al. (2018) found that most rural farmers realized the temperature had increased and there was a change in rainfall throughout the decades. Similarly, a study by Tripathi and Mishra (2017) in India found that farmers were vulnerable to warming and rainfall variability over the past 20 years. Elum et al. (2017) likewise observed the negative perception among South African vegetable farmers. Due to the changing weather over time, most farmers have experienced high temperatures, drought, low crop yields/crop failure, or high incidences of pests and diseases. Also, in the two China provinces, Anhui and Jiangsu, most farmers have found that temperatures have been rising over the past 20 years and rainfall is decreasing (Kibue et al. 2016).

Accurate perception depends on knowledge (Tripathi and Mishra 2017), experience (Foguesatto et al. 2018), demographic and environmental values (Ali and Erenstein 2017), and access to information (Tripathi and Mishra 2017; Ali and Erenstein 2017). Foguesatto et al. (2018) describe two theoretical aspects: expected utility maximization and availability heuristic that may influence the farmers' perceptions of climate change. Expected utility maximization refers to the anticipated change in farmers' well-being and focusing on some events, such as pay increases, new stereo buys, health improvements, or local biodiversity improvements. On the other hand, the availability heuristic is a mental shortcut based on the memory of events. This proves how transparent and clear a particular risk problem is and how quickly one can think of a recent instance. This means that the event can be easily remembered when the person determines the level of familiarity with the scheduled event and will appear more frequently. Even though the phenomenon is correctly realized, sometimes people do not respond to climate change effects, including constraints on capacity, resources, and scarcity (Tripathi and Mishra 2017; Alam et al. 2017).

## Coping Strategies

According to the Intergovernmental Panel on Climate Change (IPCC), there are three components of climate vulnerability: exposure, sensitivity, and the ability to adapt (McCarthy et al. 2001). Of these components, coping is an important dimension (Eriksen et al. 2005). Coping strategies indicate an individual's perceptions and efforts to manage resources in mitigating the adverse consequences of a hazard (Wisner et al. 2004). The coping strategies are mostly complicated because an event will follow a known pattern, and the previous actions are similar and a practical guide to the event (Wisner et al. 2004). Coping strategy refers to a collection of cognitive or behavioral techniques that a person or system uses to handle disruption demands using their capacity to cope (Béné et al. 2016; Manseau et al. 2005). Berman et al. (2012) defined coping capacity as actors' ability to draw on available skills, resources, and experiences as immediate responses for managing adverse stresses or shocks and maintaining persistence.

## The Debate Over Adaptation Strategies

Climate change affects poor households who mainly rely on agriculture, and they face severe challenges from climate-related events in the South Asian region. In South Asian countries, agriculture is more sensitive to climate change, and the countries have a high population (Ali and Erenstein 2017). Adopting adaptation strategies in agriculture can minimize climate change impacts (e.g., loss of soil fertility, water scarcity, crop yield changes, crop diseases) and reduce the degree of vulnerability (Ali and Erenstein 2017). Since climate change impacts will be severe in the coming years, it is essential to take adaptation strategies to tackle the existing and upcoming climate-induced consequences and risks.

The Intergovernmental Panel on Climate Change defines adaptation as “an adjustment of natural or human systems in response to actual or anticipated climate stimuli or their effects” (McCarthy et al. 2001). This definition focuses strongly on the specific threat posed by climate change and variability. Adaptation can be planned, spontaneous, reactive, or anticipatory-driven; however, it is a manifestation of adaptive capacity, since adaptive capacity is a prerequisite for adaptation (Smit and Wandel 2006; Simonovic 2017). Adaptive capacity is “the capacity to make adjustments and incremental changes in anticipation of or response to change” (Bahadur et al. 2016; Brown 2016). However, livelihoods for more substantial environmental, economic, and political changes were studied earlier, such as with a sustainable livelihood framework (Ellis 2000). This framework explains how people use livelihood resources such as human, natural, financial, social, and physical in the setting of shocks, trends, and seasonal changes. Structures mediate the selection process of strategies (e.g., public, private sector level, etc.) and processes (e.g., legislation, policies, cultures, organizations, etc.) and result in livelihood outcomes such as income, well-being, and food security (Ellis 2000).

Tripathi and Mishra (2017) pointed out that adaptation is a two-step process. First, climate change and risks involved must be perceived. Second, measures must be taken to reduce climate change's negative impacts. Perception counts on knowledge and information access, where the knowledge relies on education and experience. Tripathi and Mishra (2017) define perception as a cognitive process involving receiving and analyzing sensory information. It is, therefore, vital to understand the level of perception of people, their rightness, and how climate risk perception stimulates adaptation (Tripathi and Mishra 2017; Mase et al. 2017; Jørgensen and Termansen 2016) and attitudes toward adaptation and innovation (Mase et al. 2017). According to IPCC (2014), climate change adaptation is the “process of adjusting to the original or expected climate and its effects” to exploit beneficial opportunities and moderate harm. Although adaptive planning is characterized by different criteria such as horizon (short or long term), time (reactive or anticipatory), form (technical, institutional, legal, behavioral, or educational), and actor involvement (private or public), there are two main types of adaptation strategies: autonomous and planned adaptations (Khanal et al. 2018).

Khanal et al. (2018) identify the factors that influence decision-making in adopting climate change adaptation strategies and explore how adaptation strategies affect farm yields. Education and access to credit and services (Below et al. 2012), experience with the impacts of climate change events (e.g., drought and flood) (Tripathi and Mishra 2017), available information on climate change issues, people's belief in climate change, all variously determine decision-making to climate change adaptation strategies (Khanal et al. 2018).

## Similarities and Differences in Coping and Adaptation Strategies

Geest and Dietz (2004) defined coping strategies more accurately and distinguished them from additive techniques. The “coping” can be defined as a spontaneous response, mostly at the local level (Osbaahr et al. 2008). Ravera et al. (2011) adopted the definition of Osbaahr et al. (2008) to distinguish between (1) the unplanned response to a crisis by locals and (2) planned strategies adapted, frequently revised, and primarily implemented in long-term operations. Coping strategy is immediate for climate-induced hazards (Regmi et al. 2010). The differences between coping and adaptation strategies are explained in Table 1. In other words, a short-term coping strategy to deal with climate-related events to mediate harm and damages immediately is essential. In the long run, dealing with some of the risks, a coping strategy can be developed as an adaptation strategy. Adaptation studies have often emphasized measures to reduce susceptibility, such as changes in forms of agriculture, which are less climate-sensitive and reduce the need to cope (Eriksen et al. 2005).

Behavioral responses to changing climate can help steer adaptive response and deal with climate change behaviors. Adaptation is generally understood to take place on temporal and spatial scales. Adaptation is a long-term process of lasting fixation, while coping is a short-term temporal adjustment process (Smit and Wandel 2006;

**Table 1** Differences in coping and adaptive strategies

Characteristics	Coping strategies	Adaptive strategies
Aims	Survival	Both survival and sustainable management of socio-ecological systems
Time frames	Short-term; steps are taken immediately	Long-term, frequently revised, and evolution over several generations
Response types	Spontaneous reactions, opportunistic	Proactive, planned actions
Learning	Limited, through individual experience and innovation	Extensive, through knowledge exchange, intergenerational transfer, and institutional development
Scope	Happens at the local level	Happens at an organizational, regional, or sectoral level
Level of adjustments	A short-term process of temporary adjustments	A long-term process of enduring adjustments
Timing of actions	Associated with action in achieving desired goals during and immediately after a hazard	Associated with action in anticipation of a threat or hazard

Source: Authors' own and partially adopted from Fabricius et al. (2007)

Opiyo et al. 2015; Birkmann 2011). Adaptations can be differentiated from coping depending on the extent of responses, which can be connections made to the response's organizational scale. Adaptation typically entails actions in the setting of a threat that so often necessitates resources and information provided by institutions, while also, on the other hand, coping involves interactions taking place with immediate implementation (Osbaahr et al. 2008). Therefore, autonomous, reactive, and incremental behavioral responses may be better referred to as coping, while highly planned, practical, and transformative interventions may be considered adaptations. Galappaththia et al. (2019) suggested developing an integrated framework to understand adaptation based on arguments from different case examples from Sri Lanka, Kenya, Bangladesh, India, Southeast Asia, and the Canadian Arctic. They focus on local adaptation initiatives effectively linked with government policy through local institutions with a participatory approach.

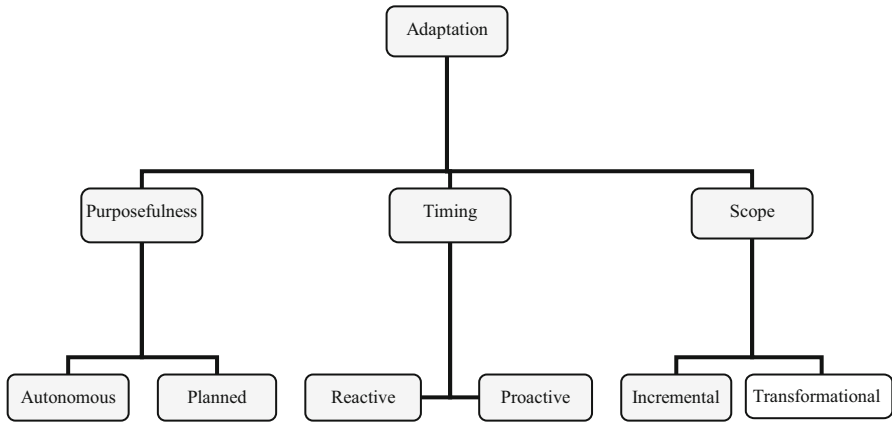
## Types of Coping and Adaptation Strategies

The coping strategies are sometimes perplexed by the presumption that an incident follows a regular pattern and that the actions taken prior against the event to cope are a reasonable pathway to corresponding events (Wisner et al. 2004). They operate on different scales of individuals or families, communities or neighborhoods, institutional city-wide, or beyond. Individual coping strategies operating at the family unit level facilitate the family's internal activities. Coping strategies are successful at the community level when the community members work together to improve and sustain their resilience. To be effective, it necessitates a fixed standard of

organization outside the family, and it may involve community-based organizations, religious organizations, or other organizations that function as an organizing entity within the community.

Abid et al. (2019) developed two coping strategies: *ex ante* and *ex post*. The *ex ante* strategy considers families who implement the strategy in advance to withstand climate shocks. *Ex post* coping strategies are measures taken by families after the climate shock. Some examples of the former approach are early planting, changing crop types, intercropping, doing regular work on the farm, etc. On the other hand, examples of *ex post* techniques include crop diversification, harvesting, low yielding, etc. (Abid et al. 2019). Wisner et al. (2004) identify different coping strategies. Preventive strategies are at individual and small group levels, meaning that people choose the strategy not to be affected by an event at certain times. They avoid hazardous locations or pick safe residential places. The impact minimizing strategy is to reduce loss and damage and facilitate recovery from the damage and risk. It is commonly referred to as “mitigation” in disaster literature but “adaptation” in climate change literature. Quite simply, this should improve access to the minimum level of food, shelter, and physical security, so people are less at risk when a disaster or climate event occurs. Specifying food storage and marketable assets may lead to higher food reserves in rural areas, but urban dwellers in a cash-based economy may adopt strategies such as having valuable merchandise. Multiple income earners in a family also offer a variety of opportunities. If families contribute to savings, it can provide a combination of income at a difficult time. The development of social support networks is the ability to take on others’ resources during difficult times. Networks can be within families, or extended family members (living near or far), in the surrounding areas, and with larger groups who have a shared identity (religious, geographical, commercial, etc.). Assistance can come in many forms, such as financial aid, psychological support, shelter when needed, or some kind of physical support.

IPCC distinguishes different adaptations: anticipatory (or proactive), responsive (or autonomous or spontaneous), and planned adaptation. Planned adaptation is the result of deliberate policy decisions which counts on an awareness that the situation has changed or is about to change and that the move has to go back, maintain, or achieve the desired state (McCarthy et al. 2001). Fischer (2019) outlines some typologies that are designed to categorize generic types of adaptation (Fig. 3). These typologies feature adaptive behavior in three dimensions: purposefulness, timing, and scope. Concerning purposefulness, the adaptation can be either autonomous or planned. Autonomous adaptation requires the spontaneous or ongoing implementation of existing knowledge and strategies, while planned adaptation involves deliberate actions considering the suitability of practices and policies to current and future changes (Füssel 2007; Birkmann 2011) directly with government support (Klein 2003). Regarding timing, the adaptation can be responsive or proactive. Reactive adaptation is an instantaneous behavioral response to restore stability, often through non-risk and securing resources. In contrast, proactive adaptation embraces practices in anticipation of new conditions to reduce future loss, risk, and vulnerability, often through planning, monitoring, awareness raising,



**Fig. 3** Typologies developed for classifying generic types of adaptation by Fischer (2019)

partnership development, and partnerships (Berrang-Ford et al. 2011; Ford et al. 2011). Regarding scope, the adaptation can be incremental or transformational. Incremental adaptation refers to small changes in the current context to avoid obstacles and to pursue the same objectives, where transformational adaptation changes the scale that is new to a particular context and primarily changes the broader biophysical, social, or economic system (Park et al. 2012; Kates et al. 2012). Shikuku et al. (2017) adopt incremental adaptation considering their study. Their research also argues that farmers do not have equal access to adaptation strategies. Indeed, it is not yet known how to rank among adaptation strategies at different levels. They also noted that introducing new yields would help address climate risk and hierarchical cropping systems without having to provide a single crop, maximizing crop yields and reducing climate-driven risk. Alam et al. (2017) mentioned farming and non-farming adaptation strategies. They identified farming adaptation strategies that include adopting new crop varieties, changing planting time, homestead gardening, planting trees, and migration and non-farming adaptation strategies which include improving people's access to finance and information.

Climate risk will affect agriculture and the livelihoods of the rural population. As a result, adaptation is the only way to address the climate's risks and dangers. Fosu-Mensah, Vlek, and MacCarthy (2012) show that local farmers adopt some adaptive methods, such as diversification of crops, choosing short-season varieties, changing crop varieties, and changing their timing of planting. Ali and Erenstein (2017) assess the factors influencing climate change adaptation practices in Pakistan. They show adaptation practices associated with education, male household heads, family size, size of land, extension services, access to credit services, and wealth. Ali and Erenstein (2017) showed that farmers adopted three adaptation methods, such as integration, during the sowing period, choosing drought-tolerant varieties, and introducing new crops. The study results also show that farmers who are relatively young and rich and have a high level of education, extensive farmland, and a joint

family use this adaptation method more often. The effects of climate change are monitored in various ways in Pakistan, such as decreasing soil fertility, increasing water scarcity, shifting in crop yields, and increasing crop diseases; and people employed in farming adopt several adaptation strategies on their farms, such as changing crop varieties, using fertilizers, quality seed and pesticides, planting shade trees, keeping them as water reservoirs, diversifying agriculture, etc. (Fahad and Wang 2018).

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## **Coping Strategies in Bangladesh: How Do They Differ in Terms of Extreme Weather Events?**

Bangladesh is one of the most vulnerable countries for climate change and climatic variability (Pouliotte et al. 2009; Pavel et al. 2013; Islam et al. 2014). In the Climate Risk Index, Bangladesh is in the sixth position and has already experienced different extreme climate-related events (Eckstein et al. 2017). Climate events such as floods, cyclones, heavy rainfall, river erosion, and droughts are most frequent in Bangladesh (Salaudhin and Ashikuzzaman 2012; Shahid 2010; Thakur et al. 2012), which severely affect the livelihoods of vulnerable populations (Ayebe-Karlsson et al. 2016; Garai 2014; Parvin et al. 2016). Issues related to climate change such as the continuous rise of temperature and changing rainfall patterns have greatly affected various sectors of Bangladesh (e.g., agriculture, water resources, and public health) (Garai 2014; Kabir et al. 2009). In this section, we review studies conducted in Bangladesh, focusing on coping and adaptation strategies. This section organizes literature on coping and adaptation strategies depending on the region's vulnerability to climate change or extreme weather events or other associated disasters.

## **Coping Strategies of Indigenous Populations Vulnerable to Climate Change**

Thirty-four meteorological stations (from 1971 to 2010) in Bangladesh use the weather data to show the country's recent climate change with a mean temperature rise of 0.20 °C per decade (Rahman and Lateh 2017). Another study on 18 weather stations from 1961 to 2014 observed a significant increase in average temperature across all months in Bangladesh (Mohsenipour et al. 2018). Besides the variation in seasonal rainfall in Bangladesh, the annual rainfall trend from 1971 to 2010 is observed (+7.13 mm per year), with the maximum rainfall in June, July, and August from 1400 to 4400 mm (Rahman and Lateh 2017). Regarding rainfall forecasts, compared to the two decades previously described, this would decrease to about -153 mm with the annual rate decreasing to -15.3 mm. However, compared to the 1971 rainfall, the annual rainfall is expected to increase by about 5.5% by 2020 (Rahman and Lateh 2017).

There is research in Bangladesh that examines coping strategies for dealing with indigenous people at risk for climate change. Ahmed and Haq (2017) explore

indigenous people's perceptions of climate change and managing forest resources to investigate their indigenous integrated coping strategies. With the adverse effects of climate change in agriculture, the study groups (i.e., Khasia and Tripura) use their own traditional and sometimes modern approach to deal with it. Among the strategies, crop diversification, modification of planting, and harvesting periods are the most commonly used in the communities. They are only dependent on agriculture, which is in extreme danger to climate change, and they are trying to engage themselves in extra income-generating activities (e.g., running a grocery store, tourist guides, producing handicrafts) (Ahmed and Haq 2017). Akhter et al. (2013) found that changing grain composition, multiple crop practices, and intensive use of chemical fertilizers and pesticides are common strategies for some ethnic groups selected to respond to climate change. Among the coping strategies, indigenous communities have been doing their best to sustain agriculture. While this effort is far from guaranteed to fail or be sustainable, indigenous populations look for alternative livelihoods (Akhter et al. 2013). In both surveys (Ahmed and Haq 2017; Akhter et al. 2013), the study of indigenous people's variations in crop variability and the change in crop type is the primary strategy implemented against climate change.

### **Coping Strategies of Populations Vulnerable to Flood**

In Bangladesh, there is a lack of preparation to manage flooding impacts. People have to face another catastrophe without enough coping with existing consequences from flood events as this is very frequent. It is known that short-term strategies against flooding cannot provide any long-term solution. Adaptation for vulnerable populations with adequate resources and access and empowered to act and use local knowledge can provide a long-term adjustment to the adverse impacts (Islam et al. 2018).

Due to lack of food, extreme poverty, inadequate income, illiteracy, and a high concentration of laborers, Bangladesh's flood-prone areas are among the worst in various disaster zones (Pavel et al. 2013). Studies conducted in the flood-hit regions of Bangladesh have revealed that floating garden, changes in farming practices, income diversification, alternative livelihoods, loan borrowing, and disposable asset sales are significant and widely practiced strategies. Pavel et al. (2014) revealed that the floating garden is an adaptation strategy to flood-prone communities in the northeast part of Bangladesh. This floating garden adaptation increased households' monthly income and reduced chances of being impoverished. Moreover, Mamun and Pavel (2014) and Pavel et al. (2014) demonstrated that the changes in farming practices could be the best way to adapt to Bangladesh's changing climate. Sometimes, this new farming practice could lead to high-yielding agricultural production for the flood-vulnerable farmers. Anik and Khan (2012) and Mamun and Pavel (2014) have studied in flood-prone areas of Bangladesh to understand adaptation to climate change through local people's knowledge. With changing climate and extreme events, local people have changed their behavior and introduced some adaptation strategies. Among the adaptive strategies, crop diversity, duck rearing,

floating gardens, wave protection walls, cage aquaculture, canal re-excavation, and dam construction were widely used. They are entirely dependent on agriculture, which is extremely vulnerable to climate change (Pavel et al. 2013, 2014).

However, vulnerable households or farmers are trying to protect their income through alternative livelihoods such as poultry and cottage industries (Anik and Khan 2012). The northeastern Bangladesh wetland region is highly vulnerable to flood-related extreme weather events (Sultana et al. 2020). The region is a flashflood-prone area since the area is low-lying and experiences high annual rainfall (Kamal et al. 2018). In a study in Sunamganj District as a haor region (wetland), Kamal et al. (2018) mentioned that people in the area are dependent on producing Boro rice as the only income source. Once the households fail to harvest paddy due to flooding, they face troubles and challenges to recover from the events. Therefore, Sultana et al. (2020) explore that those households vulnerable to frequent floods developed three ways to be resilient to floods such as local flood protection dams, community organizations working for relocating the affected families and their members, and seasonal migration which ensures diversification of livelihoods for almost 70% of the rural households. This study explores few coping strategies in the northern flood-prone area of Bangladesh such as reduced meals, borrow food, eat cheap food/less preferred food, reduce food consumption, casual laboring (work for food), migration for work, migration for safety, borrow money from NGOs, borrow money from a moneylender, borrow money from friends/relatives, sold harvest after/ in advance, sold land, etc. It is seen that most of the households changed their food habits and borrowed food as coping measures in addition to another important coping mechanism, migration with 50–70% of total households surveyed in 2017 (Sultana et al. 2020).

Brouwer et al. (2007) have shown that income diversification is a strategy for dealing with floods in Bangladesh. This strategy is mostly adapted to wealthy families who live farther away from the river. Households in flood-prone areas with preventive measures had higher incomes and lower expenditures for casualties (Brouwer et al. 2007). The 1998 floods were the mainstay of family financing, financing of disposable assets, selling disposable assets, and reducing spending (Del Ninno et al. 2003). Paul and Routray (2010) discussed preventive and mitigation strategies to combat floods. They found that potential preventive strategies were to raise the house's platform, build a flat using local and readily available materials, and avoid any risk of flooding. Some of the important measures include relying on cheap food, reducing the number of meals, eating wild vegetables, finding alternative income sources, selling land and disposable assets or items, relying on government and NGO relief, and receiving funding (Paul and Routray 2010). Parvin et al. (2016) found coping strategies that include saving, borrowing, and selling productive, domestic, and liquid assets to deal with floods.

Kamal et al. (2018) in their study found that the majority do not have access to any weather information, live in remote areas, and use previous experiences to adapt to the effects of flooding such as loss of sources of income and damage of houses and properties. In the region, poor people usually respond to the impacts of not choosing any specific work. However, wealthy and middle-income people are generally less

interested in receiving any government relief or support during flood periods. This is because they can utilize their wealth to recover damages and loss from floods. The study also finds that religion restricts women to follow adaptation strategies as their belief in religion does not allow them to work outside and talk to outsiders except their community people (Ahmed et al. 2019b; Haq 2018). Moreover, people in the community perceive that occurrences of climate change-related extreme weather events or any natural disaster are the results of increasing sinful activities and the wish of God (Kamal et al. 2018; Ahmed and Haq 2017). Kamal et al. (2018) find that people consider taking loans from NGOs and wealthy people to recover damages and loss from flood events. People in the flood-prone area of Sunamganj District also think migration to other places as resilience to disasters in finding work to maintain their subsistence and repay loans with interests (Choudhury and Haque 2016; Joarder and Miller 2013). Due to big cities' economic opportunities, rural to urban and seasonal migrations are very common in Bangladesh. However, people are now moving to cities due to natural hazard-induced inundation or loss of their settlement. Additionally, crop failure without considering the flood impacts has a substantial effect on migration (Gray and Mueller 2012).

### **Coping Strategies of Populations Vulnerable to Coastal Hazards**

Bangladesh is a country with 32% low-lying coastal area where 30% of the country's total populations live. The country's physical vulnerability is exacerbated by factors like high population density, poverty, and limited access to water supply, sanitation, energy, and health services (Huq and Rabbani 2015). Besides, certain factors, such as the geographical location in the tropical monsoon climate and the strange natural setting, make Bangladesh frequently prone to cyclones and storms (Madsen and Jakobsen 2004; Paul and Rahman 2006; Paul 2009; Malak et al. 2020). Bangladesh has been observing many cyclones in the past decades, and coastal regions are the most vulnerable to those cyclones where climate change impacts make the situation worse (Malak et al. 2020). Roughly every 3 years, a severe cyclone occurs in Bangladesh (Ali 1999). So, some particular groups, i.e., children, disabled persons, women, and elderly, are highly vulnerable to climate-induced disasters and cyclones. Elderly experience an increased vulnerability level due to socioeconomic and cultural dependency on their adult children. Significantly changes in family patterns and kinship relationships, extreme poverty, social changes, and weakening social and religious ethics lead to the breakdown of the care system of the elderly inside the family. Therefore, older people are so unsafe and look older than their actual age as they have faced at least one cyclone in their lifetime. Thus, the households with only older people develop some adaptive strategies, though few of them are gender-biased, to protect their families and themselves from the adverse effects of climate-induced cyclones. Traditionally, they plant trees on the southwestern side of their homesteads to limit storms' speed and make drainage around the settlements to quickly remove the saline water, quickly reconstruct their houses, keep dry food, and have safe water to use during the emergency (Malak et al. 2020). People living in

the coastal regions of Bangladesh generally use community-led self-instinct survival strategies such as changing crop farming to non-rice farming; raising homesteads and plinth season-specific household levels to protect themselves from heat, cold, and precipitation; changing house location; etc. in addition to government- and NGO-led strategies to tackle the adverse effects of climate change on the livelihoods, migration, and health (Alam 2018). By examining strategies to deal with coastal hazards such as hurricanes and floods, Parvin et al. (2008) found that the community adopts a different approach for different hazards. They examine coping strategies related to shelter, employment, water supply, and health. When it is a cyclone, one of the shelter-related coping strategies involves taking shelter in the cyclone centers and using strong wires or ropes tied around the house. When it is a high tide, people seek shelter in a better place and use high beds and wooden boxes with long legs. The livelihood strategies for coastal risk include investing in savings, taking out loans, selling property, raising poultry, and mortgaging land or other property. Coping strategies related to water supply and health include the use of purifying tablets, storing pure water, seeking herbal remedies, seeking religious treatment, and attending a local government hospital (Parvin et al. 2008).

Paul and Routray (2011) examined adaptive strategies by coastal populations living in areas prone to cyclones and storms in Bangladesh. They framed the coping strategy based on the sequence: well in advance of the hazard event, immediately before the hazard event, and post the hazard event. In the face of cyclone and storm surge, coping strategies are unique design or construction of houses, planting trees around the house (coconut, betel nut, and banana), and placing emergency food and items in a safe box or in place to deal with the tragic events of climate change. To do this, people take shelter in ceilings or on top of houses or trees, in cyclone shelters, and in neighboring homes. Among the post-hazard events to tackle strategies, finding alternative income sources outside of the main living option is more important than other cost-effective ways, such as relying on cheap foods, collecting wild food, investing in savings, financing consumers, borrowing money, selling disposable assets, temporary migration, and begging (Paul and Routray 2011). However, recommending adaptation strategies in the coastal regions such as adopting crop varieties, floating garden, and multiple crop cultivation, another study identified three types of obstacles in advancing adaptation technologies in agriculture and water supply in the coastal areas of Bangladesh such as people aren't aware enough about the devastating outcomes of climate-induced disasters, climate-sensitive sectors aren't adequately integrated into development policies, and there is lack of sufficient methodologies, tools, and knowledge in decision-making (Huq and Rabbani 2015). Nevertheless, some people use migration as an adaptation strategy where social costs of migration is a factor which has negative implications on the effectiveness of women migration affected by environmental disasters (Evertsen and Geest 2020).

Evertsen and Geest (2020) argue that environmental migration can better be understood by relating environmental factors with the affected people's existing social, economic, and human capital. This study results reject a general norm of Bangladesh regarding the prohibition of women's movement toward outside of the

home without the prior consent of male guardians in the sense that migrant women respondents living in Bhola slum of Dhaka city somehow took the initiative to manage the male members to migrate to Dhaka. Therefore, women play a role as active agents in the migration process due to climate risks and consequences (Evertsen and Geest 2020). Meanwhile, citing the knowledge gap between disaster risk reduction (DRR) and climate change adaptation (CCA) practitioners and challenges in integrating interventions for DRR and CCA in Bangladesh because both DRR and CCA have their systematic strategies and efforts to reduce climate-induced vulnerabilities and to increase resilience, a study claims that these challenges, i.e., lack of proper funding mechanisms, collaboration, and coordination, lack of implementation, poor governance, the sociopolitical-cultural structure of Bangladesh, knowledge, policy gaps, etc., can be overcome under the framework of political economy approach which can ensure effective integration of DRR and CCA through bringing institutional arrangement and efficient governance frameworks (Islam et al. 2020).

### **Coping Strategies of Populations Vulnerable to Drought**

Drought is a frequent occurrence in the north and northwestern Bangladesh (Ahmed et al. 2019a; Shahid 2008, 2010) where the northwest is referred to as “dry weather” (Shahid and Salleh 2009). A study conducted by Ahmed et al. (2019a) deals with how an indigenous group, the Santal, living in Northwest Bangladesh reacts to droughts’ impacts on water, food, health, livelihoods, and migration using their traditional coping strategies. People of the study area generally use pond water for various household tasks like cooking, drinking, bathing, dishwashing, and livestock management. Since they use pond water for drinking, they face cholera and dysentery diseases very frequently. Nevertheless, with the promotion of water sources by NGOs and government institutions, the reported scarcity of drinking water reduced from 100% before 2012 to 35% after 2012 (Ahmed et al. 2019a). In another mixed-method study, Ahmed et al. (2019a) mention various reasons for occurring drought, i.e., lack of precipitation, groundwater loss, excessive demand rather than supply, climate change, etc., and examine their response to drought. The main strategies are changing the types of crops, reducing water use at the family and community level, conserving water, engaging in seasonal migration, and traveling long distances to fetch water (Ahmed et al. 2019a).

Brammer (1987) showed how farmers adjust their farming practices to agriculture in Bangladesh. Farmers in drought-prone regions have been shown to regulate existing crop practices and modes to reduce crop yield loss. Among the innovative methods, expansion of arable land and irrigation, cultivation during drought, and replacement of crops were significant and successful. Among the combinations of cropping patterns, common crop patterns and grain rotation were popular (Brammer 1987). Paul (1998) examined agricultural and nonagricultural adjustments for droughts in eight northern Bangladesh districts and found strategies at the family level include replacing crops, multiple crop practices, and irrigation. In contrast,

family-level, non-widely practiced agro-coping strategies are asset sales, land, livestock, or other goods, and seasonal migration (Paul 1998).

## **Coping Strategies of Populations Vulnerable to Riverbank Erosion**

Natural disasters often occur in Bangladesh during which river erosion has a profound impact on land erosion. The country's coastal regions are prone to river erosion, and people living there cultivate shrimp, which is very close to the river channel. When the rate of flood increases, it damages land areas, including their shrimp farms (Bernzen et al. 2019). This effect makes 20,000 families homeless each year (Shafi 2010), and many of them migrate to urban areas as an adaptation mechanism (Bernzen et al. 2019). However, in recent years, the Center for Environmental and Geographic Information Services (CEGIS) predicts that the largest rivers in Bangladesh, because of the increasing frequency and severity of river erosion, will affect 29,000 families for the next few years. Mamun (1996) found that families affected by river erosion received invaluable support from their friends, relatives, and neighbors in the absence of support from local leaders. If families fail to have a successful rehabilitation in cities near their homesteads, available work could significantly adjust to the shock of riverbank erosion (Mamun 1996). Haque and Zaman (1989) concluded that the displacement of people who lost homes, land, or other property due to the river breakdown is the ultimate survival strategy. They have found that friends and relatives' moral and material support serves as a strategy for dealing with dislocation and adjustment (Haque and Zaman 1989). Displacement is an involuntary migration of riverbank erosion victims in Bangladesh (Mutton and Haque 2004).

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## **Discussion**

Climate change is one of the most challenges facing contemporary society. It is affecting several regions worldwide. Climate change-related extreme weather events (e.g., droughts, floods, storms, hurricanes, heat waves, and cold waves) are expected to increase in frequency and severity in the next coming years (Foguesatto et al. 2018). The vulnerability level is growing nowadays due to global climate change (Li et al. 2019). Climate change is increasingly affecting the livelihoods and agriculture of rural people. Effects of climate change (e.g., deficient rainfall, increase in seasonal mean temperature, floods, drought, etc.) with other social reasons such as poverty and poor economic conditions bring a gradual increase of high vulnerability to food security, particularly concerning South Asian people, who are mostly dependent on agriculture and deal with overpopulation (Ali and Erenstein 2017). To cope with the existing and upcoming risks and consequences of climate-related disasters (Elum et al. 2017), understanding of people's perception about the local climatic conditions and the influence of adaptation to minimize the adverse impacts of climate change and people's access to climate information can play an important

role (Khanal et al. 2018). Perception is a prerequisite to successful adaptation strategies against climate change effects. However, without being aware and appreciative of the potential impacts, people cannot effectively embark on climate change adaptation strategies (Makuvaro et al. 2018; Alam et al. 2017). The need for awareness-raising and capacity-building activities can enhance the farmers' awareness of climate change issues (Khanal et al. 2018). However, people's perception of climate change and experience with climate hazards contribute to how vulnerable populations will respond and consider adaptation and coping strategies (Tripathi and Mishra 2017). Moreover, people's responses to climate change issues broadly vary depending on their socioeconomic and demographic characteristics (Ahmed and Haq 2017; Makuvaro et al. 2018; Shikuku et al. 2017).

Adaptation strategies can also be for the short term and long term. Tackling food security challenges, for example, with the changing climate, adopting grain varieties can be an effective strategy in the short term, and building adaptive capacity through investment in human and social capital can be a viable strategy in the long run (Shikuku et al. 2017). Cooperation, participation, social learning, and togetherness can make it possible to tackle the imminent crisis from climate change. Since rural populations are highly vulnerable to climate change and dependent on agriculture where changes in natural rainfall severely affect their economic conditions and social atmosphere, future attention should be given to the climate education and adaptation strategies (Fosu-Mensah et al. 2012; Fahad and Wang 2018), an integrative approach to environmental sustainability (Haq 2011), and mobilization of government support (Fahad and Wang 2018) so that the vulnerable populations can cope with the immediate adverse impacts of climate change and consider adaptation strategies as socially inclusive (Forsyth 2018).

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## Conclusion

Climate change is the biggest global problem of the century. Coping with the adverse effects of climate change requires different strategies. However, adaptation or coping strategies and perception to adaptations vary from one country to another, climate-related extreme events to another kind, and from one community to another. In general, coping or adaptation strategies are context-specific and change over time. It depends not only on people's vulnerability to climate change impacts but also on economic and sociocultural factors such as education, gender, poverty, belief, empowerment, social capital, wealth status, financial inclusiveness, availability of alternative income sources, health status, and types of occupation. Thus, there is a need for awareness-raising and capacity-building activities that will boost people's awareness of climate change issues and adaptation strategies in vulnerable areas. Understanding local knowledge or climate change perception and adaptation for vulnerable populations with adequate resources can provide a long-term adjustment to the adverse impacts.

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